Potential for Bio Energy in the Dawson Creek Area

Draft Final Report - Inventory & Analysis.

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EXECUTIVE SUMMARY

This report has been prepared by Timmenga & Associates Inc. and Zbeetnoff Agro-Environmental Consulting on behalf of the City of Dawson Creek with funding provided by the South Peace Economic Development Commission.

The goal for the work conducted for this report is to identify sources of fibre from the South Peace area that can be used as a bio-fuel in municipal facilities in Dawson Creek. As well, based on identified volumes of bio-fuels, economic opportunities are investigated respecting potential power generation and wood pellet manufacturing.

This work has estimated the inventory of agricultural crop residues in the South Peace area and of the forestry activities there. The findings are based on a review of statistical data provided by the Census of Agriculture, 2005/2006, on industry information and on extensive literature reviews. No new data was developed in the course of this work.

The City of Dawson Creek operates municipal facilities such as the city hall, RCMP station, and fire hall, as well as recreational facilities such as the arena and curling rink. The Multiplex centre near the airport is also a large recreational facility. Other facilities include the Provincial building and a school. In order to replace natural gas used for heating in these facilities a system of central heating is envisioned, consisting of three clusters. The total energy use for the three clusters combined was estimated as 35,300 GJ/year, or the equivalent of 2,500 tonnes of bio-fuel. The proposed civic cluster includes the city hall, the fire hall, the RCMP buildings and the Provincial building. The recreational cluster includes the Memorial Arena, the Kin Arena, the Curling Rink and the Central Middle School. The third cluster consists of functions housed in the Multiplex.

Local agriculture can provide 4,400 tonnes of seed grass straw annually, while about 1,100 tonnes of dry wood waste can be collected from the MSW stream at the City landfill. Both bio-fuels are low cost and can be used to fire biomass boilers. Grass straw could be fed as-is or be pelleted or briquetted. Pelleting of wood waste for City use would require a larger operation and would not be cost effective for the small volume involved.

Forestry waste is potentially available from the forest industry. This would include sawdust and shavings. As well, roadside waste from harvesting operations may be available although a large portion including large diameter logs should be left in the forest as soil amendment, source of fertility and for biodiversity purposes. The availability of forestry waste is greatly dependent on the health of the forest industry. With the current depressed economic state of the forestry industry in BC, it is not expected that forestry waste will be available short term.

Wood waste is generated from highway maintenance and from land-clearing for oil and gas exploration. The wood waste could be collected for use as bio-fuel. However, bio fuel procurement from this source is not considered cost effective due to significant collection and transportation costs. As well, this material is fresh and requires drying

before pelleting. Dried grass and hay may be available from highway maintenance and would require additional effort for collecting, baling and transportation.

It is concluded that the seed grass straw and the MSW wood waste stream are available in sufficient volume to power all of the heating needs in the three identified clusters. It is recommended that a central storage facility be constructed with a capacity to pellet the seed grass straw and store chipped MSW wood waste. This would reduce required feedstock storage capacity at the boiler sites. With the installation of three biomass burners and distribution systems, the City could save between $177,000 and $250,000 in heating costs annually as compared to heating with natural gas. As well, over a period of 25 years carbon replacement credits would be generated with a total value of at least $575,000.

Should an upturn take place in the forestry industry resulting in heightened sawmilling activity, one or two 80,000 tonnes per year pellet mills could be established, producing pellets for a solid international market. Pellet mills located at or near existing (operating) sawmills are likely to be most economical.

Unless trees are harvested specifically for the generation of electrical energy, there is likely not enough feedstock to supply large scale bio-energy facilities. However, the feasibility of this option would be critically dependent on the cost of obtaining the feedstock in competition with forestry and the price obtainable for bio-energy.

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1.0 INTRODUCTION

This progress and draft final report is the second delivery requirement and milestone for the review of supply of biomass available in the South Peace Economic Region. This study was undertaken by Timmenga & Associates Inc. partnering with Zbeetnoff Agro-Environmental Consulting on behalf of the City of Dawson Creek and funded by the South Peace Economic Region Development Committee.

1.1 Purpose of the Study

The purpose of the study is to quantify potential supplies of biomass within the study area to:

- Supply bio-fuel to municipal facilities in Dawson Creek as a replacement for natural gas, and
- Establish an independent energy generating facility in the South Peace area fed with biofuels from the region.

This Report includes an inventory of biomass potentially available as a supply of bio-fuel. It addresses the supply from agriculture and from the forestry sector. A second progress report will deal with the feasibility of either space heating using bio-fuel or power generation from bio-fuel within the South Peace.

1.2 Report Organization

The report is organized as follows:

Section 2 presents background information to the study, describing the regional situation, local economy, and the scope of the interest in utilizing biomass to replace energy use derived from fossil fuels. Goals and objectives, assumptions, and issues related to sustainability are articulated.

Section 3 quantifies the potential agricultural fibre supply from field crops and from animal husbandry.

Section 4 assesses the supply of municipal solid waste (MSW) and “corridor waste”, the fibre originating from building and maintaining transportation and power corridors and right of ways.

Section 5 describes the status of forestry in BC and trends in the industry. The section also presents basic understanding in bio-geoclimatic zones and the forestry land tenure system as it relates to the situation in Dawson Creek and the South Peace. Forestry fibre supply is estimated.

Section 6 discusses several options for burning technology that can be installed in Municipal facilities in Dawson Creek.

Section 7 contains a synthesis of collected information and issues analysis into a general assessment of options for consideration in Phase 2

Recommendations are presented in Section 8.

2.0 BACKGROUND

The Peace River Regional District (PRRD) comprises seven municipalities and 119,200 km^2. The total population in the 2006 has been estimated at 64,272 persons and is increasing. The economy of the PRRD consists of agriculture, tourism, manufacturing, petroleum exploration and development, hydro-electric power generation, forestry and mining. Recent economic developments include tourism growth, coal extraction, increased utilization of aspen in pulp and wood products, diversification in the agricultural sector, and increased exploration, development and processing in the natural gas, petroleum and mining sectors.[1]

Bio-energy refers to the use of forestry, agricultural and municipal solid waste gas and land clearing debris to produce electricity and or heat. As this is a new industry in BC, there is a need to know exactly how much fuel supply may be sustained and to determine size and number of conversion plants that can be supported in this area.

Bioproducts for use in the energy sector can be sourced from waste materials or from virgin sources (forest or crops harvested specifically for energy use). Currently, most resources for use in energy production are obtained from waste streams. In case of the forestry industry, waste obtained at no or very little cost attached (available for free) is made into pellets or utilized as fuel. Once virgin sources are used, the costs for road building, logging, transportation and processing must be included in the price of the fuel. In case of waste products, such costs are included in the costs of the primary product (e.g. lumber). Total costs for obtaining virgin material can be as high as $150 per tonne or as low as $60/tonne depending on which parameters are included in its price. This may make the production of wood pellets from virgin material for space heating uneconomical, but depending on the price paid for electricity ($0.07-0.08/kWh) it may be economical for a large electricity producing facility. At this time, the City is not targeting large scale bio-fuel production facilities or facilities that generate electrical power. However, the results of a bio-resources inventory could also better position the South Peace for attracting a cogeneration plant to the area in the future.

While the City is interested in using biodiesel as a fuel, the City is not planning to implement the production of automotive or transportation fuels such as biodiesel. .

[1] http://www.peaceriverrd.bc.ca/about/

2.1 Economy

The South Peace Economic Region is comprised of that area south of the Peace River and the communities of Dawson Creek, Chetwynd, Rolla and Tumbler Ridge. The South Peace represents about one-third of the Peace River Regional District.

The agricultural sector, consisting primarily of oilseeds, grains, cattle, bison and other livestock, has been the economic mainstay of the region for decades. Agriculture comprises more than 1,800 farms and ranches and the Region contains one-third of British Columbia's total Agricultural Land Reserve.

The forest industry has expanded, with pulp, lumber and particle-board in mills in Chetwynd and Dawson Creek. BC has recently increased the annual allowable timber cut for the region. However, since the end of 2007 many mills in the area closed, some permanently, due to the US housing crisis, the low prices for lumber and the high Canadian dollar.

Oil and gas exploration are at an all-time high, reporting annual revenues approaching the $1.5 billion mark.[2]

Tourism has become a more important aspect of the economy, with visitors traveling the Alaska Highway each summer.

The district's administrative center is in Dawson Creek. Dawson Creek is a city of about 12,000 people. Historically a farming community, its economy has diversified to include forestry, oil and gas, and transportation. The City maintains 26 municipal buildings, has a fleet of 40 vehicles, a $25 million annual budget and employs 110 full-time staff.[3]

2.2 Sustainability and Environmental Impact

The City of Dawson Creek has embarked on a mission to become more sustainable in social, cultural, economic and environmental terms. Currently, much of the effort is focused on reducing the City's environmental impact. In 2005, the City commissioned a study by the Pembina Institute toward the development of a Community Energy Plan. The first phase of the investigation has identified baselines for:

- Types of energy consumed,
- Costs involved,
- Current and future energy consumption patterns for the municipal operations of Dawson Creek, and
- Environmental implications (greenhouse gas emissions).

This study showed that every year, the City spends about $1 million on energy, consisting of:

- $258,000 for natural gas (primarily for heating public buildings);

[2] See Hamilton, G. 2008. New gas fields fuel record rights sales. Vancouver Sun. May 23.
[3] http://www.planningforpeople.ca/index.asp

- $514,000 for electricity (used in nearly all areas of operations, but water and sewer are the biggest users of electricity);
- $148,000 for petroleum fuel (mostly for vehicles).

Municipal energy consumption in Dawson City has the following characteristics[4]:

- Total 2004 energy use was 18,300 MWh[5], represented by 8,468 MWh of electricity, 7,813 MWh of natural gas and 2,020 MWh of gasoline and diesel
- Natural gas heating of municipal facilities is ~$260,000 annually, representing about 30,000 GJ[6] of energy. This natural gas use is excluding the Multiplex which was completed after the Pembina report was published. The Multiplex adds some 21,000 GJ of energy per year. To bring this in perspective, this is the same amount of heat required for growing 2 hectare of greenhouse crops within the Lower Mainland (18,500 – 25,000 GJ/ha/year, depending on crop).
- The City has undertaken a sewer-energy project to review the feasibility to generate biogas and energy from the City's sewage treatment facilities.

2.3 Goals and Objectives

In light of the drive to increased sustainability and potential energy self sufficiency, and to lower the City's environmental foot print, Dawson Creek looks to ways to reduce the use of natural gas in municipal facilities. This may be accomplished in many different ways: energy conservation, replacement of fossil fuels by bio-fuels, the recovery of heat, the use of geothermal etc. As well, the City and the South Peace Economic Region are interested in opportunities for economic diversification into the bio-energy economy. Bio-energy refers to the use of forestry, agricultural and municipal solid waste to produce electricity and or heat from (waste) fibre. As this is a new industry in BC, there is a need to know how much fuel is available in order to determine size and number of plants that can be supported in this area.

This report investigates the potential availability of bio-resources and calculates the amount of energy that could be generated. The bio resources to be investigated within the South Peace area included fibre and pellets from waste wood and agricultural crops.

In order to assess the viability of using bio-energy in the City and in the South Peace, this report has the following objectives:

- Quantify the bio-resources potentially available - wood waste (fresh mill debris, stored mill debris, logging slash, road side waste), agricultural waste or agricultural by-products (wheat straw, canola straw, flax straw, other stover, animal manures), and domestic waste (wood residue, land clearing waste, source separated wood products, biosolids or sewage sludge);
- Evaluate the potential for use of these resources through: pelleting and burning, burning as is; gasification/pyrolysis, anaerobic digestion/recovery of

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4 http://www.planningforpeople.ca/what_we_are_doing/energy_plan/phase_1/documents/Energy_Baseline_Report.pdf

5 A megawatt hour (MWh) is the amount of energy consumed if 1,000,000 watts are used for 1 hour, or 1 watt is used for 1,000,000 hours. One MWh is equivalent to 3.6 gigajopules.

6 One million BTU (MMBTU) = 1.054615 gigajoule (GJ). One gigajoule is equivalent to 26.8 m^3 of natural gas.

landfill gas, and other methods, and describe the technologies needed for pre-processing and final use;

- Calculate the energy to be generated from the identified resources and technology combinations
- Estimate the cost of each selected bio-fuel per GJ of energy, including infrastructure, and operations and maintenance.

2.4 Assumptions and Considerations

This study is geared towards indicating whether or not there is enough fibre available in or near Dawson Creek to operate the municipal facilities on green energy[7], and whether or not there is enough fibre available to operate a regional green energy facility. As fibre can originate from many different sources, advice from Steering Committee was obtained in order to reflect their priorities.

Under the green energy banner, it is preferable that biomass required for power generation in Dawson Creek facilities and a South Peace power facility originate from residues rather than from biomass grown for the purpose of fuel supply. The priority of the Steering Committee was that the fibre source should not be restricted to one or two residues.

To be politically acceptable, the generation of residues and biofuels should not create impacts on existing industries, compete for a food resource or harm biodiversity. The Steering Committee was of the opinion that obtaining fibre should have the least impact on the community and environment (efficiency in conservation).

The Steering Committee desires that the bio-resource generation be sustainable in terms of both economic and environmental practices.

The bio-resource must be non-GMO, and the fibre crop should be suited to growing in the region.

The carbon foot print should be lowered by not using residue from crops grown as a bio-resource that have high requirements for chemical fertilizer and high petroleum inputs, and such project should be described.

The mechanism of a free market will be adhered to in obtaining residues. There may be competing uses, especially if the lumber prices are low and the energy prices are high. Wood residue and whole trees may be redirected from the lumber processing industry to the bio-fuels industry depending on price. This will need to be looked at in light of the assumption, above, that existing industries will not be harmed. If chips from waste wood produced by a lumber mill go to a pulp mill, one needs to be careful not to compete for the supply of the pulp mill by redirecting the chips to an energy facility. It is assumed that the chip supply is not a potential bio-fuels feedstock, and only wood waste is considered available for use.

[7] Green energy indicates sources of energy which are considered environmentally friendly and non-polluting. Some sources of green energy may be more "green" than others when life cycle accounting is taken into consideration.

3.0 AGRICULTURAL OVERVIEW

This section deals with the agricultural source of fibre. The section describes how data was gathered, presents trends in the South Peace region, and estimates the volume of byproducts available from agriculture.

3.1 Source of Information

The best statistical sources of information on agricultural operations in the Peace River Region are from the Agriculture Canada Census of Agriculture. This database is updated at five year intervals coinciding with the national census.[8] Although new questions are added, core information on land in crops, livestock and number of farms has been collected since 1885.

There is no agricultural statistical information that coincides with the boundaries of the South Peace Sub-Region. The best proxies are the statistics associated with Area D (Census Consolidated Subdivision 23, CCS 23) and Area E (Census Consolidated Subdivision 21, CCS 21) in the Peace River Census Agricultural Region (CAR 55)[9]. These two CCSs comprise the area of The Peace River CAR south of the Peace River and represent about 43% of the CAR. (see Figure 1).

Information on CCSs 21 and 23 has been reported separately since 2001. This means that the trends indicated for the South Peace region are only since 2001, while those for the 1991-2006 period represent the CAR as a whole.

As a rule of thumb, the South Peace Area has represented about 52% of the farms and approximately 45% of the acreage in the Peace River Census Agricultural Region (see Figure 2).

3.1.1 Area of Farms

For the Peace River CAR as a whole, the total area of farms in 2006 was 868,600 ha. This area is about 8% greater than 1991 and the increases are mainly attributable to more land in 1) improved grazing and pasture and 2) unimproved grazing, pasture and hay land. Since 2001, agricultural land area in the CAR has increased 2%.

The South Peace represents about 43% of the farm area of the CAR. This proportion has declined from 48% of the CAR since 2001. South Peace farm area declined 7.5% between 2001 and 2006.

3.1.2 Number of Farmers

For the Peace River CAR as a whole, the total number of farms in 2006 (1,700 farms) has not changed significantly since 1991, although the number of farms increased by more than 100 in the interval before falling back.

The South Peace includes about 52% of the farmers in the CAR. This proportion has declined from 53% of the CAR in 2001.

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[8] While an effort is made to survey every farm operation in Canada, some farms are inevitably missed primarily because of the difficulty in correctly identifying an agricultural operation when none of its farm operators live on or near it. Nevertheless, the estimated undercoverage rate for the 2006 Census of Agriculture was 3.4%.

[9] Statistics Canada. Agriculture Census. 2006. Reference Maps

Figure 1: Census Divisions and Consolidated Census Divisions, British Columbia, 2006

Figure 1: (Continued) Legend

41	**Cariboo**		**49**	**Kitimat-Stikine*)**		**53**	**Fraser-Fort George***	
	10	Cariboo D		13	Kitimat-Stikine C (Part 1		19	Fraser-Fort George H
	12	Cariboo E		*20*	*Kitimat-Stikine C (Part 2)*		38	Fraser-Fort George A
	14	Cariboo F		28	Kitimat-Stikine B		42	Fraser-Fort George C
	15	Cariboo G		39	Kitimat-Stikine A		44	Fraser-Fort George D
	16	Cariboo H		41	Kitimat-Stikine D		46	Fraser-Fort George E
	17	Cariboo L					48	Fraser-Fort George F
	19	Cariboo A	**51**	**Bulkley-Nechako***			50	Fraser-Fort George G
	21	Cariboo B		15	Bulkley-Nechako C			
	26	Cariboo C		17	Bulkley-Nechako D	**55**	**Peace River**	
	27	Cariboo I		19	Bulkley-Nechako F		21	Peace River D
	39	Cariboo J		28	Bulkley-Nechako B		23	Peace River E
	41	Cariboo K		31	Bulkley-Nechako E		40	Peace River B
				51	Bulkley-Nechako A		42	Peace River C
47	**Skeena-Queen Charlotte***			53	Bulkley-Nechako G			
	16	Skeena-Queen Charlotte A				**57**	**Stikine***	
	21	Skeena-Queen Charlotte C					22	Stikine Region
	27	Skeena-Queen Charlotte D						
	32	Skeena-Queen Charlotte E				**59**	**Northern Rockies**	
							11	Northern Rockies A
							13	Northern Rockies B

3.1.3 Land Use

As Table 1 shows, the distribution of land uses in 2006 is remarkably similar between the Peace River CAR and the South Peace area.

Unimproved grazing, hay, and pasture lands account for the largest area of land use. comprising about 40% of total farm area and approximately 168,000 ha in the South Peace

In 2006, only about 29% of the total farm area in the Peace River agricultural region was used for cropping, i.e., improved lands harvested for hay, silage or seed. In the South Peace, land in crops comprised about 112,700 ha. Improved land for grazing and pasture account for about 12% of total farm area. In the South Peace, this area is about 46,600 ha.

The residual agricultural land base is categorized as “other” and primarily represented by land on which farm buildings, barnyards, lanes, home gardens, greenhouses are located, improved idle land, woodlots, Christmas tree lots, windbreaks, bogs, marshes, sloughs.

Figure 2: Peace River Regional District

Table 1: Distribution of Land Use, Peace River Agricultural Region, 2006[10]

	Peace River CAR			South Peace Area		
	# Farms	# Ha	Land Use # Ha - 2006	# Farms	# Ha	Land Use 2006 - # Ha
Total farm area	1,699	885,485	100.0%	880	382,255	100.0%
Land in crops (exclud. Xmas trees)	1,434	253,733	28.7%	729	112,708	29.5%
Summer fallow (SMF)	324	23,536	2.7%	108	5,728	1.5%
Improved pasture	860	111,507	12.6%	426	46,626	12.2%
Unimproved pasture	892	345,172	39.0%	491	168,286	44.0%
All other land (includ. Xmas trees)	1,431	151,537	17.1%	732	48,908	12.8%
		As a Percentage of Land in Crops (Above)				
Wheat	117	19,072	7.5%	60	12,843	11.4%
Oats	456	24,103	9.5%	227	12,182	10.8%
Barley	181	13,766	5.4%	87	7,697	6.8%
Mixed grains	19	1,268	0.5%	8	x	
Rye	13	318	0.1%	9	x	
Canola	102	23,307	9.2%	52	16,485*	14.6%
Dry field peas	27	2,280	0.9%	9	904	0.8%
Alfalfa	757	76,549	30.2%	435	36,962	32.8%
Other tame hay	637	66,022	26.0%	273	21,205	18.8%
Potatoes	8	14	0.0%	6	x	
Forage seed for seed	131	26,672	10.5%	30	3,200**	2.8%
All other field crops		288	0.1%	0	729	0.6%
Total vegetables	15	27	0.0%	10	x	
Total fruit, berries and nuts	12	x		6	11	0.0%
Nursery	11	x		6	x	
Sod	2	x		1	x	
Xmas trees	9	47	0.0%	6	27	0.0%
Greenhouse (sq. m.)	17	5,720		14	x	
Notes: "x" = Data withheld for confidentiality reasons. "*" = CCS 23 only "**" = Based on anecdotal evidence						

3.1.4 Crops

In 2006, the primary crops in the Peace River CAR consisted of alfalfa (30%), other tame hay (26%), forage seed for seed (11%), oats (10%), canola (9%), wheat (7.5%), and barley (5%) (see Table 2).

In 2006, the areas of the primary crops in the South Peace River area were similar to the Peace River CAR as a whole. Most significant crops, by area, consisted of alfalfa

[10] Source: Statistics Canada. 2006. Agriculture Census. http://www.statcan.ca/english/freepub/95-629-XIE/2007000/landuse.htm

(33%), other tame hay (19%), wheat (11%), oats (11%), canola (10%), and barley (7%), forage seed for seed (5%).

While the South Peace area accounts for about 45% of the land in crops in the Peace River CAR, proportionately more wheat (67%), barley (56%), rye (56%), and canola (71%) is grown in the South Peace than the CAR. The South Peace also grows proportionately less improved forages (32%) and forage seed for seed (12%) in relation to the Peace River CAR. (see Table 3).

3.1.5 Livestock

In the Peace River CAR in 2006, about 51% of the farms have horses or ponies and 48% of farms have cattle. Cattle numbered 145,500 head, horses 10,100 head, and bison 10,300 head. There were about 39,200 chickens in 2006. Other livestock types are much less significant in the region.

In the South Peace in 2006, 51% of the farms have horses or ponies and 47% of farms have cattle. Cattle numbered 70,000 head, horses 5,500 head, sheep 3,500 head, and bison 3,000 head. There were about 16,000 chickens in 2006. Other livestock types are much less significant in the region.

3.1.6 Manure Production and Use

In the South Peace, approximately 60% of the farms produce or use manure from livestock and of those, 46% of the farms apply manure to their land. The total land area receiving manure in composted, or liquid form (unincorporated, incorporated or irrigated), amounted to 6,000 ha and equivalent to only 1.5% of the total land area or 10% of the land prepared for seeding in the region.

3.1.7 Tillage of Fields Prepared for Seeding

Farm practices are of interest to biofuel feedstock availability from agricultural residues because incorporation of crop residues for replenishment of the ground nutrients and erosion control likely precludes their use/availability as biofuel raw resources.

In the Peace River CAR in 2006, about 22% of all land prepared for seeding was zero tilled. Conventional tillage, incorporating residue into the soil accounted for 48% of land preparation practices.

In the South Peace in 2006, zero-till is being used on 22% of the land prepared for seeding. Tillage incorporating crop residue accounted for 46% of land preparation practices (by area).

Table 2: Land Use Trends in the Peace River Census Agricultural Region, 1991 to 2006[11]

	Peace River Agricultural Region								Land Use 2006 - Ha	% change 1991 to 2006 - # Ha	% change 2001 to 2006 - # Ha
	1991		1996		2001		2006				
	# Farms	# Ha	# Farms	# Ha	# Farms	# Ha	# Farms	# Ha			
Total farm area	1,694	823,977	1,823	837,183	1,774	868,599	1,699	885,485	100.0%	7.5%	1.9%
Land in crops (exclud. Xmas trees)	1,517	259,723	1,591	257,169	1,570	279,396	1,434	253,733	28.7%	-2.3%	-9.2%
Summer fallow (SMF)	610	45,972	444	29,608	469	30,764	324	23,536	2.7%	-48.8%	-23.5%
Tame pasture	774	88,960	818	96,991	793	92,525	860	111,507	12.6%	25.3%	20.5%
Natural pasture	1,001	273,934	1,043	282,545	971	292,669	892	345,172	39.0%	26.0%	17.9%
All other land (includ Xmas trees)	1,371	155,388	1,551	170,871	1,441	173,244	1,431	151,537	17.1%	-2.5%	-12.5%
Check		823,977		837,184		868,598		885,485	100.0%		1.9%
Wheat	354	40,553	239	34,563	179	26,353	117	19,072	7.5%	-53.0%	-27.6%
Oats	557	20,724	528	23,789	516	24,677	456	24,103	9.5%	16.3%	-2.3%
Barley	478	30,733	35	30,867	248	21,327	181	13,766	5.4%	-55.2%	-35.5%
Mixed grains	39	1,306	18	526	18	822	19	1,268	0.5%	-2.9%	54.3%
Rye	50	1,619	33	1,337	30	750	13	318	0.1%	-80.4%	-57.6%
Canola	350	39,677	218	24,866	148	22,552	102	23,307	9.2%	-41.3%	3.3%
Dry field peas	18	488	565	3,270	48	2,968	27	2,280	0.9%	367.2%	-23.2%
Alfalfa	575	41,087	768	64,030	778	75,529	757	76,549	30.2%	86.3%	1.4%
Other tame hay	747	61,840	748	55,554	687	67,862	637	66,022	26.0%	6.8%	-2.7%
Potatoes	17	18	14	26	15	102	8	14	<0.0%	-22.2%	-86.3%
Forage seed for seed	227	21,285	148	18,189	212	36,198	131	26,672	10.5%	25.3%	-26.3%
All other field crops		349		74		132		288	0.1%	-17.5%	118.2%
Total vegetables	15	26	20	58	18	24	15	27	<0.0%	3.8%	12.5%
Total fruit, berries and nuts	13	6	12	5	8	10	12	x			
Nursery	4	12	10	15	11	51	11	x			
Sod	2	x	2	x	2	x	2	x			
Xmas trees					8	39	9	47	<0.0%		20.5%
Greenhouse (sq. m.)	19	10,971	14	11,786	23	7,245	17	5,720		-47.9%	-21.0%

[11] Source: Statistics Canada. Agriculture Census. 1991; 1996; 2001; 2006.

Table 3: Land Use Trends in the South Peace Region, 2001 to 2006, and Comparison to the Peace River CAR[12]

	South Peace Region (CCS Areas D & E)							South Peace as % of Peace River Census Agricultural Region			
	2001		2006		Land Use 2006	% change 2001 to 2006- # Farms	% change 2001 to 2006 - # Ha	2001		2006	
	# Farms	# Ha	# Farms	# Ha				# Farms	# Ha	# Farms	# Ha
Total farm area	**933**	**413,173**	**880**	**382,255**		**-5.7%**	**-7.5%**	**52.6%**	**47.6%**	**51.8%**	**43.2%**
Land in crops (exclud. Xmas trees)	**814**	**129,177**	**729**	**112,708**	**29.5%**	**-10.4%**	**-12.7%**	**51.8%**	**46.2%**	**50.8%**	**44.4%**
Summer fallow (SMF)	**191**	**10,783**	**108**	**5,728**	**1.5%**	**-43.5%**	**-46.9%**	**40.7%**	**35.1%**	**33.3%**	**24.3%**
Tame pasture	**399**	**41,171**	**426**	**46,626**	**12.2%**	**6.8%**	**13.2%**	**50.3%**	**44.5%**	**49.5%**	**41.8%**
Natural pasture	**541**	**170,128**	**491**	**168,286**	**44.0%**	**-9.2%**	**-1.1%**	**55.7%**	**58.1%**	**55.0%**	**48.8%**
All other land (includ. Xmas trees)	**738**	**61,913**	**732**	**48,908**	**12.8%**	**-0.8%**	**-21.0%**	**51.2%**	**35.7%**	**51.2%**	**32.3%**
Check		**413,172**		**382,256**	**100.0%**		**-7.5%**		**47.6%**		**43.2%**
Wheat	**92**	**16,824**	**60**	**12,843**	**11.4%**	**-34.8%**	**-23.7%**	**51.4%**	**63.8%**	**51.3%**	**67.3%**
Oats	**252**	**10,969**	**227**	**12,182**	**10.8%**	**-9.9%**	**11.1%**	**48.8%**	**44.5%**	**49.8%**	**50.5%**
Barley	**128**	**12,288**	**87**	**7,697**	**6.8%**	**-32.0%**	**-37.4%**	**51.6%**	**57.6%**	**48.1%**	**55.9%**
Mixed grains	**8**		**8**			**0.0%**		**44.4%**		**42.1%**	
Rye	**15**	**436**	**9**			**-40.0%**		**50.0%**	**58.1%**	**69.2%**	
Canola	**73**	**12,648**	**52**	**16,485***	**14.6%**	**-28.8%**	**30.3%**	**49.3%**	**56.1%**	**51.0%**	**70.7%**
Dry field peas	**22**		**9**	**904**	**0.8%**	**-59.1%**		**45.8%**		**33.3%**	**39.6%**
Alfalfa	**475**	**41,109**	**435**	**36,962**	**32.8%**	**-8.4%**	**-10.1%**	**61.1%**	**54.4%**	**57.5%**	**48.3%**
Other tame hay	**323**	**26,548**	**273**	**21,205**	**18.8%**	**-15.5%**	**-20.1%**	**47.0%**	**39.1%**	**42.9%**	**32.1%**
Potatoes	**9**		**6**			**-33.3%**		**60.0%**		**75.0%**	
Forage seed for seed	**63**	**6,857**	**30**	**3,208***	**2.8%**	**-52.4%**	**-53.2%**	**29.7%**	**18.9%**	**22.9%**	**12.0%**
All other field crops	**n/a**	**229**	**n/a**	**729**	**0.6%**		**218.3%**				
Total vegetables	**13**	**20**	**10**			**-23.1%**		**72.2%**	**83.3%**	**66.7%**	
Total fruit, berries and nuts	**5**		**6**	**11**	**0.0%**	**20.0%**		**62.5%**		**50.0%**	
Nursery	**5**		**6**			**20.0%**		**45.5%**		**54.5%**	
Sod	**1**		**1**					**50.0%**		**50.0%**	
Xmas trees	**6**		**6**	**27**				**75.0%**		**66.7%**	**57.4%**
Greenhouse (sq. m.)	**14**		**14**					**60.9%**		**82.4%**	
Notes: * = CCS 23 only.											

[12] Source: Statistics Canada. Agriculture Census. 1991; 1996; 2001; 2006.

3.1.8 Land Use Trends

Changing land use in the Peace River CAR over the 1991-2006 period has resulted in a decline of land in crops (-2%) and summer fallow (-47%), countered by an increase in the areas of improved and grazing and pasture land (+25%) and unimproved grazing, pasture and hay land (+26%).

In the 2001-2006 period, the area of land in crops in the CAR has declined over 9% to 29% of total farm area, in response to economic challenges in the agricultural sector. A portion of the annually cropped lands has been converted to perennial forage uses.

Land use trends in the South Peace have mirrored land use changes in the CAR, but in some cases the changes have been more pronounced. Land in crops in the South Peace has declined almost 13%, while the area of improved grazing and pasture lands has increased 13%. Summer fallow area has declined almost 50% since 2001.

3.2 Agricultural Trends in the South Peace

3.2.1 Cropping Trends

Since 1991 in the Peace River CAR, the areas of rye, barley, wheat, and canola, acres have declined significantly, while the areas of dry field peas, and forage seed for seed, alfalfa, and oats have increased. However, since 2001, the area of virtually all crop types has declined, with the exception modest gains in canola, mixed grains, improved grassland, and mixed grains (see Table 2).[13]

Since 2001, wheat, barley, and improved forage acre has dropped substantially in the South Peace while canola area may have increased 30% (see Table 3). Oats and alfalfa area has also increased. Confidentiality limitations on Statistics Canada data do not allow for hard statistical conclusions for some of the other crops. Nevertheless, anecdotal evidence and partial statistics suggest that forage seed for seed area probably has declined significantly to around 3,208 ha in the 2001-2006 period. Based on data for CCS 23 only, canola area in the South Peace was at least 16,485 ha in 2006.

3.2.2 Livestock Trends

In the Peace River CAR, the numbers of cattle and horses have increased in the 1991 to 2006 period by 34% and 65%, respectively. In the same period, sheep numbers have declined 47%, with most of the decrease since 2001.

In the South Peace, the numbers of cattle and horses have increased in the 2001 to 2006 period by 1% and 15%, respectively. In the same period, sheep numbers have declined 56%. Lama/alpaca numbers, while low, have increased in the period.

Chicken numbers have increased in the Peace River CAR, while decreasing in the South Peace.

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[13] Swath grazing, commonly used in the Peace River Region, consists of swathing a cereal crop but leaving it in windrows in the field. Cattle are brought onto the field in the winter to graze the swath. High wildlife populations can cause losses in this system. Fibre is used as animal feed and may not be available for other uses.

3.2.3 Farm Practices Trends

Tillage
Use of zero-till has increased by 339% in the Peace River CAR in the 1991 to 2006 period. Conventional tillage, incorporating residue into the soil, declined by 60% in the period.

In the South Peace, zero-till increased by 22% between 2001 and 2006. In the same period, tillage incorporating crop residue decreased by 20% (by area).

Manure Application
In the Peace River CAR, the number of farms using manure and the area receiving manure has more than doubled in the 1991 to 2006 period.

In the South Peace, the number of farms using manure and the area receiving manure has increased 50% and 32%, respectively, in the 2001 to 2006 period. With the current high prices for fertilizer, manure applications to crop land are likely to increase. Manure may not be available for non-fertilizer use.

3.3 Total Agricultural By-Product Production

The products harvested in conventional crop production on arable acreage in the South Peace consist of meat, seed, oilseeds, hay, and grazing feedstock. For the purpose of this study, these products are not considered "wastes" and have current established market values that are not feasible in alternative energy feedstock applications at the present time.

Other crop products harvested for animal farming application consist of straw (feed and bedding) and chaff (feed). Excesses, and/or under-utilized quantities, of these products can be considered easily accessible potential bioenergy feedstock in situations where chaff and straw are typically deposited onto the land during the combine's cleaning process.

In addition, several agricultural residues from both crops and livestock production in traditional agricultural systems have the natural function of replenishing the soil with organic matter, recycling nutrients through application to the land base, preventing erosion, and enhancing ecological systems. The use of this feedstockfor bioenergy may raise other issues with respect to the actual availability of "waste" in agricultural systems.

This section quantifies the total quantities of agricultural by-products generated in South Peace agricultural activities without making assumptions about their availability for bioenergy use. Just because farmers are making use of agricultural byproducts in certain applications today does not preclude the availability of the material for bioenergy feedstock in the future.

3.3.1 Crop Residues

Residues generated in field crop production can be a function of primary product yields. The following table presents target yields for the South Peace region and the estimated amounts of chaff and straw produced, by crop.

An Alberta study estimated typical amounts of chaff for various field crops. These values are presented in Table 3. Recoverable wheat chaff volume is estimated at 20 to 25 lbs per bushel, which would amount to between 800 and 1125 lbs per acre. Volumes of chaff from barley and oats are less than one half the volumes from wheat per bushel, although yields of wheat and barley are higher.

Table 4: Typical amounts of harvestable straw and chaff per bushel of grain[14]

Crop	Soil zone	Pounds of straw per bushel of grain*	Pounds of chaff per bushel of grain**
HRS Wheat	**Brown**	**50**	**20 - 25**
	Dark Brown	**65**	
	Black	**80**	
CPS Wheat	**Brown**	**40**	**20 - 25**
	Dark Brown	**50**	
	Black	**60**	
Barley	**Brown**	**30**	**5 - 10**
	Dark Brown	**35**	
	Black	**45**	
Oats	**Brown**	**30**	**5 - 10**
	Dark Brown	**35**	
	Black	**45**	
Canola	**Brown**	**40**	**15 - 20**
	Dark Brown	**50**	
	Black	**60**	
Peas	**Brown**	**40**	**20 - 25**
	Dark Brown	**50**	
	Black	**60**	

*** Amount of harvestable straw, assuming about 80 per cent recovery in cereals, and 50 per cent in peas and canola, with 2 to 4 inch stubble left**
**** Amount of harvestable chaff, assuming no weed chaff**
Source: Estimating the Value of Crop Residues, Agdex 519-25. March 1999.

[14] See http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1156

Chaff

Chaff has potential nutritional and bioenergy feedstock value. As nutrition, its value has been compared to hay. Chaff collection from one system has been estimated at the feed equivalent of approximately 0.59 bales of hay per acre with an imputed value of $23.60.[15] However, chaff is commonly discharged out the end of the combine during harvest. A consideration in the utilization of chaff is the development of collection systems that are compatible with current large scale harvesting systems. Table 4 indicates the quantities of chaff produced by different field crops.

Cattlemen often allow cattle access to chaff left in the field. Alternative handling systems are to collect it in chaff wagons or collect the chaff in the field, then to spread it on straw and bale it up. A major cost component associated with chaff collection is transportation, as the product is light and bulky. Chaff collection and removal from the field has the agronomic advantage of removing weed seeds as well.

Straw

Straw is the main by-product of grain production. Straw can be baled and sold as feed or as bedding. Straw and crop by-products such as chaff can also be used as a soil amendment. With modern combines that disintegrate crop residue and spread it evenly on the field in one pass, it is not necessary to remove crop residue from the field, unless the farmer chooses to do so. With the high fertilizer prices, crop residue is returned to the soil as a form of fertility.

Cereal Straw

Cereal straw is either worked into the soil after harvest or used as bedding and feed. The straw collection infrastructure is well developed in western Canada and consists of baling and storing dry straw (i.e., less than 20% moisture) for later use. In general, straw biomass from cereal crops (e.g., wheat, barley, oats), canola and legume production is low compared to the biomass feedstock potential of corn and dedicated "energy" crops such as switchgrass, hybrid poplar, reed canary grass

Cattlemen often bale straw for use as bedding or as a feed supplement. A proportion of the straw is also returned to the field to control erosion. Barley and oat straw have higher nutritional value but are more prized as feed than wheat straw. Nevertheless, straws are a low protein – low energy feed.

Canola Straw

Canola harvesting results in canola stubble being processed into chaff. As with cereal crops, collection systems to harvest canola chaff are not very compatible with current harvesting systems and few commercial uses for canola chaff currently exist. The volume of straw from canola is lower than cereal grains and must be recovered at harvest since it disintegrates in the combining process.

Grass Straw

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[15] See http://www.bioenergyupdate.com/magazine/security/Bioenergy%20Update%2011-02/bioenergy_update_November_2002.htm

Grass seed is typically grown over a six year cycle in which yields are attained in 4 of the 6 years (years 2 & 3 and years 5 & 6). Years 1 & 4 are establishment years. Grass seed straw (aftermath) is customarily removed from fields in order to provide for better growing conditions for the following year's crop. Although the straw has a higher nutritional value than cereal straw, it is more complicated to use as a livestock feed because of its nutrient variability, need to be supplemented in cattle diet to avoid malnutrition and pregnancy complications. Some grass varieties grown for turf seed have high levels of endophyte infection, a fungus that also wards off insects and disease in grasses. Turf breeders select for the pest resistance that these endophyte-infected plants acquire but the straw can cause disorders when used as cattle feedstock.

Grass seed yields in the South Peace attain only up to one third of the irrigated yields obtained in Oregon (the area responsible for over 85% of North American grass seed production), Straw yields in the South Peace are estimated to be about 50% of Oregon straw yields, or in the vicinity of 1.8 tonnes per ha.

In Oregon, most grass seed straw is removed from fields in bales. Grass seed straw is compressed into blocks for shipment to Asia, for use as fish feed, as well this straw has some feed value of about $10/tonne as roughage. While the exact values are not available for the Peace, is can be assumed that grass seed straw will have a value of up to $25/tonne, with the farmer absorbing some or all of the baling costs as part of the seed production costs.

The farm-gate price for seed grass straw may vary related to demand. As baling costs are typically absorbed in the seed production costs, its costs could be as low as transportation, or as high as the costs for baling and transportation. It must be kept in mind that not only the South Peace produces a surplus of seed grass straw. The North Peace produces large quantities, and in Alberta the crop is popular as well. Bio-energy purchase costs may be low due to the large supply.

Table 5 indicates the quantities of straw produced by different field crops.

Table 5: South Peace region - yields of crops, chaff and straw production.

Crop	Expected Yield (Bu/ac)*	Chaff Per Acre** (lbs)	Chaff Per Ha (tonnes)	Straw Per Acre** (lbs)	Straw Per Ha (tonnes)
Wheat (HRS/CPS)	40	800-1,000	1.98 to 2.47	2,000	2.25
Barley	60	300-600	0.74-1.48	1,800	2.02
Oats	80	400-800	0.99-1.98	2,400	2.69
Canola	25	375-500	0.93-1.24	1,000	1.12
Feed Peas	40	800-1,000	1.98-2.47	1,600	1.80
Grass seed	400 lbs/ac	n/a		1,630	1.83

Notes: * - Based on Farming For Profit Enterprise Budgets for the Peace River Region.
http://www.agf.gov.bc.ca/busmgmt/budgets/grain_oilseed.htm
**** - See http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agdex1156**

Based on the areas of crops in the South Peace in 2006, the estimated total chaff and straw production for various crops is presented in Table 6. It is estimated that total chaff and straw production in the South Peace may be 75,100 tonnes and 103,235 tonnes, respectively. Only seed grass straw can be seen as a suitable source for bio-energy.

Table 6: Estimated volumes of chaff and straw produced in the South Peace region annually

Crop	South Peace Area 2006 (harvested hectares)	Chaff yield per ha (tonnes)	Total chaff (tonnes)	Straw Yield per ha (tonnes)	Total Straw (tonnes)	Total Residue per ha (tonnes)
Wheat (HRS/CPS)	**12,843**	**1.98-2.47**	**25,400-31,700**	**2.25**	**28,838**	**4.23-4.72**
Barley	**7,697**	**0.74-1.48**	**5,700-11,400**	**2.02**	**15,555**	**2.76-3.50**
Oats	**12,182**	**0.99-1.98**	**12,100-24,100**	**2.69**	**32,825**	**3.68-4.67**
Canola	**16,485**	**0.93-1.24**	**15,300-20,400**	**1.12**	**18,508**	**2.05-2.36**
Feed Peas	**904**	**1.98- 2.47**	**1,800-2,200**	**1.80**	**1,624**	**3.78-4.27**
Forage Seed	**3,208**	**n/a**	**n/a**	**1.83**	**5,885**	**1.83**
Total	**53,319**		**60,300-89,900**		**103,235**	
Average per ha			**1.41**		**1.94**	**3.35**

Notes: N/a = not applicable

Out-of-Condition Hay and Straw
South Peace cattle operations usually have a quantity of hay and straw left over from previous years that is no longer suitable for feed, especially if it is stored outdoors. While this product could be used at low cost in bioenergy production, it is probably unrealistic to rely on a supply on an annual basis.

Out-of-Condition Grains
It is anticipated that spoiled and/or unmarketable grains may be generated in farming operations. However, these amounts are likely to be small and intermittent on a year-to-year basis.

3.3.2 Livestock Manures

South Peace livestock production is presented in Table 7.

The numbers indicated indicate the inventory as of the Census date in 2005. It has been assumed that these figures represent the average number of animals housed on farms throughout the year. Coefficients of animal manure production have been generated in a previous study[16] and are applied to the major South Peace livestock categories.

[16] See Timmenga, Zbeetnoff and Lauriente. 2005. Evaluation of Options for Fraser Valley Poultry Manure Utilization. Report prepared for the BC Poultry Environmental Steering Committee.
http://www.agf.gov.bc.ca/poultry/publications/documents/evaluation_poultry_manure.pdf

Table 7: Livestock numbers in the South Peace

Animal Type	2001			2006			% Change 2001-2006 (# of Farms)	% Change 2001-2006 (# of Animals)
	# of Farms	# of Animals	% of Farms	# of Farms	# of Animals	% of Farms		
Hens/chickens	113	17,697	4.3%	79	15,716	4.1%	-30.1%	-11.2%
Turkeys	22			10			-54.5%	
Other poultry	38	310	0.1%	20			-47.4%	
Cattle and calves	458	69,350	16.8%	413	69,971	18.3%	-9.8%	0.9%
Pigs	38	2,271	0.5%	24			-36.8%	
Sheep	69	7,860	1.9%	45	3,477	0.9%	-34.8%	-55.8%
Horses and ponies	454	4,813	1.2%	452	5,536	1.4%	-0.4%	15.0%
Goats	44	467	0.1%	25	373	0.1%	-43.2%	-20.1%
Bison	24			24	2,981	0.8%	0.0%	
Deer	5			4			-20.0%	
Lamas, alpacas	21	66	0.0%	30	118	0.0%	42.9%	78.8%
Rabbits	10	127	0.0%	0	0	0.0%	-100.0%	
Fox	2			0	0	0.0%	-100.0%	
Elk	1			0	0	0.0%	-100.0%	
Wild boars	4	106	0.0%	2			-50.0%	
All other	0	0	0.0%	0	0	0.0%		
Bees	11			14			27.3%	

Table 8: Manure production by livestock type in the South Peace

Animal type	# Animals	Moisture content (%)	Manure - wet weight (tonnes)	Manure - dry weight (tonnes)
Poultry	18,716	0.31	238	164
Dairy	1,794	0.9	52,168	5,217
Hog	3,000	0.9	15,420	1,542
Beef	68,177	0.65	120,312	42,109
Horse	5,536	0.72	80,826	22,631
Total				71,664

Moisture content of the various manures varies as a function of diet, manure handling system, and addition of litter in intensive operations. Beef manure is estimated to account for almost 60% of the total manure (dry weight) generated in the region, followed by horse manure (32%).

Recoverability of manures from livestock operations is a prime consideration in determining the overall manure inventory. Manure recovery from intensive livestock operations, such as dairy, hog, commercial poultry and beef feedlot operations would be expected to be good and in excess of 80% of the amounts produced. On the other hand, recovery of animal manures from pastured or grazing animal operation would be close to zero.

3.4 Total Agricultural By-Product Availability

There are three main classes of crops for biofuel production that can be grown on agricultural soils. These are:

- waste biomass from monoculture crops,
- monoculture crops themselves, such as tame fescues and other grasses, wild rye and other native perennial prairie grasses, willow, switch grass[17], hybrid poplars, and reed canary grass, used almost exclusively in Finnish bioenergy plants[18]
- high-diversity mixtures of native grassland plants grown under low-input scenarios, including on under-utilized and abandoned soils, marginal agricultural lands, and corridors.

This report only deals with the first option.

The availability of crop residue (waste biomass) for bioenergy production is affected by one core factor: the quantity that should be left in the field to ensure the long term sustainable productivity of the land. This factor depends on a host of site specific factors including weather, crop rotation, existing soil fertility, slope of the land, wind patterns, rainfall patterns, farming culture and tillage practices.

For wheat crops in the South Peace, the excess straw available to be harvested as bioenergy feedstock has been estimated at about 800 lbs per ace or 0.89 tonne/ha.[19] It should also be noted that about 22% of the land was zero-tilled, indicating that somewhat less residue would be required to sustain soil than under conventional tillage.

3.4.1 Crop Residue Availability for Bioenergy Feedstock

Crop residues that are currently used for animal feed and bedding are technically available as bioenergy resources. The market will determine if they are channeled into bioenergy or continued to be used in agricultural applications.

South Peace cereal and oilseed crop areas require between 60% and 70% of the residues generated by crop production, annually, to maintain the sustainability of the soil.[20] This means that only 30% to 40% of the residue should be expected to be available for bioenergy production and this amount is indicated to average between 1.05 and 1.24 tonnes per ha (0.42 to 0.50 tonne per ac).

Perennial ryegrass and tall fescue seed yields are best maintained over the life of the stand when at least 60 percent of the residue is removed.[21] Nevertheless, full straw management systems are also being introduced in Oregon that recycle all residue on

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[17] See Jannasch, R. et al. 2001. Changing the energy climate: clean and green heat from grass biofuel pellets. In http://www.reap-canada.com/online_library/Reports%20and%20Newsletters/Bioenergy/10%20Changing%20the.pdf

[18] See http://tyotehoseura.fi/uk/publication/teho-magazine/teho06_2.htm#isolahti

[19] Meilke, G. 2008. BC Ministry of Agriculture. Personal Communication.

[20] Meilke, G. 2008. BC Ministry of Agriculture. Personal Communication.

[21] http://forages.oregonstate.edu/organizations/seed/osc/brochures/water-quality/residue.html

the fields, with the observation that the amount of straw produced for export is declining.[22]

Baling typically results in removal of about 75% of the grass straw, although an Oregon study to assess biomass resource availability there assumed that 85% of grass straws generated could be recovered.[23] For the South Peace, this value has been calculated at 1.37 tonne per ha (0.55 tonne per acre).

Table 8 indicates what these considerations mean in terms of volumes of agricultural biomass available for bioenergy feedstock. It is estimated that there may be about 62,420 tonnes of agricultural crop residue available for bioenergy production, annually.

The costs per tonne of straw or hay are estimated at between $75and $110, depending on the bale size, equipment etc. Currently, large square bales of hay (1200 -1500 lbs) are available for $160/tonne (off farm) in the Dawson Creek area. [24] Round bales of hay (~1000lbs) are for sale in the Interior of BC for $55 to $77 per tonne. [25] Transportation will be extra.

Seed grass straw is typically baled and then removed from the field. Thus bailing is part of the operational costs of the seed production. Typically the straw is stored off-site until a use is found. [26] The straw has a nutritional value as roughage of about $10/tonne. With additional loading and transportation, Seed grass straw may have an attached cost of $25/tonne.

Table 9: Estimated volumes of chaff and straw available for bioenergy feedstock in the South Peace region annually

Crop	Total Chaff Available (tonnes)*	Total Straw Produced (tonnes)*	Total Residue Produced (tonnes)*	Total Residue Available for Bioenergy (%)	Total Residue Available for Bioenergy (tonnes)
Wheat (HRS/CPS)	25,429-31,722	28,838	54,268-60,561	35%	18,994-21,196
Barley	5,696-11,392	15,555	21,251-26,946	35%	7,438-9,431
Oats	12,060-24,120	32,825	44,885-56,945	35%	15,710-19,931
Canola	15,331-20,441	12,350	33,839-38,950	35%	11,844-9,097
Feed Peas	1,790-2,233	1,624	3,414-3,857	35%	1,195-13,632
Seed Grass Straw	n/a	5,885	5,885	75%	4,414
Total	60,306-89,908	103,235	163,542-193,144		57,240-67,600
Average per ha			3.34		1.07-1.27

Note: * - Tonnes are expressed in field dry tonnes, between 10 and 20% moisture content.

For the purpose of this report, grass seed straw is seen as a viable fibre source for bio-energy. In the South Peace, potentially 4,400 tonnes of dry grass seed straw is

[22] http://cropandsoil.oregonstate.edu/newsnotes/0707/seed-prod.html
[23] See McNeil Technologies Inc. 2003. Biomass resource assessment and utilization options for three counties in Eastern Oregon. Report prepared for the Oregon Department of Energy. http://www.oregon.gov/ENERGY/RENEW/Biomass/assessment.shtml
[24] See Peace forage website accessed May 6, 2008: http://www.peaceforage.bc.ca/Feed_Sale_Mainpage.htm#Highway%2016%20Region%20Feed%20for%20Sale
[25] See: http://www.farmwest.com/index.cfm?method=pages.ShowPage&pageid=349
[26] Harvey Glazier, BC Ministry of Agriculture and Lands, 2008. Personal Communication.

available, a sufficient amount to supply Dawson Creek's municipal facilities with biofuel

3.4.2 Manure Feedstock Availability

Potential feedstock availability for bioenergy production is a function of several factors:

- whether it can be easily collected. In this respect, manures generated from confined livestock operations are efficiently collected and handled. Manures from range animals are likely not recoverable
- the consistency in which it is stored and handled. Manure with high moisture contents will require extensive drying before they are capable of being used as biofuels. Use of this feedstock entails more handling requirements.
- presence of other ingredients, such as sawdust, shavings and straw, which may be used in livestock areas. Cellulosic additives reduce moisture content and improve the consistency of manures for handling and conversion to bioenergy feedstock. Thus, manures from broiler chickens, horse manure with sawdust or shavings and cattle manure with bedding are more adaptable to bioenergy conversion.
- current usage. In intensive livestock operations, manure management is an integral component of the overall nutrient planning on the farm. This means that the manure is likely to have a readily identifiable economic benefit which must be compensated in order for the raw resource to be diverted to a bioenergy use.

Not all manure production in the South Peace is easily recoverable under current farming systems. Manure production in confined livestock operations, such as dairy, poultry and hog farms, would be mostly recoverable.

Beef manures are calculated to represent about 59% of all manure generated in South Peace. Beef finishing operations in feedlots may represent 15% to 20% of the South Peace beef cattle numbers and 40% of manure production. The remainder of the manure (60% of total beef manure production) would be generated in grazing and pasturing situations and would not be easily recoverable.

Horse manures, which in the winter would likely contain sawdust, shaving or straw additives in enclosed situations, would be stockpiled on farms. During other seasons of the year, the animals would be dispersed on the land and the manure would not be recoverable. It has been estimated that about 60% of the horse manure would be stockpiled on farms under normal operating situations. Table 9 presents these calculations.

Livestock manure is applied to the land to replenish nutrients and fibre. It is noted from Section 1.7, above, that about 10% of the seeded crop area, or 6,000 acres, receives some form of manure treatment annually. If these manure applications are at agronomic rates, the rate of application could be about 20 cu. yd. per acre, or the equivalent of 7.5 tonnes per acre and amounting to 45,000 tonnes in the region. This amount exceeds the supply calculated in Table 9 (4th column). It is more likely that individual farmers apply manure to arable fields at rates based primarily on disposing of manure from their mixed operations.

Manure handling systems in poultry, dairy and hog operations are likely to be more sophisticated than those in beef and horse operations. As such, it is probably reasonable to assume that the most of this supply would be tied up in existing applications. The 6th column of Table 10 suggests that 30,400 dry tonnes of manure may be considered accessible feedstock for bio-energy production.

Table 10: Estimated volumes of animal manure available for bioenergy feedstock in the South Peace region annually, by livestock type

Animal Type	Total Manure Available (tonnes)*	Recoverable Manure (%)	Recoverable Manure (tonnes)*	Total Recoverable Manure Available for Bioenergy (%)	Total Recoverable Manure Available for Bioenergy (tonnes)
Poultry	164	100%	164	0%	0
Dairy	5,217	95%	4,956	0%	0
Hog	1,542	100%	1,542	0%	0
Beef	42,109	40%	16,844	100%	16,844
Horse	22,631	60%	13,579	100%	13,579
Total	71,664		37,085		30,423

Note: * - Tonnes are expressed in dry weight.

Manure is often available for trucking costs. For instance, poultry manure is available in the Fraser Valley for $4.50/cubic yard (~$13.50/tonne) delivered to Delta, a three hour round trip. However, as a fertilizer replacement in crop production and the rising prices of fertilizer, the price for poultry manure may increase in the near future to reflect the real value of its nutrients.

3.4.3 Short Rotation Energy Crops

Various investigations world-wide have identified short rotation energy crops as having the potential to supply feedstock for bio-energy production. These options have real and/or perceived connotations with respect to creating competition for land resources between crops for food and crops for fuel. Growing crops specifically for energy production may require a paradigm shift in policy from the use of “waste” or “residue” by-products of agricultural systems to create sustainable energy to the use of bio-energy systems to create sustainable development.

A related consideration is that high yield energy crop production would likely entail the use of petrochemical inputs, which would complicate the greenhouse gas (GHG) impacts of energy crop production and use. One study indicates that monoculture crops grown specifically for bio-energy create greater GHG emissions, and more agrichemical pollution per chemical than either waste agricultural biomass or low-input high-diversity mixtures of native grassland perennials.[27]

[27] See Tillman, D., J. Jason and C. Lehman. 2006 Carbon-negative biofuels from low-input high diversity grassland biomass. In Science Vol. 314(5805): 1598-1600. http://www.sciencemag.org/cgi/content/full/314/5805/1598

The attractiveness of some high biomass crops includes that they can be grown on lower quality lands with lower inputs of water and fertilizer than conventional crops. Combustion systems also require less energy to convert the biomass into fuel. Switchgrass, for example, would be expected to yield about 10 tonnes/ha, on average, and 100 to 250 GJ per hectare.[28] The material could be converted into conveniently handled fuel through well developed pelleting processes.[29]

3.4.4 Low-Input High-Diversity Native Grassland (LIHDNG)

Grassland areas with low intensity management on degraded soils have been found by some researchers to yield more biomass than monoculture grass crops. Species diversity is indicated to be a key factor in higher yields.[30]

Timing of LIHDNG harvesting may affect species of wildlife, especially if harvesting is conducted in mid-summer. Precautions necessary to avoid unnecessary impacts would vary by location. Nonetheless, biomass quality for bioenergy production is not affected by letting grass stands over-mature.

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[28] See Samson, R. et al. 2002. An ecological response to North America's energy concerns. http://www.reap-canada.com/online_library/Reports%20and%20Newsletters/Bioenergy/7%20Grass%20Biofuel.pdf

[29] Resource Efficient Agricultural Production (REAP) – Canada (http://www.reap-canada.com/bio_and_climate_3_2.htm) and the Energy Probe Research Foundation (http://energy.probeinternational.org/) have been strong proponents of the use of grass biofuel pellets for heat energy production in Canada because of the more efficient fuel cycle and significantly more reduced GHG emissions compared to other alternative energy crops, such as corn and wheat.

[30] See Brahic, C. 2006. Humble grasses may be the best source of biofuel. In http://environment.newscientist.com/article.ns?id=dn10759

4.0 MUNCIPAL SOLID WASTE (MSW) AND CORRIDOR DEBRIS IN THE SOUTH PEACE

As the largest city in the area, Dawson Creek produces Municipal Solid Waste (MSW). According to the 2008 Draft Solid Waste Management Plan[31] for the Peace River Regional District, the Bessborough Landfill annually accepts 18,145 tonnes of MSW. As the landfill is the closest landfill to Dawson Creek (15 km), it is assumed that most, if not all the waste is generated in Dawson Creek. On a regional basis, the waste composition was evaluated in 2006, and results of this evaluation are used for the review of the region's Solid Waste Management Plan.

The waste composition is described in Table 11, below.

Table 11: Municipal solid waste produced in the Dawson Creek area

Materials	% of total	Tonnes
Paper and Paper board	24	4,360
Glass	4	725
Ferrous metals	4	725
Non-ferrous metals	1	180
Plastics	13	2,360
Organics - kitchen waste	15	2,700
Organics – Y&G waste	10	1,800
Wood waste	6	1,100
Construction & Demolition	5	900
Textiles	6	1,090
Rubber	1	180
Composites	8	1,450
Hazardous products	2	360
Total materials	**99%***	**17,930 t**
Note: * Does not add to 100% due to rounding		

Current recycling rate in the region is 8% and includes wood waste, tires, metal/white goods at the landfill, and rigid plastics, glass, aluminum and paper, cardboard and newsprint at recycling depots. Municipal statistics[32] show that Dawson Creek collected 403 tonnes of recyclables during the months of December to February, which can be extrapolated to a total of about 1,700 tonnes annually.

Wood waste will be separated (with a lower tip fee for encouragement) and chipped for landfill cover starting the spring of 2008. This wood waste, most likely received in a dry form, would make a good bio-fuel. Approximately 1,100 tonnes is available annually. The tip fee would off-set cost for chipping and transportation, so it would be available for free or for a nominal cost. MSW wood waste would supply less then half of the City's heating requirements.

[31] See: http://peaceriverrd.bc.ca/quick_links/Lettalktrash/documents/stage2rpt.pdf
[32] See: Newsletter April 2008: http://www.prrrdy.com/pdf/pRRRdySays-%20Apr%2008.pdf

4.1 MSW for Energy

Of the MSW stream generated in Dawson Creek, some 43% could potentially be diverted to energy use. This includes paper and cardboard, plastics and wood waste. The combination of these three materials could be seen as refuse derived fuel (RDF). Typically, RDF is produced by shredding the dry fraction of MSW, and separating-out metals, glass and other non-burnables. The resulting material is then pelletized and transported to an RDF co-generation facility. Wet organic waste is excluded. Using a shredding and sorting process, typically from 75% - 85% of the dry MSW weight could be recovered as RDF.[33]

A reasonable estimate for RDF production would be 7,800 tonnes annually for the City of Dawson Creek. This could be as low as 6,700 tonnes because of the beneficial re-use of wood as land fill cover. RDF is likely not suitable as a bio-energy source as capital costs for suitable burners and for air pollution control equipment would not fit the scale of the projects considered here.

4.2 Biosolids

The City of Dawson Creek operates a sewage treatment facility treating 5.5 million litres each day. The facility consists of two anaerobic ponds two aerobic ponds, and a finishing pond. Estimating an average biological oxygen demand of the incoming sewage of 250mg/L as biological oxygen demand (BOD) the facility is estimated to treat 600 tonnes of organic load annually, and to produce 150 tonnes of dry weight sewage sludge (about 700 tonnes wet). It is expected that a portion of the organic load would be generated as methane gas in the anaerobic portion of the lagoon. Typically, in the conversion of a kg of BOD to a m3 of CH4, the yield is about 0.47 at a temperature of 35^{o}C. In the Dawson Creek anaerobic lagoons this conversion rate is lower due to the temperature, and may reach 0.21 m3/kgBOD. Thus, the anaerobic part of the Dawson Creek sewage lagoon probably could generate 160,000 m^3 of methane gas.[34] With an energy content of 0.039 GJ/m3, capturing all of the bio-gas would generate 6240GJ of energy, less than 18% of the City's required use for heating.

Biosolids production at the Dawson Creek treatment facility is low, and it is not expected that a conversion of the lagoons to covered anaerobic digesters or a replacement of the lagoons with an aerobic digester system including an anaerobic sludge digester, will yield enough gas to operate a electricity generating facility or a boiler.

[33] See: http://www.p2pays.org/ref/11/10516/refuse.html

[34] 600,000 * 0.21 = 126,000m3 of methane gas. This is the equivalent of:
126,000m3/0.022.4 (m3/Mole) = 5,625,000 Mole of methane. With a Mole weight of 16 gr, the total weight of methane produced would be 90 tonnes of methane annually. This represents a tCO2E evolution of 90 * 21 = 1,890 tonnes per annum.

4.3 Organics - Grass Clippings and Yard and Garden Waste

The organic fraction of MSW consists of yard and garden waste, grass clippings and kitchen waste. Except for tree pruning and leaves, these materials have a high moisture content, and would not be suitable for energy use.

A suitable diversion for these materials would be composting in either an in-doors in-vessel composting facility or with a mobile in-vessel composting unit (such as AgBag), as the total volume will include kitchen and food waste. The use of an in-vessel system will eliminate vector and leachate challenges.

Dawson Creek is located in a semi-arid area, and thus yard and garden waste, grass clippings and leaves could be composted in a turned windrow system. Composting could include the disposal of soiled horse bedding from the Dawson Creek Exhibition Centre.

4.4 South Peace Corridors

Corridors for highways, pipelines and transmission lines require frequent maintenance. As well, fibre is generated when corridors are installed. This section deals with road corridors, gas pipelines, and hydro transmission corridors.

4.4.1 Road Corridors

The province of BC has highway systems throughout the South Peace. The landscape maintenance of these roads is contracted out to private operators under 10 year contracts and involves the control of grass and weeds in the rights-of-way. A typical undivided rural highway right of way may be 50 to 60 metres in width, of which the grassed strips on the sides of the paved roadway (12 to 13m) may each be 20 metres. Typical grass control requires 1 to 3 mowings of a shoulder or extended shoulder strip on each side of the highway ranging from 4 to 8 metres in width.

The South Peace road system is maintained by Caribou Road Services (South) Ltd.[35] which consists of 2,460 kilometres of roads. Maintenance includes mowing, debris removal, brushing and site distance clearing. Caribou Road Services typically mows 50% of the road sides and machine-brushes the other 50%. A one kilometre highway, as described above, would require between 8,000 and 16,000 m^2 of mowing twice a year. Agricultural yields of hay in the South Peace are about 2 tonne per ac. annually, or 5 tonne per ha. For the purposes of discussion only, assuming a right-of-way yield of 1 tonne per acre annually (2.5 tonnes per ha), each kilometre of highway generates between 2 and 4 tonnes of grass annually. Typically, grass is mowed and left on the road side. With an assumed 25% of the road sides suitable for mowing, bailing and collecting, the annual yield of dry baled grass from the roadside would be between 1,200 and 2,400 tonnes of biomass. The costs, include baling, loading and transportation, are estimated to be about $50/tonne.

Cuttings and brushing residue is typically left on the land and degrades quickly. Once every 4 years Caribou Road Services will hand brush the road sides. Branches and trees are hand-felled and then chipped in a mobile chipper. The mobile chipper blows the chips into the forest for disposal.

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[35] See: www.caribouroads.com

The total chip production from trimming roadways is estimated at 4,800 tonnes per year, [36] or about 3200 tonnes dry. The calculated chip cost is $60 per tonne, based on an hourly rate for the truck and driver of $75/hour.[37]

4.4.2 Gas Pipeline Corridors

The South Peace Pipeline is proposed by Spectra Energy. This 86.1 kilometres of 20-inch (51 cm) raw gas pipeline facilities, including pipeline segments south and north of an existing 12-inch (30 cm) pipeline owned by Storm Exploration Inc., will run approximately north-south along parts of the Kiskatinaw River.[38]

The gas pipeline corridor or Right-of-Way is estimated to be 100 ft (33 m) and includes the (temporary) access road, the pipeline and the areas for storage of soil and topsoil. As well a snow removal zone is included. Building a pipeline thus requires the clearing of a 33 m. wide corridor.

For the 86 km pipeline an area of 283 ha will need to be cleared of trees and vegetation. The pipeline is located within the Boreal Spruce and White Spruce bio-geoclimatic zone.[39] This forest type is estimated to produce a stem volume of 400 m3 per ha, of which some 200 m3 is merchantable timber (with a diameter >12.5 cm). With the assumption that the merchantable timber is being removed commercially, some 200 m3/ha must be disposed of. The total pipeline construction would generate a one-time volume of 56,000 m3 of wood waste mostly from stem and branches, or the equivalent of approximately 20,000 BDT. Recovering this wood waste will require significant resources in chipping and trucking. Chipping and trucking costs are estimated to be in the $75 – 90/tonne range, and may be significantly higher. For use as a bio-fuel, drying and pelletizing may be required at an additional cost of $75/tonne.

The maintenance of gas and oil pipelines will not generate significant wood waste. Vegetation management procedures during operation are performed in accordance with the pipeline's plan and procedures and include regular mowing, cutting, and trimming along most of the permanent pipeline ROW. Routine vegetative maintenance clearing would not be performed more frequently than every 3 years, unless requested and/or approved by appropriate state and local agencies. However, a corridor that does not exceed 10 feet (3.3 m) in width centered on the pipeline could be maintained annually in a herbaceous state as required to facilitate periodic corrosion and leak detection surveys.[40]

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[36] Mike Jennings, Northland Chippersale, Langley BC; Personal communication 2008. A rough estimate was made based on chipping season (6 months) and the typical feeding rate for a chipper operated in a road side clearing project. Assuming that 50% of the roads (1,200 km) need maintenance requiring hand felling and chipping and with a ratio of maintenance of 1 in 4 years, each year about 300 km is maintained in this fashion. Two chipper crews, producing 20 tonnes of chips per day, would work 6 months of the year.

[37] As chips are typically blown back into the forest, the additional transportation of chips would need to be considered if they are to be recovered for biofuel application . A chipping crew would typically require the transport capacity of 2 ten-tonne trucks to catch the chips and transport them to a central facility.

[38] See: http://www.spectraenergy.com/businesses/projects/south_peace/SouthPeaceFactSheet.pdf

[39] See page 49 for explanations.

[40] Argonne National Laboratory , 2007 Natural gas Pipeline technology review. http://corridoreis.anl.gov/documents/docs/technical/APT_61034_EVS_TM_08_5.pdf

4.4.3 Hydro Transmission

Province-wide, the BCTCV has 18,000 km of line and 75,000 ha of Rights-of-Way. Their vegetation management plan is to mow when weeds are 10% of the cover. Some edge tree removal will take place. Table 12, below, shows the estimate of the Rights-of-Way.

Table 12: Vegetation control requirements associated with existing BC Hydro transmission lines in the South Peace

Segment #	Existing Hydro Lines	Line Size	Length (km)	Width (m)	Vegetation Control Area (ha)
1	Kennedy to GM Shrum Generating Station	500 kV	120 km	140 m	1,680 ha
2	GM Shrum to Peace Canyon Generating Station	Not in the South Peace	23 km	140 m	322 ha
3	Peace Canyon to South Taylor	2 – 138 kV	108 km	118 m	1,274 ha
4	South Taylor to Dawson Creek	138 kV	54 kn	30.5 m	165 ha
5	Peace Canyon to Chetwynd	138 kV	50 km	30.5 m	153 ha
6	Chetwynd to Dawson Creek	138 kV	100 km	30.5 m	305 ha
7	GM Shrum to Tumbler Ridge	230 kV	145 km	36.5 m	529 ha
	Total (not including Segment 2)				4,056 ha

While wood waste will be generated in the maintenance of the hydro line Rights-of-Way, as vegetation control would mostly include mowing and brushing, it is expected that it may be difficult and expensive to recover.

Should a new Site C dam be constructed in the Peace River, this will require new transmission Rights-of-Way of about 167 ha. Clearing of this Right of Way would generate 33,000 m3 (12,000 BDT) of wood debris that is chippable and about the same amount of merchantable timber.

Table 13: Additional vegetation control requirements associated with future proposed BC Hydro transmission lines in the South Peace

Segment #	Existing Hydro Lines	Line Size	Length (km)	Width (m)	Vegetation Control Area (ha)
2	Peace Canyon Generating Station to GM Shrum	Not in the South Peace	No change		
3	Site C to Peace Canyon (expansion of a portion of the existing right-of –way)	2 – 500 kV	76 km	22 m	167 ha *
	Total				167 ha

Notes: * = Represents tree removal during row enlargement and vegetation control in subsequent years

4.4.4 Petroleum and Natural Gas Exploration

Petroleum- and natural gas-related land sales in the northeast region have averaged over $300 million annually since 1997, accompanied by a larger number of drilled wells.

This exploration has been assisted by a 5 year provincial program to improve access to oil and gas development areas. Since 2004/5, Heartlands Oil and Gas Road Rehabilitation Strategy (HOGRRS) Projects in Northeast BC has improved access to exploration areas by upgrading roads used by industry to allow for all-season use. In fiscal 2005/6, BC invested $16.5 million to widen and/or repair 87 km in the South Peace. In 2007, Regional Transportation Advisory Committees (RTACs) have been set up for various regions of BC, including the Northeast region, to advise on transportation investment priorities into the future.

According the Ministry of Energy and Mines [41] published map of HOGRRS and Royalty Credit road building and upgrade efforts, most roads are built north east of Fort Nelson. In the South Peace the road building activity is south west of Dawson Creek/Pouce Coupe, with the following activity:

Royalty Credit Halfmoon Road	(~10km)
HOGRRS Heritage Hwy 52 N	(~37km)
HOGRRS Boundary Hwy 52E	(~40km)

In addition to the road upgrades, various land clearing activities take place such as well head clearing, seismic lines, and local access roads. New activities take place after crown land is being "disposed of" through royalty auctions. In BC, approximately 600,000 ha of land is being auctioned off each year, most of it in the Fort Nelson area.

From a brief review of the North Field and the South Field maps for oil and gas wells, it we assumed that not more than 5% of all oil and gas activity takes place in the South Peace. Most activity is located north east of Fort Nelson and in the North Peace. It can be concluded that approximately 30,000 ha of new leases (5% of the total in BC)

[41] See map at link: http://www.em.gov.bc.ca/dl/oilgas/INFRASTRUCTURE/MEMRoadProjects200405.pdf

is allocated to the South Peace. We can also assume that not more than 1% of the new land leases will need to be cleared for further development. This means that annually 300 ha of land may be cleared. With the average clearing volume of non-merchantable timber of 200 m3/ha, the availability for other uses will be 60,000 m3 or 22,000 BDT. As this material will be located away from industrial centres, the cost for this material to reach these centres is estimated as $40 per tonne for loading and transportation plus $35/tonne for infield chipping and grinding, for a total of $75/tonne.

Table 14: Hectares of land disposed of in BC for oil and gas exploration

Calendar Year		Hectares Disposed	Total Tender Bonus	Average Price ($/ha)
1978		699,218	$177,459,967.82	$253.80
1979		502,116	$191,041,605.35	$380.47
1980		441,297	$181,266,803.81	$410.76
1981		598,233	$60,776,402.86	$101.59
1982		166,441	$16,724,133.06	$100.48
1983		141,148	$26,014,217.09	$184.30
1984		237,085	$61,754,227.62	$260.47
1985		391,139	$87,767,976.64	$224.39
1986		217,695	$28,640,857.26	$131.56
1987		259,594	$44,186,704.51	$170.21
1988		515,537	$99,972,231.73	$193.92
1989		403,807	$88,283,852.96	$218.63
1990		529,875	$130,622,073.38	$246.51
1991		349,392	$59,710,106.05	$170.90
1992		245,320	$39,642,592.11	$161.60
1993		514,621	$143,450,069.50	$278.75
1994		738,065	$208,019,408.05	$281.84
1995		714,765	$130,611,234.53	$182.73
1996		564,624	$128,008,289.14	$226.71
1997		735,979	$216,774,834.78	$294.54
1998		482,831	$96,343,470.18	$199.54
1999		730,553	$176,169,284.25	$241.15
2000		692,894	$248,239,512.27	$358.26
2001		854,201	$439,467,190.13	$514.48
2002		848,917	$288,466,253.92	$339.81
2003		733,487	$646,678,833.68	$881.65
2004		540,427	$232,378,712.60	$429.99
2005		579,402	$533,985,782.86	$921.62
2006		690,744	$629,849,173.78	$911.84
2007		595,559	$1,047,107,705.74	$1,758.19
2008 (current to Apr.24/08)		**169,744**	**$317,070,575.31**	**$1,867.93**
5 Year Average	(2003-2007)	627,924	$618,000,041.73	$984.20
10 Year Average	(1998-2007)	674,902	$433,868,591.94	$642.86
15 Year Average	(1993-2007)	667,805	$344,369,983.69	$515.67
20 Year Average	(1988-2007)	603,050	$279,189,030.58	$462.96

5.0 FORESTRY WOOD RESIDUE

Wood biomass for combustion can be obtained from many sources. Economically, the most feasible sources of feedstock are wood wastes or by-products of wood manufacturing processes. The most significant issues associated with using energy-producing wood wastes in combustion processes are the availability of the resource, the cleanliness of the resource, its uniformity in material content, consistency of moisture content and the costs.

This section provides perspective on the forestry industry and estimates how much fibre could be available for bio-energy. The wood waste supply has been extensively studied and trends are presented. Coastal logging was important in the early part of the 20th century; its importance waned in the 1960s resulting in the closure of many sawmills in the Lower Mainland and on Vancouver Island. During the 1980s Interior forestry became more intensive and competitive. Currently, with economic factors such as low lumber prices, a high dollar, and off-shore competition of low cost lumber and fibre, and with the mountain pine beetle damage in BC, the BC forest industry has fallen on hard times.

Important trends seen in BC's Lower Mainland and in the Southern Interior, may also affect northern forestry. In order to fully understand the trends and their impacts, some of the factors that affect the growth of trees (local bio-geo climatic zones) and the forest tenure system have been highlighted. Within this context, the annual volumes of wood fibre available for bio-energy have been estimated.

5.1 Trends in Forestry Wood Residue Supply

The belief is that large quantities of forestry waste are generated in the BC along the coast and in the interior. This section will show some of the constraints in the wood waste supply. It deals with a general description of the supply in Lower Mainland as an example of an area where after an abundance of wood debris up to the 1970s and the early 1980s, a shortage is experienced, the supply in the Interior in BC, which could be considered at a peak of wood waste production, but is experiencing upcoming supply issues, and the area around Dawson Creek, the study area.

5.1.1 Lower Mainland

The trends in the Lower Mainland can be seen as a guidance for the remainder of the Province. The area was the first to develop forestry in the late 19th century, and was also the first area to abandon major forestry activities due to the exhaustion of the resource. Since the 1950s and 1960s all but few of the sawmills have disappeared from the Vancouver scene.

In 1996 when the last survey was completed for the Fraser Basin [42], the majority of wood residue available in the Lower Fraser Basin was recycled, both as boiler fuel and as pulp chips. Approximately 600,000 m^3 (~160,000 tonnes) of wood residue out of a total produced of 22,000,000 m3 was available from the forest industry at that time. All other wood waste was allocated to pulp mills as boiler fuel and as pulp furnish.

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[42] PGL Organix – 1996. Inventory of Wood Residues in the Lower Fraser Basin and on Eastern Vancouver Island. Report for Environment Canada. DOE FRAP 1996-05

Currently, the availability of wood waste in the Lower Mainland is extremely tight, indicating virtually complete allotment and reuse of the resource available from the local lumber manufacturing industry. This has led to the importation of wood waste from the Interior in the form of shavings, sawdust, cut ends and bark for use in livestock production, as a soil conditioner and landscaping materials. For instance, sawdust and shavings are imported from Merritt and beyond, while bark is transported in from the Fraser Canyon. This has driven up the prices for wood debris in the Lower mainland. Sawdust, shavings and processed wood waste are used as bedding in poultry barn and horse stables. As well, the expanding blueberry industry in the Lower Mainland absorbs a large quantity of this material to ridge the rows newly planted blueberries.

Prices for delivered wood waste, saw dust and shavings are increasing rapidly. Several greenhouses in the Lower Mainland use hog fuel as a source of energy and have made specific supply arrangements with sawmills in the Lower Mainland and in the Interior. Demolition and Construction waste and land clearing waste are available as low grade fibre resources, and are still disposed of in a conventional manner.

With the current slowdown in the forest industry, wood debris is becoming very scarce in the Lower Mainland.

5.1.2 BC Interior

In the BC Interior, wood residue generated by the forest industry is utilized as boiler feed, is incinerated or is made into wood pellets. EnviroChem[43] estimated in 2004 a surplus of 2 million Bone Dry tonnes (BDT) of wood residue incinerated in bee-hive burners, which is similar to the 2003 estimate by Girard[44] and higher than the BC Hydro estimate done in 2002 and 2004 (1.6m tonnes)[45,46]. The BC Hydro estimate was based on a survey of all sawmills to assess the wood waste generated by each mill. BioCap (2008) in an updated guide [47] suggests that while 11 million tonnes of mountain pine beetle killed wood may be available for energy use, the actual amount is much lower because of inaccessibility and enhanced cutting of pine. As well, pine may not be cut for reasons of biodiversity, water quality, visual aesthetics, and protection of mid term timber supply. The pine beetle epidemic has also led to selective and enhanced cutting of stands with >70% of pine.

Due to changes in the forest industry, the estimated amounts of wood residue may need to be adjusted. The softwood lumber dispute with the US forced the BC lumber industry to become more competitive. This challenge taken up by the forest companies in the Interior, while those on the coast only improved marginally. This resulted in an increase in lumber production in the areas around Prince George, Quesnel and

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[43] EnviroChem Services Inc. Identifying Environmentally Preferable uses for Biomass Resources: Stage 1 Report March 2004. http://www.cec.org/files/PDF/ECONOMY/Biomass-StageI_en.pdf

[44] R. Girard, 2003. Wood waste and air quality issues –MWLAP. PowerPoint presentation. http://www.bcclimateexchange.ca/doc/GreenEnergy2003/RichGirardApril25GreenE.ppt

[45] BC Hydro, 2002. Green Energy Study for British Columbia: Phase 2 Mainland. http://www.bchydro.com/rx_files/environment/environment3927.pdf

[46] BCHydro, 2004. 2004 Integrated Electricity Plan: Part 3 Resource options. http://www.bchydro.com/rx_files/info/info10227.pdf

[47] BioCap Canada, 2008. An Information Guide on Pursuing Biomass Energy Opportunities and Technologies in BC for First Nations, Small Communities , Municipalities and Industry. Updated version February 25, 2008 http://www.energyplan.gov.bc.ca/bio-energy/PDF/Bio-energyInfoGuide.pdf

Williams Lake. It is now estimated by some industry sources that around Prince George alone there is a surplus of wood debris of 3 million tonnes (2 million tonnes is white wood), and industry sources indicate a surplus of 4 million tonnes in the whole Interior, rather than the 1.6 to 2 million tonnes as reported earlier[48]. However, on-going changes in the productivity of the wood processing industry leads to more product (lumber and chips) and less waste and estimates may have to be revised downwards.

EnviroChem estimated that 15 million m^3 (4,000,000 tonnes per year) of "bugwood" (Mountain Pine Beetle damaged wood) would be come available over the next 10 years. Current estimates are for a total of 230 million m^3 (61,000,000 tonnes)[49] over that period. In some areas salvage logging takes place and pine is cut in a ratio larger than that of the natural stand. [50] It is expected that harvestable pine will be exhausted in about 10 to 13 years, and that the AAC could be reduced to 40 to 45 million m3 for the province. This is also echoed by Don White in his paper sponsored by the Business Council of BC and by the Council of Forest Industries (COFI).[51]

The forest industry in BC currently suffers from economic challenges. A downturn in the US construction market, combined with a high Canadian dollar has caused the closure of several sawmills in the Interior. While some mills may open again in due course, it is expected that many closures will be permanent. Since 2001, 47 saw mills closed in BC including 11 closures in 2007. Prior to 2001, 82 sawmills were operating in the southern interior region and 36 in the northern interior region.[52] In addition to saw mills, there were operating at least 9 chipmills, 25 pole mills and 19 pulpmills.

5.1.3 Existing Demands for Wood Waste

The forest industry in BC typically generates large quantities of residual wood fibre and bark. Historically, this wood fibre was either incinerated in bee-hive burners or landfilled. Due to the environmental risks involved with either disposal method, the industry changed over to other residue disposal or re-use options.

In the 1970's and 1980's a fibre-board industry was established in BC. In the 1990's, many pulp mills built or upgraded their boiler systems to make them suitable for bio-fuels such as sawdust, bark and pulp and paper mill sludge. Currently, large capacity is installed in BC[53]. Biomass boilers generate heat and electricity for the operations of the large pulping complexes. Recent examples are the NW Energy Co-generation plant in Williams Lake, generating 60MW of power from biomass, the fluidized bed boiler at Norske in Powell River with 32MW, Crestbrook's 40MW, Howe Sound Pulp and Paper's 80 MW, power boiler of Talbot in Mackenzie, generating 14MW, and Riverside in Armstrong 20MW. The total installed capacity at BC pulp mills and other biomass facilities is approximately 600MW according to BC Hydro's 2002 estimate, and may be

[48] John Swaan, personal communication.

[49] Rudledge, D. 2004. COFI Presentation. October. http://www.cofi.org/library_and_resources/presentations/2004/pdf/MountainPineBeetleForResAssConfRoutledge.pdf

[50] BC Ministry of Forests, 2007. Monitoring Harvest Activity Across 16 Mountain Pine Beetle Impacted Timber Supply Areas. www.for.gov.bc.ca/hts/MPB_**Harvest**_2007.pdf

[51] Don Wright, 2007. Responding to the Challenge of the Mountain Pine Beetle. http://www.bcbc.com/

[52] Interior, see: http://www.cofi.org/forest_industry_BC/geographic_impact/southern_interior.htm and http://www.cofi.org/forest_industry_BC/geographic_impact/northern_interior.htm

[53] IEA Bio-energy Newsletter for IEA Task 26 Biotechnology for the Conversion of Lignocellulosics to Ethanol NUMBER 3, NOVEMBER 1998 http://www.ieabio-energy.com/library/67_ieanews3.htm

higher as Canfor in Prince George (48MW) and Weyerhaeuser in Kamloops (30 MW) [54] are being established. The new capacity will absorb approximately 600,000 tonnes of wood waste, reducing BC Hydro's 2002 estimate for unused capacity by 30%. BC Hydro stated that in March, 2004, three more facilities were in the planning stage.[55] Such large facilities and others in the pulp and paper industry will attract biomass generated over large areas, resulting in longer trucking distances to transport the biomass to the boiler sites and increasing scarcity of wood debris in many areas. This was the case for Howe Sound Pulp and Paper, which planning for a new power boiler appeared to have been shelved due to a lack of available wood waste in the surroundings.

BC Hydro has estimated an unused capacity of wood biomass of 240 MW, including land clearing and demolition debris. [56] This has attracted entrepreneurs willing to build generating capacity. One facility, either in Kazlo or in Quesnel, would generate between 220 and 300 MW of electrical power for about $70/MWh.[57] The facility would be supplied from an area of 145 X145 km. The recent (March, 2008) BC Hydro Bio-energy call will increase the pressure on the wood supply even more, as facilities have been proposed for a total of between 350 and 500 MW generation capacity. One such facility is proposed for Mackenzie. It is imperative that any project proposed to utilize the fibre supply for the generation of electricity, secures a fibre supply.

It appears that the currently proposed facilities will oversubscribe the "waste" fibre supply by a factor of 3 to 4, when a fully operational forest industry is considered. With the current (maybe permanent) slump in the industry, future and also currently operating power boilers will run out of a supply of cost effective wood waste.

5.2 Physical Factors and Land Tenure.

This section addresses some of the factors that may affect the timber production and thus the potential for generation of bio-energy products in the area around Dawson Creek.

5.2.1 BC Tenure System[58]

Forestry wood residue is commonly generated as a by-product of the logging and saw milling industry. In most of BC, logs are supplied through the system of timber tenures, where companies obtain the rights for harvesting trees on a certain parcel or in a certain volume. The three main timber tenures used in the BC forestry sector include:

A Forest Licence – a licence that provides the right to harvest a given amount of timber in a timber supply area each year for the duration of the license. The licensee is responsible for the operational planning, road building, fire hazard abatement,

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54 Process West Newsletter http://www.processwest.ca/Past_Issues.htm?ID=307

55 BCHydro, 2004. 2004 Integrated Electricity Plan: Part 3 Resource options. http://www.bchydro.com/rx_files/info/info10227.pdf

56 BC Hydro, 2002. Green Energy Study for British Columbia: Phase 2 Mainland. http://www.bchydro.com/rx_files/environment/environment3927.pdf

57 Kumar, A et.al., 2006. BC's Beetle Invested Pine: Biomass feed stocks for producting power. Bio-energy conference, Prince George, BC. http://www.bio-energyconference.org/docs/speakers/2006/Kumar_BioEn06.pdf

58 Ministry of Forest and Range. Bio-energy Opportunities Using Wood Resources. www.for.gov.bc/hts/bioenenergy/primer_IPP.htm

reforestation and stumpage payments. Forest Licences within the timber supply area are not readily available.

A Tree Farm Licence – a replaceable, area based licence with a term of 25 years. The TFLs include long term tenure to the forest resource.

A Timber Sale Licence – the rights to harvest based on a competitive auction. Operational planning and road building may not be included. A Timber Sale Licence is not replaceable and has a term of two years.

Other forms of timber tenure are available, and have been allotted on a small scale.

The relevance of the timber supply licence system to the City of Dawson Creek is that should the City or an entrepreneur wishing to obtain raw lumber from the forest for energy production or other uses, this can only be done on a timber sale licence, as both the forest licence and the tree farm licence are long term and all volume has been allocated. Alternatively, the entrepreneur could obtain a fibre supply from one of the existing licence holders.

5.2.2 Bio-Geoclimatic zones

Plant growth (including trees) is dependent on several factors including climate, exposure and soils, as well as water supply. The combined effects of growth factors can be described with system of bio-geoclimatic zones. Such a system classifies the plant community based on the variety of species and the growth rate, as a reflection of the soil, climate, and other factors, and can be used for prediction purposes.

The South Peace Regional District area is made up of four biogeoclimatic zones.[59] In the eastern part of the area, the vegetation is dominated by the Boreal White and Black Spruce zone (BWBS). This bio-geoclimatic zone covers most of the subject area. The BWBS is shaped by short growing seasons and long cold winters. Trees include white spruce, black spruce lodgepole pine, tamarack, balsam poplar, and birch. Grassland communities occur along the rivers in the area.

From the BWBS west wards a range of “pockets” of Spruce-willow-birch (SWB) exist. These areas are sub-alpine and are characterized by severe winters with moderate snow cover. Tree species include white spruce, black spruce, and in areas above 1200m willow and birch shrubs pre-dominate.

At the western edge of the South Peace Regional District area the Englemann Spruce – Subalpine Fir (ESSF) bio-geoclimatic zone is found. This zone lies between the alpine tundra and the lowland forests throughout much of the interior of BC. This zone includes the Engelmann spruce and subalpine fir, several species such as the lodgepole pine are common in the drier pockets.

The Alpine Tundra zone can be found in the southern most part of the South Peace Regional District. This zone does not support significant timber supply.

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[59] Valentine, KWG., P.N.Sprout, T.E.Baker and L.M.Lavkulich, 1978. The soil landscapes of British Columbia. The Resource Analysis Branch, Ministry of the Environment, BC.
http://srmwww.gov.bc.ca/soils/landscape/1.4vegetation.html

5.3 Productive Forest Lands near Dawson Creek

Figure 4, below, shows the productivity of forest lands as displayed in the Atlas of Canada.[60] The map shows that the highest percentage of productive land is in the eastern part of the Peace River Regional District (dark green colour indicating 75-98% productive forest land). The western part of the District is covered by medium productivity lands (mid-green colour indicating 50-75% productive forest land). The figure also shows that saw mills are located inside the South Peace area (Chetwynd) and just out side the area (Fort St John, MacKenzie).

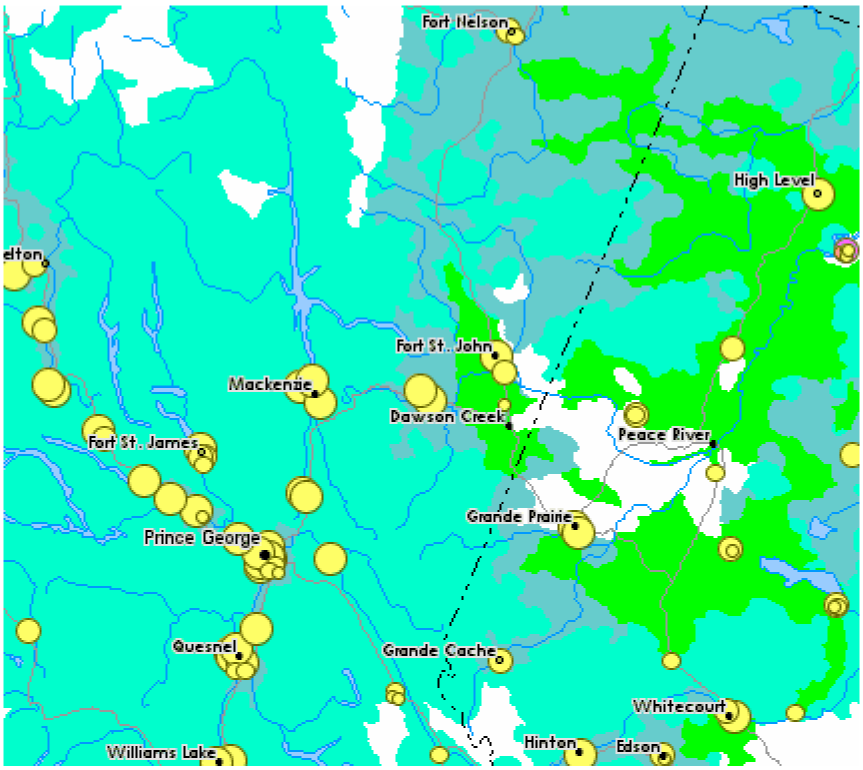

Figure 4: Sawmills near the South Peace area.

[60] http://atlas.nrcan.gc.ca/site/english/maps/environment/forest/useforest/proforlanduse

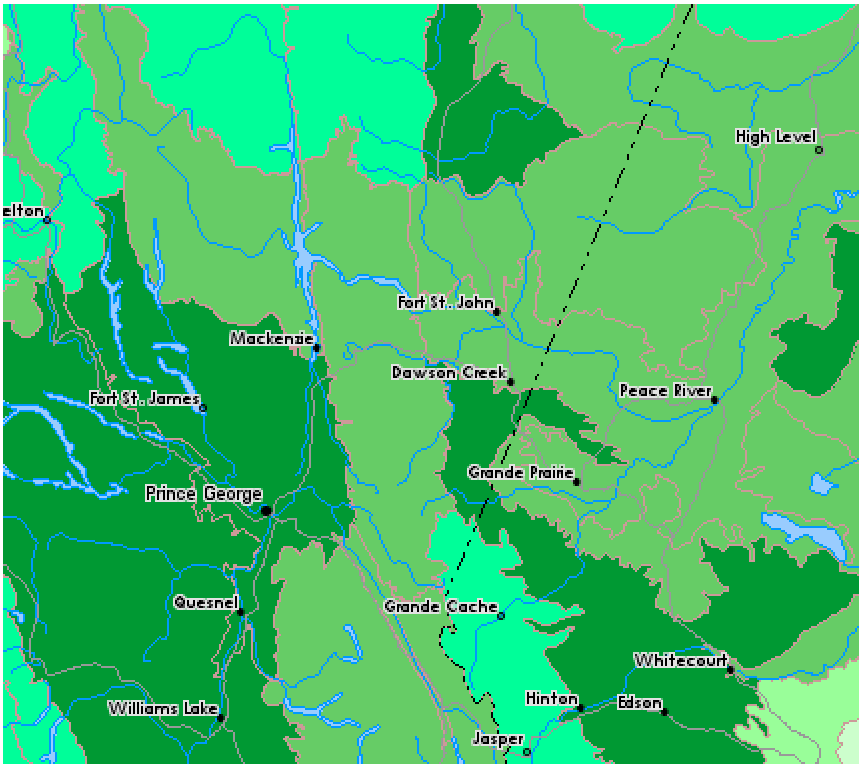

Figure 5:Vegetation types the region. (Source Atlas of Canada)

The Atlas of Canada sawmill map[61] shows that the north-eastern part of the forest supply area is mostly supplying broad leaf based lumber (lime green), while the western and southern part supplies mostly coniferous based lumber (green), with a mixed supply from in-between areas (grey).

5.3.1 Timber Supply Areas

Timber supply in BC is managed in Timber Supply areas (TSA). The Dawson Creek timber supply area roughly overlaps with the South Peace Regional District. The timber supply management structure is includes Tree Farm License 48 granted to Canfor, and the general Dawson Creek Timber Supply Area. The TFL 48 covers 644,700 ha while the TSA covers 2.3 million ha. The total timber supply covers 2.9 million ha. of forest land.[62],[63],[64] Figure 6, below, indicates the boundaries of the Dawson Creek Timber Supply Area, while Figure 7 below outlines the TFL 48 owned by Canfor.

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61 http://atlas.nrcan.gc.ca/site/english/maps/environment/forest/useforest/sawmills
62 http://www.for.gov.bc.ca/hts/tsa/tsa41/index.htm
63 www.for.gov.bc.ca/hts/tsa/tsa41/tsr2/info.pdf Dawson Creek Timber Supply Area Information Report 2000.
64 Dawson Creek Timber Supply Area Analysis Report 2002. www.for.gov.bc.ca/hts/tsa/tsa41/tsr2/**analysis**.pdf

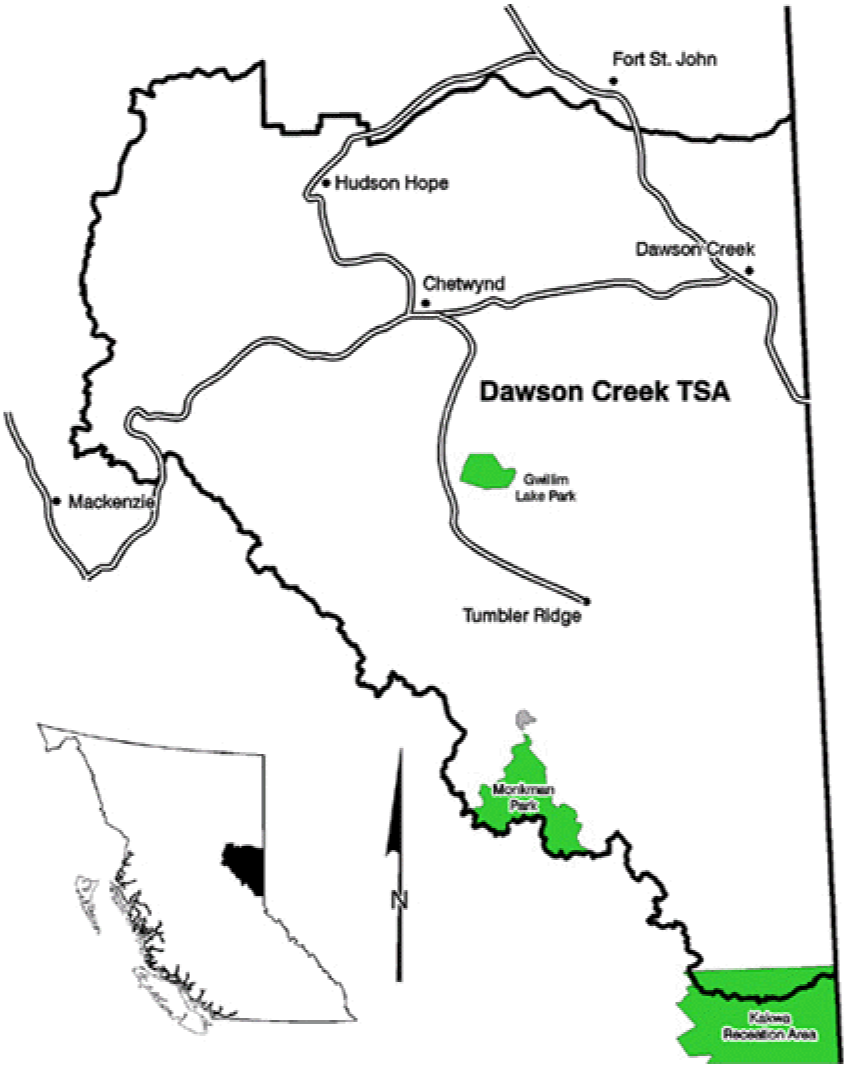

Figure 6: Dawson Creek Timber Supply Area. (Source: BC Min of Forest)

5.3.2 Volumes of Timber Supply in Dawson Creek area.

The timber supply around Dawson Creek is obtained from two areas: the Dawson Creek TSA and the Chetwynd TFL 48. This section estimates the total timber supply for the area.

Dawson Creek TSA

Approximately 1.4 million ha is productive forest land of which 59% is covered with coniferous species and 41% contains mostly deciduous species. The current timber harvesting land base is 730,000 ha and future timberland area is estimated as 696,000 ha. [65] Of the 730,000 ha, 469,900 is in conifers (White spruce 34%, lodge pole pine 25%, sub-alpine fir 6%) and 260,300 ha is considered deciduous (aspen 29% and balsam poplar 6%). Many areas contain mixed stands.

[65] Scheithauer, F., 2006. Dawson Creek Timber Supply Area Vegetation Resources Inventory [Draft Plan] BC Ministry of Forest & Range/ Louisiana Pacific Canada Ltd. www.for.gov.bc.ca/hts/vri/reports&pub/tsa_vpips/**dawsoncreek**tsa_vripi_vpip_draft.pdf

The Dawson Creek Timber Supply area contains between 23 and 31% as pine, with 19% of the timber harvesting land base covered with >70% of pine[66], mostly in small lodge pole pine stands. Extended pine harvesting takes place in the Dawson Creek Timber Supply Area. Approximately 44% of the harvest is pine as compared to an average stand density of 23-31% pine and the pine fraction of the timber harvesting land base of only 19%. Pine is thus overharvested in the Dawson Creek Timber Supply Area, primarily as salvage logging.

The Annual Allowable Cut for the TSA was 1.73 million m3 per year prior to 2000. The AAC was divided into 864,500 m3 (49%) of coniferous trees and 886,5000 m3 (51%)of deciduous trees. In 2003, the AAC was upgraded to 1.86 million m3 per year.

TFL 48(Chetwynd)

TFL 48, also known as the Chetwynd TFL, is held by Canadian Forest Products Ltd. (Canfor) and comprises five supply blocks in the western half of the Dawson Creek Forest District in the Prince George Forest Region. The blocks are clustered around the communities of Chetwynd and Tumbler Ridge, which lie to the west and southwest, respectively, of Dawson Creek. These areas are mainly spruce (39%), lodgepole pine (38%), aspen (14%), cottonwood (6%), and balsam (3%) stocked. [67]

TFL 48 covers 644,700 ha, with an annual allowable cut of 580,000m3/year, of which 525,000 m3 is for coniferous species and 55,000 m3 for deciduous species. [68] [69]

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[66] BC Ministry of Forests, 2007. Monitoring Harvest Activity Across 16 Mountain Pine Beetle Impacted Timber Supply Areas. www.for.gov.bc.ca/hts/MPB_**Harvest**_2007.pdf

[67] TFL 48 Canadian Forest Products Ltd. Vegetation Resources Inventory Sampling Plan .JS Thrower & Associates, August 2000. [download]

[68] www.cila.bc.ca/old_news/newsnumber149.htm

[69] BC Ministry of Forests: Tree Farm License 48, 1996. www.for.gov.bc.ca/hts/tsr1/ration/**tfl**/t**48**/httoc.htm

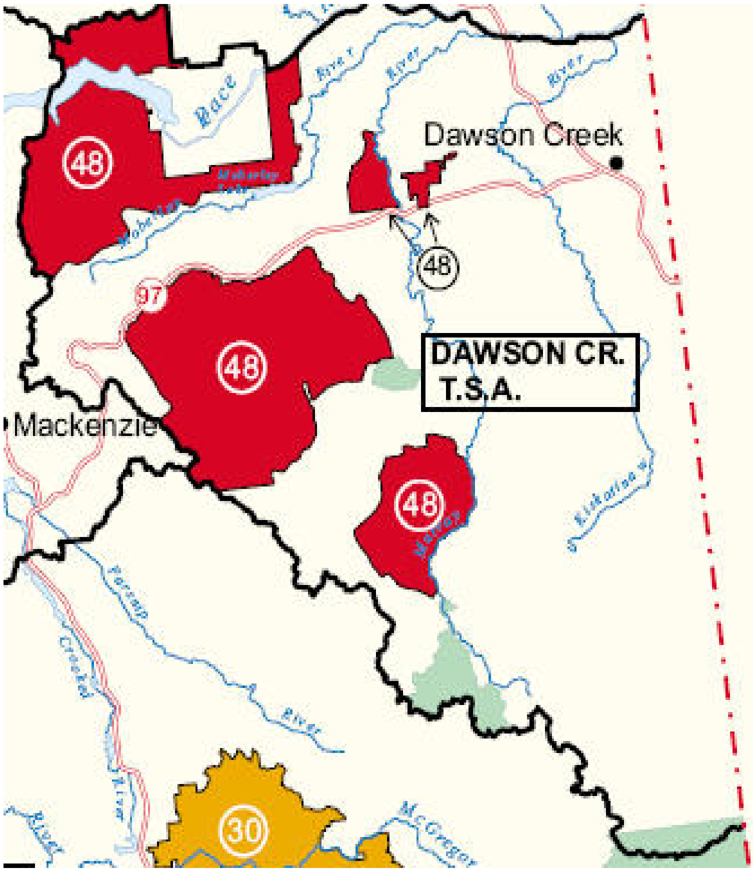

Figure 7: Tree Farm License 48 (Chetwynd) area (Source: Scheithauer, 2006).

5.3.2 Total Allowable Annual Cut

The total AAC for the Dawson Creek timber supply area is 2.44 million m3 per year, consisting of 1.86 million m3 in the TSA and 0.58 million m3 in TFL 48.

The total allowable annual cut covers 911,000 plus 525,000 m3 and equivalent to 1.44 million m3 of coniferous species and 948,000 plus 50,000 m3 and equivalent to 998,000m3 of deciduous species. Currently, the AAC fairly reflects the amount of timber harvested.[70]

5.4 Fibre Waste on Site

Logging activities such as felling, de-branching, bucking and yarding generate wood waste that is not merchantable. The wood waste includes branches and needles, tops with stem diameter smaller than the merchantable specifications (normally 5” (12.cm) diameter, sometimes smaller than 6”, dead trees, and broken timber. Different stands and ecosystems each generate a more or less specific volume of wood debris. Stems are yarded to central locations along the roadways, sorted there, and left-over wood waste may be piled at these locations (roadside wood waste). The total of wood waste in a forest, both a mature forest and a freshly logged area, is called coarse woody

[70] Pedersen, L., Chief Forester, 2003. Allowable Annual Cuts in BC: the Agony and the Ecstasy. Presentation to UBC Faculty of Forestry. March 20, 2003. http://www.for.gov.bc.ca/hts/pubs/jubilee_ubc.pdf

debris (CWD). Generally CWD is defined as dead woody material greater than 10 cm in diameter in all stages of decay, and consists of above-ground logs, bucking waste, exposed roots, and large fallen branches. [71]

In young and mature forests, CWD provides shelter, nesting and denning sites, and foraging opportunities for many organisms ranging from fungi, salamanders and squirrels, to black bears. As downed wood rots, it slowly releases valuable nutrients into the soil. Coarse woody debris can also help stabilize slopes and act as nurse logs for young seedlings. Retaining large pieces of scattered wood on the ground after harvesting, rather than yarding them to landings or roadsides, increases coarse woody debris and helps maintain site productivity and biodiversity.[72]

It is often viewed by the public that logging debris and road side waste is a valuable resource that can be used for non traditional fibre uses such as preparing wood pellets and boiler fuel, as well as wood chips and other products. However, the removal of logging debris and road side waste would decrease the amount of wood waste remaining on the forest floor. In yarding stems to a central location virtually all CWD is removed from the surroundings. Stems are sorted at the road side and rejects are piled there.

A recent study (Densmore et.al 2007) [73] compared CWD in a mature stand to the CWD on logged sites in light of biodiversity needs rather than economic values of the wood waste. The study showed that in the SBS (Sub Boreal Spruce) bio-geoclimatic zone near Prince George, BC, a total average volume of CWD is found of 145m3/ha post harvest. The pre-harvest CWD in similar cut blocks and forest stands was 176m3/ha with 60% of the downed wood in the larger pieces. The study also showed that a post-harvest volume of CWD of 145m3/ha would decay to a level of 22m3/ha at an age of 90years, or about 15% of that of a natural stand of the same age. The study concluded that adequate volumes of CWD are required throughout a managed rotation to provide for important ecological processes. In order to keep CWD in the forst it should either be moved back from the road side or not yarded to the road in the first place.

The SBS bio-geoclimatic zone is the zone of the interior plateau around Prince George, with a mixture of spruce and pine. While the bio-geoclimatic zones in the Dawson Creek Timber supply area are different from the zone included in the study, the SBS zone of Prince George is closest in features and tree crop to the areas around Dawson Creek. It can be expected that harvest residues are somewhat similar.

Roadside and in-field salvage of low economic wood (broken or otherwise) has been seen as a method of increasing the economic value harvesting by removing more fibre from the forest. A study in North Carolina showed that with on-site chipping of waste

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[71] BC Ministry of Forests, 2000. Provincial coarse woody debris short-term strategy. Victoria. www.for.gov.bc.ca/hre/deadwood/DTgui3.htm

[72] http://www.for.gov.bc.ca/hfp/publications/00062/page9.htm page 7,

[73] Nancy Densmore, John Parminter, and Victoria Stevens, 2005. Coarse woody debris: Inventory, decay modelling, andmanagement implications in three biogeoclimatic zones. BC Journal of Ecosystems and Management 5 (2). http://www.forrex.org/publications/jem/ISS26/vol5_no2_art3.pdf

wood on a logging site, more than 33% of all wood (>2.5cm or 1" diameter) would be removed from the site, including over 51% of all coarse wood >10cm or 4". [74]

Harvest residue left at a cut block site is often seen as a steward ship concern as it may affect wildlife and reforestation. A study by Zielke and Bancroft (2007) [75] concludes that this is not the case, except for some localized impacts on coastal heli-log sites and some sites where large scale beetle wood salvage took place and large quantities of road side waste was left behind. Generally, impacts on non-timber resource values or fire risk were not apparent from the study. However the study found that there was a higher concern with lack of woody debris on some interior pine sites mechanically harvested with a high degree of wood y materials skidded to roadside and piled with exhibiting soil disturbance and compaction.

The need for CDW to be left in a post harvest cut-block is described in guidelines. The Biodiversity Guidebook [76] suggests that a general level of 50% of natural levels should remain after harvesting with sufficient large pieces represented to remain for the long term. As well the Short tem Strategy for Coarse Woody Debris Management in British Columbia Forests (2000)[77] states that large pieces are more important than smaller pieces, that large pieces of CWD must be preserved, and that (small scale) salvage programs must be related to biodiversity enhancing programs. Large pieces of wood are important for the biodiversity and wild life values in new stand replanted after harvest. Although some of the CWD could be utilized as value added products, it must be kept in mind that the larger pieces left after logging have a high value for biodiversity. These large pieces are also prime supply for any value added timber use. With roadside chipping of waste wood, it is expected that at least 60% of the large dimension waste will be removed from the site. This will be counter the biodiversity guidelines. Therefore it cannot be expected that cut block and roadside waste will play a large role in the use of fibre for non-lumber uses such as energy generation.

5.5 Wood processing within and near the Dawson Creek Timber Supply Area.

Several saw mills and wood processing industries are found near Dawson Creek. Mills are located in Chetwynd, Mackenzie, Dawson Creek and Fort St Johns/Taylor. As well, pulp mills are located in Chetwynd, Taylor and Mackenzie.

5.5.1 Wood processing facilities in and near Dawson Creek

Several facilities are located near Dawson Creek that process logs into pulp or lumber. These facilities are listed by town and include:

Chetwynd

Tembec Pulp BCTMP mill processing hardwood: capacity 160,000 mtpy of pulp.
Chetwynd Forest Industries/West Fraser, processing, 170,000 Mfbm production or ~750,000m3 of wood processed annually

[74] Hess, G. and D Zimmerman, 2000. The Effect of satellite Chip mills on Post-Harvest Woody Debris. http://scsf.env.duke.edu/files/chip6II.pdf

[75] Zielke,K. and B. Bancroft, 2007. Harvest Residue and Forest Stewardship: an examination of four BC Forest Districts. http://www.for.gov.bc.ca/HFP/publications/00184/Harvest%20Residue%20Monitoring%20Report%20Final.pdf

[76] http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/biodiv/biotoc.htm

[77] http://www.for.gov.bc.ca/hre/deadwood/DTgui3htm

Canfor Chetwynd Operation (closed), 240,000 Mfbm production or ~1 million m3 of wood processed annually; all by-products went to Prince George

Mackenzie
Atibity Mackenzie groundwood pulp and news print (stopped production in 2007)
Atibiti Mackenzie (two saw mills), producing 336,000 Mfbm or 1,470,000m3 of wood processed annually, all by-products to the pulpmill. Closed as of end of 2007.
Pope and Talbot pulp and paper
YG Forest Products
Canfor Mackenzie (closed) 502,000 Mfbm produced, 2.2 million m3 of wood processed.

Bear Lake
Canfor Polar stud mill in Bear Lake produced 263,000 Mfbm of studs and dimensional lumber. The mill was under the June/July 2007 closure to reduce inventory. The mill appears to be operating in February 2008.

Dawson Creek
Louisiana Pacific OSB, processing 600,000m3 of deciduous timber, no waste.

Farmington
Yones and Linharber ~ 30,000 m3

Fort St Johns/Taylor
Canfor Pulp BCTMP mill (operating on deciduous wood with a production of 60,000 mtpy of pulp, and coniferous wood producing 160-190,000 mtpy of pulp).
Canfor Saw mill operations (2), production 300,000 Mfbm and processing ~ 1.3million m3 of wood annually, all by-products to the pulp mill.

Pulp facilities are users of logs, chips and other wood products as furnish for the pulping process. Hog fuel, bark and other fiber are used in power boilers to generate process heat and electricity. Pulp and paper mills take large quantities of such materials from the saw milling section. Biosolids and some ash are the only bioproducts that are discharged from a pulp and paper mill complex. A pulp and paper mill complex is a net importer of wood chips, hog fuel and other wood waste. Pulp mills requiring coniferous wood will not generate usable fibre for bio-energy recovery. All such fibre is used in-house for heat and power generation.

Sawmills and pulp/paper mills, and also veneer plants, use raw logs. The Canfor Taylor pulp mill and the Tembec Chetwynd mill are both processing hardwood such as aspen into hardwood pulp for export. It is assumed that the deciduous trees harvested in the Dawson Creek area, primarily supply the veneer mill in the City of Dawson Creek and the two pulp mills in the area. Generally, such mills de-bark the trees received and then pulp the trees. Bark and wood waste is primarily used as boiler fuel. The veneer mill, and the pulp mills thus do not generate wood waste for other uses. Very little, if any, wood waste can be expected to be generated by the hardwood processing facilities.

The saw mills in the region generally use pine and spruce in their process. Of the volume of wood harvested and shipped to the lumber mills, 47 to 49% is transformed into lumber (COFI, 2007; PWC, 2007[78]). Of the remainder, chips would include 37 – 38%, and sawdust and shavings would be 13-16%. The reports cited do not include hog fuel (bark and waste wood), and likely include waste for value added products such as finger jointed lumber and composite beams, under the “chips” category, as the mills would have a choice of chipping the waste or supplying the value added processors. Sawdust is generally available for further uses.

With full production it can be assumed that in the Dawson Creek area, most if not all of the sawdust is available for other uses, as well some of the chips fraction could be diverted to energy use. However, several mills have discontinued production for the time being. This means that the amount of waste fibre available of other uses is restricted.

The AAC volume must be discounted for waste left on-site. Recent studies showed that, on average, 145m3/ha of logging waste was left on-site. With an average merchantable volume of wood for white spruce at an average site in the SBS (Sub Boreal Spruce) zone of 693m3/ha (TIPSY[79] evaluation for white spruce, naturally regenerated, 140 year old stand with an Site Index of 19.60), the harvestable lumber volume would be around 550m3 per hectare. This means that the AAC should be discounted by 21%.

Table 15 below, provides the volume of wood debris that is potentially available for the generation of energy, should all sawmills be in production. The Table shows that 239,000 m3 of sawdust (~86,000 BDT) is potentially available from sawdust and shavings from coniferous lumber harvested in the South Peace Regional District.

The volume of material available would be suitable to operate one commercial size pellet mill for exporting pellets to Europe or for domestic use. Should a pellet mill be envisioned, it must be noted that the total sawdust and shavings supply will be divided between three centres: Fort St John, Chetwynd and Mackenzie. In order to set up one pellet mill, the actual supplies should be identified in each of these centres, as sawmills would receive logs from other TSAs and TFLs as well. Most likely there would be sufficient volume for two pellet mills based on the processing volume of all mills. It also must be kept in mind that, at the end of 2007, Canfor closed mills in the region, in Chetwynd and in Mackenzie. As well, AtibitiBowater closed two sawmills and their newsprint mill in Mackenzie.[80] The chips from the Chetwynd Canfor mill were transported to Prince George for inclusion in the pulping process there. Actual volume based on operating sawmills and current beneficial reuse of sawdust should be established before a pellet mill is constructed.

[78] Price Waterhouse Coopers, 2007. Report on the Economic Impact of the BC Pulp & Paper Industry. BC Pulp and Paper Industry Taskforce. http://www.pulpandpaperbc.ca./publications.html

[79] TIPSY - Table Interpolation Program for Stand Yields. BC Ministry of Forests. Version 4.1. http://www.for.gov.bc.ca/hre/gymodels/tipsy/model.htm

[80] Prince George Citizen December 6, 2007. http://www.princegeorgecitizen.com/index.php?option=com_content&task=view&id=107150&Itemid=557

Table 15: Available fibre for bio-energy based on full utilization of AAC by sawmills.

Waste Type	M3	Available for Bio-energy	Remarks
Coniferous AAC	1.44million		Gross volume
Discounted AAC	1.14million		Volume without roadside waste
Roadside Waste	300,000	0 – 15%	Most Roadside waste required for biodiversity.
Lumber (47%)	535,000	0%	Utilization as lumber, only; could be diverted if price is right
Chips (32%)	398,000	0%	Sawmill waste processed as chips and exported to pulp mills
Sawdust(16%)	182,000	100%	Sawmill waste as sawdust
Other waste (5%)	57,000	100%	Estimated bark and other fibre
Available for energy	**239,000 – 284,000**		**Bark, sawdust and shavings, roadside waste**

5.6 Cost of fibre supply

The cost of the fibre supply is a critical factor in the equation for a bio-mass to energy facility. Historically, fibre for bio-mass to energy was a free resource produced when logs were transformed into market lumber. The market lumber absorbed all the costs for harvesting and transporting logs to the sawmill, road building, replanting and silviculture. Costs also included stumpage fees.

Costs also vary widely. This can be expected as all sites are different and different costs must be assigned to accessibility, remoteness, road building, logging practices including related to slope and aspect etc. transportation, and distance to end-user. As well, other uses of the site and the lumber may affect the costs of the fibre supply destined for bio-energy generation.

Logs

While mountain pine beetle affected trees may be available for fuel, costs incurred for road building, felling trees, transporting trees to a central location, and chipping of the harvested wood will add to the costs of the resource. Direct use for energy may be economical depending on the price for green electricity, any additional processing such as drying and pelletizing may make direct harvest for energy production, uneconomical. In the case of sawmill residue, the costs of harvesting and transportation are absorbed by the cost of the product (cut lumber).

Other variables are affecting the surplus wood left in the forest. For instance, saw logs are topped at 5 inch diameter with the top left in the forest. To increase the productivity of a saw mill, the trend is to top at 6 inch diameter, which leaves further fibre behind. Under the current practices this means that no stumpage will be paid for the tops left behind.

The cost of the lumber was calculated by Routhledge (2006)[81] based on a large scale survey of the BC industry. Costs of logs or chipped fibre brought to the mill was approximately $129/ oven dry tonne (ODT), assuming white spruce has a density of 360kg/m3. [82] Costs included:

- Development $4/m3
- Logging and Loading $15/m3
- Admin & Silviculture $10/m3
- Processing (chipping)
- Whole log facility "in town" $10/m3
- Bush chipping $5/m3
- Transportation $1.80/m3/hour, If assume 60km/hr ave speed $0.03/m3/km; 4 hour trip.
- Crown charges ($0.25/m3)

Other sources provided somewhat different costs.[83] Costs for sawlogs is around $38.00 per m3, while pulp logs are $28 – 30/m3, the equivalent of respectively $105 and $78 – $83 per BDT, assuming a dry bulk density for white spruce of 390kg/m3. Pulp logs could be as low as $64/BDT on sites where roads are present; chipping is extra.

Biocap, 2005[84] quotes delivered cost of harvested and chipped pine beetle killed wood at a range from $19 to 41 per m3, with their estimated value of $27/m3. This is the equivalent of $48 – 105/BDT with their value of $69/BDT. The highest value of $41/m3 was obtained from BC Ministry of Forest and was based on field data collection.

Roadside Accumulations

The costs of using roadside accumulations as a source of energy was discussed by Sauder, 2006[85].

[81] Routhledge, D.A., 2006. British Columbia mountain pine beetle epidemic: the wood residue potential. Presentation to the Bio-energy conference Prince George. http://www.bio-energyconference.org/docs/speakers/2006/Routledge_BioEn06.pdf

[82] White Spruce – fact sheet. http://www.saskforestcentre.ca/uploaded/White_Spruce_tech_sheet.pdf

[83] Marvin Adrian, 2008 Woodland Equipment Inc. personal communication.

[84] Biocap, 2005. Kumar et al. British Columbia's Beetle Invested Pine: biomass feedstock for producing power. Final Report April 30, 2005. www.biocap.ca/images/pdfs/2005-04-30_Final_Report.pdf

[85] Sauder, T., 2006. Forest Feedstock for a bioeconomy- and overview. Presentation Faculty of Forestry UBC, May 2007. http://www.biomass.ubc.ca/docs/FI_Sauder_07.pdf

Costs include:

Piling of accumulations	$2.76/BDT
Grinding in field	$12.35/BDT
Transport	$29.59/BDT
Road maintenance	$9.00/ BDT

Total costs per BDT was estimated at $53.70.

Several companies have experimented with on-site chipping of road side waste. It has been suggested by industry sources[59] that costs were "all over the map" and were very dependent on local conditions and hauling distances. Total costs per BDT may be significantly higher than the quoted value.

Hog Fuel

Hog fuel is the ground bark and waste wood from a logging and primary processing operation including saw mills, pulp mills, log sorting operations etc. Large industrial power boilers connected to pulp and paper facilities burn large quantities of hog fuel. This fuel source is often hauled in over long distances. Hog fuel is typically free of charge at the mill, its value is based on the trucking costs.

In the interior (2008) pulp mills receive hog fuel for power boilers for between $45 – 52 per BDT. Beyond this price range natural gas is a competitive fuel.

Wood Pellets

Wood pellets are being manufactured in the Interior of BC from mill-derived wood waste consisting primarily of sawdust and shavings. Wood pellets are consistent in quality and do not vary much between production facility. However, differences have been seen in quality and ash content between bark pellets (brown pellets) and white wood pellets and between pellets from different species. For example pellets made from pine sawdust appears to have higher ash content. Wood pellets are delivered in the Lower Mainland for between 120 and 140/tonne, with a target energy price equivalent of $7.50/GJ. The mill gate price (2006) was $100/tonne, and may be higher in 2008. Currently (2008) wood pellets are in short supply in Western Canada. The majority of pellets are shipped to Western Europe to satisfy the bio-energy market. Due to carbon credits and higher energy prices in Europe, pellets are a competitive fuel even with transport from western Canada via the Panama Canal is calculated in.

Wood pellets are produced by 12 companies, all located in the Interior of BC. Their total production in 2004 was between 360,000 to 400,000 tonnes of pellets, of which 300,000 to 350,000 tonnes are exported to Europe,[86, 87] including to industrial users such as Alcan in the UK. PWC (2007)[88] stated that the BC pellet production capacity is approximately 600,000 tonnes per year, spread over 12 plants. The current volume is just under 1 million tonnes, with export to Europe of some 800,000 tonnes. The wood pellet industry expects to reach 1.5million tonnes of production in the next year or two. The market for pellets in Germany, Sweden, Italy and France are growing rapidly, which will increase the pressure on the BC pellet production and the domestic

[86] John Swaan, personal communication
[87] Brian McCloy, BC Ethanol, personal communication.
[88] Price Waterhouse Coopers, 2007. Report on the Economic Impact of the BC Pulp & Paper Industry. BC Pulp and Paper Industry Taskforce. http://www.pulpandpaperbc.ca./publications.html

supply. Pellet prices in Europe are around €150 for power plants and €190 for domestic use. It is expected that these prices will be increasing in the near future.

Wood pellets are not yet manufactured from wood specifically harvested for the purpose. An extra tonnage charge of $20 to $30 would be required to make the practice cost effective.

6.0 COMBUSTION SYSTEMS

This section will describe some of the options for heating systems that may be suitable for supplying the heating needs of municipal facilities in Dawson Creek. In addition to natural gas combustion systems, several other types of combustion systems can be used for generating heat. These include systems for combusting mass wood waste (hog fuel), straw, systems for wood pellets and coal, and gasification and pyrolysis equipment.

6.1 Hog Fuel and Biomass Systems

Several hog fuel systems have been installed in the Lower Mainland for the heating of greenhouses. These include the installations (number of operations) by Vyncke[89], Binder[90], and others. The systems are generally large and are suitable for servicing heating needs of 300,000 GJ/year, or about 8 times the energy in natural gas used by the City of Dawson Creek. Smaller systems are available in North America and in Europe. For instance the Challenger line from Advanced Recycling Equipment from eastern Pennsylvania, ranges from a low of 10,000 GJ/year to those required by large greenhouses. This system has been tested with a range of biomass fuels including fescue grass, manure, switch grass, corn and straw.[91]

Combustion systems typically operate with low pressure water heating systems. The water temperature is often not higher than 65°C and the pressure of the boiler system is less than requiring a full time boiler engineer on staff. Facilities must be outfitted with emission control devices to maintain the emission of particles under the emission standards. Systems for the size required in Dawson Creek range from $350,000 to 500,000 including an electrostatic precipitator. Systems must be authorized with an air emission permit from the BC Ministry of Environment.

In conjunction with a local saw mill, the City of Revelstoke operates a biomass burner to provide heat for the mill's kiln and hot water for heating of municipal buildings. The facility generates 1.5 MW or 45,000 GJ/year. Wood waste is obtained at zero costs.[92]

Denmark is the leader in district heating and co-generation, and the use of biomass for energy and heat generation. Approximately 40% of the Danish district heating is bio-fuel powered.[93] Denmark operates a system including 60 straw based and 70 wood based district heating systems, most of which are CHP (combined heat and power). As well, Denmark citizens operate 500,000 wood stoves, 70,000 wood boilers, 30,000 pellet furnaces and 9,000 straw furnaces.[94],[95]

Mass combustion systems fired with baled straw, have been in operation in Denmark since 1998. One power plant, the Amager plant, burns pelleted straw at a rate of

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89 See: http://www.vyncke.com/
90 See: http://www.binder-gmbh.at/Englisch/Unternehmen1/unternehmen.html
91 See: http://www.advancedrecyclingequip.com/app2/dynarea/view_article/147.html
92 See: http://cdeamap.navlar.com/cases/revelstoke.pdf
93 See: http://www.dff.dk/In,_,English.aspx
94 See: http://ens.dk/sw14615.asp
95 See: http://biomass.ucdavis.edu/materials/reports%20and%20publications/2004/2004_Assessment_SMUD_ReGEN.pdf

130,000 tonnes annually.[96] It appears that the straw pellets are co-fired with fuel oil. The large mass combustion systems are designed for power generation, but heat is extracted for district heating as well.

An example of a small district heating plant powered on straw is the Sabro plant, owned by 49 farmers. The plant is fuelled by approximately 4,000 tonnes of straw annually, and produces 3.2 MW of energy for space heating.[97] Some co-firing with heating oil has been reported (1.6% of heat generation). This appears to be typical for straw-fired plants.

6.2 Wood Pellet Systems

Several wood pellet systems have been marketed for space heating, especially in green houses. These include systems by Crone/ATS[98], Decker[99], Blue Flame Stoker[100], and Binder, among others. Wood pellet systems are based on coal fired technology and can be used for either fuel, as coal (lower grade bituminous) and wood pellets are similar in calorific value. Smaller systems are available for domestic space heating. For larger facilities, a pellet burner is connected to a standard low pressure hot water boiler. Advanced Recycling Systems and others market biomass systems suitable for burning grass and straw briquettes.

Binder, a company from Austria, installed two 1.4 MW wood pellet burner boilers in the North Slave Correctional facility in Yellowknife NT. Over the first year of operations, the facility saved on heating oil and reduced the operating costs by nearly $58,000 over the cost of heating oil. [101]

Wood pellet burners are relatively clean in emissions. However, emission controls such as bag houses, cyclones or electrostatic precipitators are required to meet emission control regulations. Facilities would require an air emission permit from the BC Ministry of Environment.

6.3 Gasification and Pyrolysis Systems

Several systems are being commercialized using the gasification[102] and pyrolysis[103] types of technologies. Pyrolysis is the generation of oil and gases from carbon rich materials under high heat and low oxygen pressures. Pyrolysis technologies can be segregated into three main types: gasification, fast pyrolysis and carbonization.

- Gasification is a process which generates mostly gases and some ash and char. Gasification is commonly performed in fluidized bed reactors, horizontal

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[96] See: http://www.cogen3.net/presentations/asean/cogenweek2004phil/manila/Successstoriesofcogenerationprojects.pdf
[97] See: http://lib.kier.re.kr/caddet/retb/no88.pdf
[98] See: http://www.contenue.nl/en/crone/links/
[99] See: http://www.deckerbrand.com/
[100] See: http://www.blueflamestoker.com/home.html
[101] http://www.pws.gov.nt.ca/pdf/publications/Biomass.pdf
[102] Gasification is the breakdown of carbon-containing materials into syngas by thermal decomposition that takes place in the presence of a controlled amount of oxygen or air. The producer gas that is generated can be used either in boilers or cleaned up for use in combustion turbine/generators. By-product slag (ash) is inert.
[103] Pyrolysis is the thermal degradation of waste in the absence of air to produce charcoal , pyrolysis oil (bio-oil), and syngas (primarily methane, carbon monoxide and hydrogen). Pyrolysis and thermal gasification are related technologies. Pyrolysis technology is not as well developed as gasification.

reactors or upflow reactors to generate the highly flammable gases (>85%) and some ash (<10%) and some oils(<5%).. In Canada, gasification technology is beind developed using (clean) wood waste by Nexterra, OPT Organic Power Technologies Ltd. and by several small Canadian companies for large and small systems. Very few gasification systems are operating commercially in Canada. Nexterra is operating a demonstration facility in the Interior of BC, and many companies sell the designs for facilities. Plasco is testing a system for gasification of municipal solid waste near Ottawa, On. Non-Canadian companies include Recovered Energy (US) and Gussing (Austrian, producing electricity), and Biomass Technology Group (BTG, The Netherlands), among others.

- Fast pyrolysis is a process which produces mostly bio-oil, bio-gas and ash. Fast pyrolysis systems being tested (DynaMotive, Ensyn, Applied Bio-Refinery) mainly use the upflow fluidized bed reactor, or hot sand bed (Ensyn). Fast pyrolysis typically provides 75% oil, 12% char and 13% gas. Fast pyrolysis works at moderate temperatures and relatively short process times. Typically a dry carbon rich feedstock is required. The bio-oil can be used for transportation fuel (bio-diesel or bunker C equivalent) or for the recovery of industrial chemicals (bio-refinery concept). Pyrolysis technology has been demonstrated in Canada in semi commercial stage, but full commercial use has not been accomplished. Typically, systems are of a large size and may not be suitable for the municipal facilities in Dawson Creek.

- Carbonization systems produce primarily charcoal and some waste heat. The charcoal can be transformed into activated charcoal for the filtration industry.

6.4 Combined Heat and Power

Combined heat and power systems are typically installed in natural gas burning facilities. Natural gas is used in a turbine or reciprocal engine to generate electricity. The efficiency of the generation process is somewhere between 25 and 30%. When the waste heat is recovered from the generating process and is used for space heating, the total efficiency rises to 75 -85%. This system of CHP is also used for landfill gas and biogas feedstock.

CHP is possible with burning of biomass. In such systems, the biomass is used to generate steam which drives the electrical turbines. Alternatively, syngas can be generated from biomass using gasifiers.[104] Syn-gas is then used to power steam boilers or it can be used directly in turbines or reciprocal engines. The use of syn-gas in turbines and reciprocal engines is not well developed and challenges exist with tars and scaling of turbine blades.

While the Municipal facilities in Dawson Creek require heat, electricity could be generated using CHP. However, the CHP is primarily for generating electricity with

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[104] See: http://www.biomassenergycentre.org.uk/pls/portal/docs/PAGE/BEC_RESOURCES/PUBLICATIONS/SHEET%204%20CHP%20V3.0B.PDF

utilization of heat as a by-product. This would require a significant scale-up from covering the heating needs, and may not be of an appropriate scale for the City.

6.5 Other Sustainable Energy Forms

In discussions with the Project's steering committee, questions were raised regarding other energy efficient sustainable heating technologies. Two of such technologies include the various forms of geothermal heating and geo-storage of solar heat.

6.5.1 Geothermal

Interest in geothermal resources in BC for energy has increased since first investigations in the mid-1970's, subsequent drilling, reports on its potential,[105, 106] and interest in reducing greenhouse gas emissions.[107,108] By definition, a geothermal resource must have a temperature in excess of 80 degrees Celsius at the surface, in which case it is owned by the Province and approvals and authorizations are administered under the *Geothermal Resources Act* by the Ministry of Water, Land and Air Protection. If the water is below 80 degrees Celsius at the surface, there are still water licensing requirements to comply with. Geothermal may not be available in Dawson Creek.

Heat can be extracted from ground water or soil by low temperature systems, including ground water systems or bore hole or closed systems. In groundwater geothermal systems, groundwater is extracted from a well, passed through a heat exchanger or heat pump, and its heat energy is transferred to circulating fluid (air) on the building side. In borehole systems, vertical boreholes are drilled and fitted with sealed U-tubes, or horizontal pipes / tubes are laid in the shallow ground. Energy from the ground is transferred to a fluid that circulates through the tubes. For instance the new Sunset Community Centre in Vancouver is outfitted with a closed geothermal system for heating and cooling the centre.

6.5.2 Geo-storage Systems

Most energy storage systems are for small scale applications and the technology is relatively new in Canada. The Pacific Agricultural Research Centre (PARC) in Agassiz, BC has installed a larger Aquifer Thermal Energy Storage (ATES) system.

One energy saving system that has been developed in the Netherlands is the Closed Greenhouse (CG) or "Gesloten Kas".[109] This system has been demonstrated in the Netherlands and is now installed in at least five commercial greenhouse operations in The Netherlands. In this system, heat from the sun is collected in a small part of a greenhouse complex, is transferred from the greenhouse air into water by a heat exchanger and is then stored as warm water in the aquifer. When heating is required, the warm water is pumped back up from the aquifer, and is supplied as the main source of heat for the greenhouse. The warm water routed through a heat exchanger and warm air is pumped into the greenhouse. Proven energy savings of 20%,

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105 Nevin, Sadlier-Brown and Goodbrand Ltd. 1985. A preliminary evaluation of the low grade geothermal potential of the Fraser Valley Lowland, Southwestern British Columbia. Report to the Geological Survey of Canada.
106 See Ghomshei, MM and TL Sadlier Brown. 1996. Direct Use Energy from the Hotsprings and Subsurface Geothermal Resources of British Columbia. Richmond: BiTech Publishers Ltd.
107 See BC Hydro 2004 Integrated Electricity Plan. http://www.bchydro.com/rx_files/info/info8977.pdf
108 BC Ministry of Energy and Mines. 2002. Energy For Our Future: A Plan For BC.
109 Innogrow website: http://www.innogrow.nl/nl/1_00geslotenkas.html

production increases of 20%, and water savings of 30% are obtained when the facility is located in an area that is suitable for aquifer storage of heat.

6.6 Emissions from Biomass Facilities

The emissions from biomass facilities include air emissions and the discharge of ash. The quality of emissions will depend on the type of fuel used and the configuration of the burning facility. This section focuses on wood and grass straw as these are the fuels that may be applicable for Dawson Creek.

Auburn Universtiy completed emission tests for Advanced Recycling Equipment.[110] The test compared emissions from a mass burn of switch grass, Sericea (a legume) and Fescue, as well as wood.

Table 16: Burning test by Auburn University.

Parameter	**Units**	**Switch grass**	**Sericea**	**Fescue**	**Wood**
Moisture Content	%	10.8	15.2	8.7	30
Heat value	BTU/lbs	7,200	7,000	6,900	6,800
Ash *	%	3.7	2.7	8.7	0.5
CO	ppm flue	2.0	24	17	3
NOx	ppm flue	53	77	67	10
SOx	ppm flue	3.7	6.1	8.7	-

* Particles were not measured as the test facility was outfitted with a cyclone.

The test results show that the heating value of grasses is similar to that of bulk wood, but that the ash content is higher. This was also confirmed in tests by Cornell University.[111] This is to be expected as grasses contain a large amount of minerals. However, only switch grass showed fusion of the ash at a low temperature of 1850^{o}F and was considered not suitable as a source of boiler fuel. Fescue, Sericea and wood did not show ash fusion.

Wood contains less nitrogen than grasses. This is clear from the NOx measured in flue gases. As NOx is a potent greenhouse gas, compared to wood emissions, emissions from grasses may lower any amount of carbon credits when used as a fossil fuel replacement.

In general, non-pelleted wood waste will generate stack emissions that include primarily particles in the form of fly-ash. The estimated level of emissions will be around 150 mg/m3 when a facility is operated without air emission controls. Emission controls such as bag houses, wet scrubbers or electrostatic precipitators could bring particle emissions down to required levels. For a wood burning facility in BC, the emissions of particles should be brought down to below 50mg/m3 and preferably below 20 mg/m3 based on air emission permits recently approved by the BC Ministry of Environment. Wood waste and biomass facilities require Ministry of Environment authorization for air emission, unless they are operated for agricultural use only and

[110] http://www.becllcusa.com/pdf/AuburnCombustionSystemTesting_Introduction.pdf
[111] See: http://www.grassbioenergy.org/res/pellet_stove_demo.asp

generate less than 180mg/m3 of particles (Agricultural Waste Control Regulation) or are authorized otherwise through Metro Vancouver in the Lower Mainland.

Emission standards are trending downwards. Metro Vancouver is developing a bylaw for the air quality in the Lower Fraser Valley. [112] The proposed limits for biomass burners and natural gas heaters are as follows:

Table 17: Metro Vancouver proposed air emission standards for urban environments

Parameter	**Allowed Concentration (mg/m3)**
NOx	120
PM10	15
CO	400
Opacity	5

Depending on the source and species of wood, various volumes of ash will be generated. For pine, the ash content can be up to 2%, consisting of precipitator or fly ash and bottom ash. Pelleted wood will generate between 0.5 and 2% ash, depending on the species and pellet quality (bark pellets and pine derived pellets generate more ash). Ash from other biomass can be up to 8%. Wood ash has a high pH, and contains metal oxides, primarily calcium and magnesium oxide. Depending on the combustion characteristics of the facility, the wood ash may contain unburned carbon and is black in colour. Although quality wood ash can be used as a fertilizer, it is typically discharged to landfill.

6.7 Pelleting

Both wood waste and agricultural biomass can be pelleted into small size (3/8") pellets. Both fuels can also be briquetted. Typically, wood waste is required to be ground and dried to around 10% moisture. The pelleting or briquetting process liquefies the wood's lignin to cement the pellet. This process requires high pressure.

Pelleting or briquetting grass or straw biomass requires less pressure. As well, material is received as hay or straw and is air dry. Hay and straw requires some shredding before pelleting, but no drying.

Costs for pelleting of both wood and grass and straw biomass have been reviewed.[113] Reported costs for wood waste pellets are $12/tonne for drying and $59/tonne for pelleting, for a total of $71/tonne. The costs for grass pellets (switchgrass in this case) were $0/tonne for drying and $25 – 40/tonne for pelleting for a total of $25-40/tonne.

[112] http://www.gvrd.bc.ca/air/pdfs/Prop_Amend_AQ_Bylaw%20.pdf
[113] Roger Samson, Opportunities for Growing, Utilization & Marketing Bio-Fuel Pellets. Presentation Reap-Canada. www.reap-canada.com/online_library/Reports%20and%20Newsletters/Bioenergy/1%20**Opportunities**.ppt

7.0 ASSESSMENT

This section assesses the supply and availability of fibre from agriculture and forestry to meet the needs of Dawson Creek.

7.1 Requirements for Dawson Creek

The energy needs to be supplied by possible bio-fuel based energy are indicated in Table 18. Data was obtained from the Pembina Report prepared for the City of Dawson Creek in 2005.[114] Multiplex data were obtained from the Multiplex Energy Audit Study, 2007.[115] Heating requirements for the school and the Provincial building were estimated. The total natural gas consumption is the equivalent of 11,000 MWh/year or 39,000 GJ.

Table 18: Current energy use in Dawson Creek municipal facilities

Municipal Facility	**Electricity (MWh/year)**	**Natural Gas (MWh/year)**
Multiplex (highest estimates)	4,600	5,900
Exhibition ground	138	171
Airport	572	962
Centennial Pool	To be closed	
Kin Arena	394	587
Memorial Arena	1,028	1,229
Curling Rink	92	-
City Hall	476	36 (combined with Fire Hall)
RCMP (total)	571.1	433
Fire Hall	159	436 (combined with City Hall
Other Facility		
Provincial Building (estimated)	714	650
Central Middle School @ 10th @ 107 Ave (estimated)	800	600
Total	**9,544**	**11,004**

[114] http://www.planningforpeople.ca/what_we_are_doing/energy_plan/phase_1/documents/Energy_Baseline_Report.pdf

[115] Demand Side Energy Consultants Inc., 2007. Review Report: South Peace Community Multiplex City Of Dawson Creek. Consultants report to the City of Dawson Creek. 14pp; Appendices.

Based on the layout of the facilities, clustering of energy needs is possible. Three clusters can be identified

1) **Multiplex** (with exhibition grounds)
2) **Civic Cluster**: City Hall, RCMP, Fire Hall and Provincial Building
3) **Recreation Cluster**: Memorial Arena, Kin Arena, Curling Rink and Central Middle School

Current energy use in these clusters can be replaced by biomass facilities as shown in Table 19.: The total energy need for the three clusters is 9,860 MWh or 35,300 GJ per year.

Table 19: Requirements for natural gas for municipal facilities in three Dawson Creek clusters

Cluster	**Natural Gas (MWh/year)**
Multiplex	5,900
Civic Cluster	1,560
Recreation Cluster	2400
Total	**9,860**

Combined heat and power from biomass requires a larger facility outfitted with a pressure steam system and turbines. Not only would such a facility be 2 times the size as a regular biomass heating system due to the reduced heating efficiency, it also requires by law a full time pressure vessel engineer on site at all times. Regular heating systems can operate on low pressure systems and do not need supervision from a licensed engineer. Biomass based CHP is likely not suitable for the Municipal Facilities in Dawson Creek.

7.2 Total Fibre Feedstock Available in the South Peace

The following table provides an overview of the fibre sources available in the South Peace . Animal wastes are generally higher moisture and more suited to digestion that in turn, creates methane that can be combusted to produce heat and electricity.

Table 20: Available fibre feedstock in the South Peace

Type of material	Estimated volume (tonnes annually, as is)	Estimated dry weight (BDT)	Comments
Straw	~60,000	~60,000	Straw and hay are valuable commodities, or used as soil conditioner on-site
Straw from seed grass production	4,400	4,400	Seed grass straw not currently utilized. Available dried and baled.
Sawdust/shavings	98,000	82,000	This option requires mills that operate. Green wood.
Roadside waste, logging	<24,300	<16,200	This option requires mills that operate; Short term in pine beetle wood harvest area. Needed to be left in the forest for biodiversity; green wood, or partly dry
Standing trees (based on AAC)	615,600	410,000	Needs to bid on a supply contract, green wood. Road building, harvesting, transportation, chipping, replanting costs must be incurred.
Road Maintenance grass (as hay)	1,200 – 2,400	1,200 – 2,400	Needs handling, baling and transportation; dry product
Road maintenance, wood (as green chips)	4800	3,000	Needs collection system for collected chips, green wood.
RoW & Exploration (as green chips)	20,000	13,440	Needs collection, chipping and transportation; long distances on poor roads, green product.
MSW wood waste (as dry wood)	1,100	1,100	Available and attracts tip fee to cover chipping and transport. Dry product

7.3 Energy Value and Costs of Residue

This section will describe the energy values and costs per GJ for various bio-fuels available in the South Peace. The comparison is useful for the selection of one or several potential fuel sources for the Municipal Facilities in Dawson Creek.

The use of biomass for energy depends on the heating value and the energy density. Heating value is primarily determined by the moisture content and the energy density is the physical density of the material. The energy values of various feedstock is presented in Table 19. Note that the conversion of this feedstock into energy is likely to occur at about 75% efficiency.

Table 21: Energy content and estimated cost per GJ of various fibre resources

Product	GJ/per tonne used as biofuel	Estimated Cost ($/tonne used as biofuel)	Estimated $/GJ
MSW wood waste (dry)	18	free	free
Grass Straw baled	15	$25	$1.67
Sawdust	14	$28 - 32	2.00 - 2.28
Road side wood waste	14	$36	$2.57
Hog fuel	14	$36	$2.57
MSW wood waste (dry, pelleted)***	18.5	$65	$3.50
Grass Straw pellets **	15	$60	$4.00
Grass from Road Maintenance	14	$60	$4.30
Road Maintenance (chips) #	12	$60	$5.00
Grass from Road Maintenance, (pelleted) **	15	$95	$6.30
Pellets from harvested fibre*	18.5	>$135	$7.29
Road side maintenance (pellets)*	17	$135	$7.94
Pellets from wood waste *	18.5 (effective)	$100 - 140	$5.40 – 7.56
Oil and Gas RoW (chips)	12	$106	$8.90
Oil and Gas RoW (Pellets)*	17	$181	$10.65
Straw baled	14	$100 - 160	$7.14 – 11.40

* = Assume pelleting and drying cost is $75/tonne; no process loss
** = Assume pelleting cost is $35/tonne; no process loss
*** = Assume pelleting cost only is $65/tonne; no process loss.
# = Assume moisture content of fresh chips is 50%.

The information provided in Table 21 suggests that the most cost effective fuels for heating municipal facilities are:

1) Chipped wood waste from the MSW collection system
2) Baled grass straw

3) Bulk hog fuel and sawdust; other wood waste (generally green, larger volumes required)
4) Pelleted MSW wood waste (if pelleting machine available)
5) Briquetted grass straw (to be pelleted in-house)

7.4 The Opportunity

Bioresources feedstock to replace the use of natural gas in Dawson Creek's municipal facilities is plentiful in the South Peace. As well, there is opportunity to generate electricity and to produce wood pellets for economic gain.

7.7.1 Fuel Replacement in Municipal Facilities

For the replacement of natural gas in Dawson Creek's municipal facilities, sufficient material is available from agriculture, municipal waste and forestry. MSW wood waste which is received with a tip fee that can cover storage, chipping and transportation is available at about 1,100 tonnes per year. Seed grass straw, while having less caloric value than wood waste, is available at low cost at about 4,400 tonnes per year. As the requirements for all of Dawson Creek's municipal facilities is around 2500 tonnes of fuel – depending on the caloric value – a combination of municipal wood waste and seed grass straw would cover all of the heating needs. Alternatively, roadside mowings could be baled and used as a source of energy, however this resource is somewhat more expensive than fescue straw.

MSW wood waste and seed grass straw could be burned chipped or shredded as both are in a dry state with assumed moisture content of around 15%.

Two of the municipal heating clusters are located down town Dawson Creek. These facilities would not have space for a large storage facility which would be required for bulk straw firing. Therefore the straw should be pelleted, briquetted or cubed for easy storage and feeding. Pelleting of grass straw is a low cost operation, but as the grass straw is generated once a year in the summer, the pelleting facility should be able to store the entire harvest.

Switching municipal facilities from natural gas to biofuels would have several main benefits:

1) lower fuel costs
2) utilize wasted materials, and
3) decrease the carbon foot print.

By adopting low cost seed grass straw as a fuel or to use the MSW wood waste, the City would save an estimated $5 to $7 for each GJ of energy replaced as related to a future natural gas price of $9/GJ delivered. For the three facilities the fuel cost savings would account to savings of $177,000 to $247,000 annually for the annual requirement of 35,300 GJ of energy.

The carbon foot print would be lowered by replacing natural gas with an equivalent energy amount from bio-fuels, which are carbon neutral. The carbon replacement would be around 1,250 tonnes of C with a tCO2e (tonnes of carbon dioxide equivalent) of 4,575 tonnes per annum. If the MSW wood waste is diverted from landfill, this tCO2 equivalent will be larger as no methane will be generated from 1100 tonnes of wood.

This would be an equivalent of 25,000 tCO2e over the 25 or so years that the wood would take to decompose in a landfill. Over 25 years the total tCO2e generation would be 144,000 tCO2e with a current monetary value of about $700,000 at voluntary compliance prices of $5/tCO2e. While direct replacement is well established, no mechanism has been approved in Canada for the avoidance of wood waste going to a landfill. Until the landfill avoidance protocol is established, the monetary value of the reduction of the carbon foot print would be $575,000.

7.5.2 Production of Energy

Opportunity exists for the generation of energy from bioresource feedstock. The forest industry in the South Peace is supplying sawmills with logs. The sawmill operations produce sawdust, shavings and hog fuel. Potentially enough wood waste would be produced from the sawmill operations for energy generation. However, wood waste is in high demand, and pulp mill operations locally and in Prince George may be supplied with the generated wood waste for boiler operations. As well, the current state of the forest industry, and the expectation that improvements in the markets may not bring the lumber production to the same volume as before, merits a careful approach of energy generation as large financial risks are involved. Energy generation can only be undertaken under two conditions:

1) the fibre supply is secured in advance, and
2) a process is selected that can sustain the supply of wood fibre that is specifically harvested for the purpose of energy production.

The first condition requires that arrangements are made with current harvesting and sawmill operations to secure sawdust, shavings, cut-offs, bark and roadside waste. In the long term, a license may be obtained to harvest timber especially for the purpose of energy production.

The second condition requires that the electricity prices paid to an independent power producer are high enough to include harvested lumber as feedstock. The indication is that the price paid by BC Hydro under future bio-energy calls may be sufficiently high to support a supply of wood waste of over 80/tonne. This means that only wood can be supplied where road building costs, replanting costs and silvicultural costs are absorbed by other wood uses. The energy production will thus directly compete with the supply of pulp wood and possibly lumber production.

An energy production facility should be strategically located in an area with sufficient wood supply, a road system and transmission lines. If other marketable products could be generated from the facility, such as charcoal or bio-liquids, this would assist in the economic picture of the energy production.

7.5.3 Wood Pellet Production

Fuel pellet production can best be tied in with operating sawmills. This means that such pellet plants should be located in Fort St. John, Chetwynd or MacKenzie close to the source of sawdust and shavings. The timber supply of the South Peace could support one 80,000 tonnes per year pellet facility. However, fibre for local saw mills is not only obtained from the South Peace area but also from the surrounding areas. Thus, two or three pellet mills could be supported in the area.

While theoretically enough sawdust and shavings are available to operate two or three 80,000 tonnes per year pellet operations, successful pellet mills will entirely depend on the health of the sawmilling sector. Costs for road building, harvesting, chipping, transportation and replanting may still be too high to sustain an economically viable pellet production based on virgin wood rather than on wood residue. With the current complete shutdown of the forestry industry in MacKenzie and partial shutdown in both Chetwynd and Fort St John, production of pellets from saw mill waste may not be feasible in the short term due to lack of sawdust and shavings.

8.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions follow from the preceding research and analysis:

Agricultural residue
Agricultural waste is available for beneficial reuse. While various sources are generated, the source with apparently the least use is the hay/straw from the seed grass production. About 4,400 tonnes are available annually at relatively low cost.

MSW wood residue
Dry wood waste received at the municipal landfill could be a good resource of bio-fuel. As a tip fee covers chipping and transportation, this material would be virtually free. About 1,100 tonnes is available annually.

Corridor Grass Residue
Public highways are maintained through mowing and brushing. Should the mowed grass be hayed and baled, a resource of up to 2400 tonnes could be available. Costs for this resource include gathering, baling, stacking and transportation.

Forest Industry residue
Wood fibre from the forest industry is available in the region. Two types can be distinguished – wood waste directly generated from milling operations such as sawdust, shavings, bark and cut-offs. The estimated amount based on a fully operational sawmilling industry is 98,000 wet tonnes annually. Actual amount may be substantially less as the sawmilling industry is going through a down turn and many mills have closed in the region. Additional wood fibre can be obtained from road side waste, the broken logs left behind at the harvesting site in piles. While some of this material could be harvested for beneficial re-use, the majority of this coarse woody debris should be spread on the landing to serve biodiversity needs of a newly planted forest rather than removed from the site or burned. Some 25,000 tonnes is estimated to be available annually. Actual volumes will be based on the site's management, the future demand for lumber and the progress of removal of pine beetle damaged wood.

Wood fibre can be obtained from road maintenance and oil and gas exploration land clearing as well. Road maintenance could be a continuous source of wood fibre. Brushed wood waste is currently chipped and then left in the forest. Such fibre would be priced based on transportation needs, as the cutting, handling and chipping are covered by the road maintenance contract. With the set-up of a collection system this could be recovered. The recovered wood would be green and would need drying and pelletizing, requiring extra resources. Approximately 4800 tonnes would be available annually. Wood fibre from oil and gas exploration will be more expensive than fibre from road maintenance as currently chipping and hauling is not included and work sites are mostly far removed from existing transportation corridors, making transportation expensive.

The current and future slowdown of the forest industry may free-up timber allocated to saw mills and pulp mills. Fibre within the annual allowable cut may become available for other uses such as energy. However, harvesting and transportation costs for this timber will equal those for saw logs, as all costs must be allocated to this alternative use.

Fuel Alternatives for the Municipal Facilities
Sufficient fibre is available in the area to fuel the municipal facilities in Dawson Creek. The total requirement for the facilities reviewed is 35,300 GJ annually the equivalent of some 2,500 tonnes of either wood fibre or grass straw.

Burner and boiler systems are commercially available for bio-fuels. By using clusters of buildings heated with one boiler system, economies of scale could be reached. Three clusters are envisioned; Civic buildings – City Hall, RCMP, Fire hall and the Provincial Building; Recreational buildings – Memorial Arena, Kin Arena, Curling Rink and the Central Middle School; and the Multiplex. As two of the three clusters are located in the centre of Dawson Creek it is advisable to select (wood) pellets for these facilities as pellets burn cleaner, and only emit small amounts of NOx. Particle emissions could be reduced further with help of electric precipitators. The Multiplex boiler could be powered by straw bales or by fibre pellets. Any boiler equipment should also be able to burn chipped dry wood.

Enough fibre is available from grass straw to operate a small pellet mill to provide the municipal facilities with grass fibre pellets. A central storage and pelleting facility for grass straw could be built. This facility would then supply the three cluster units with pellets or briquettes using a Just-In-Time system, reducing storage requirements at each of the cluster units. Sawdust and shavings and chips from road maintenance are fresh and require drying. Pelletizing wood waste is not recommended as a capital intensive facility is required including a drying kiln.

The estimated annual costs in saving fuel would range from $177,000 to $250,000. An additional $575,000 could be secured over 25 years in carbon credits from natural gas replacement.

Economic Opportunity – Wood Pellets
With a fully operational sawmill industry, up to three 80,000 tonnes/year pellet mills could operate in the area. These pellet mills should be located at or near sawmills in Fort St. John, Chetwynd or MacKenzie. Pellets could be produced for export to Europe as part of the efforts of the Wood Pellet Association of Canada. This could be for-profit operations that provide additional employment to the region. At this time European pellet prices are not high enough to sustain pellet production from timber harvested for the purpose of pellet production due to costs for harvesting, chipping, transportation, replanting and silviculture. A viable pellet industry depends on a healthy sawmilling sector.

Economic Opportunity – Energy Production
In light of the down-turn in the forest industry and the current mill closures, only energy production based on fibre that is specifically harvested for the purpose, should be considered. Economic feasibility of bio-energy production will depend on the fibre supply costs and the price paid by BCHydro for bio-energy.

Recommendations
This report supports the following recommendations:

- At this time, it appears less risky to pursue a bio-fuel feedstock option based on agricultural residue rather than forestry residue.
- Central heating systems for three clusters appear feasible: The Civic cluster; the Recreational cluster and the Multiplex.
- A small pellet or briquetting mill in Dawson Creek should be considered to supply the municipal facilities with pellets made from grass-seed straw. A pellet mill could be sized larger than is required for the municipal facilities to anticipate future sales of pellets. The mill should contain sufficient storage for the entire annual bio-fuel needs.
- Longer term, opportunity exists for a wood pelleting plant to be located near operating sawmills in Chetwynd, Fort St John or MacKenzie to produce feedstock for the international market and provide employment opportunity in the area.

9.0 STANDARD LIMITATIONS

This report has been prepared by Timmenga & Associates Inc. of Vancouver, BC for the City of Dawson Creek, BC. Funding was provided by the South Peace Regional Development Commission. The work was performed to conform to a proposal accepted by the Client.

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