Strategic Financing for the Bio-Fuel Industry: A Northern British Columbia Perspective

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Project Submitted In Partial Fulfillment Of

The Requirements For The Degree Of

Master Of Business Administration

The University Of Northern British Columbia

April 2007

ABSTRACT

Despite the abundance of biomass feedstock in Northern British Columbia (BC) and the existence of a mature forest products industry, the bio-fuel industry is slow to develop. Several barriers, including the lack of awareness, lack of capital, lack of incentives, lack of guaranty for long-term availability of feedstock and technological limitation are impeding the development of this industry.

This study used both primary and secondary sources of information as well as exploratory research to evaluate:

1. The nature and amount of biomass feedstock available in BC and in Northern BC
2. The status of the technologies that are emerging in the market place for conversion of biomass into fuels and chemicals.
3. The incentives offered by the provincial and federal governments to assist and promote the development of a bio-fuel industry in Northern BC.
4. The options that can be used to finance these technologies in Northern BC.

While Northern BC has vast biomass resources and there are several biofuel technologies that can be demonstrated in the region, their capital intensity calls for risks sharing and for strategic financing options. Effective use of government incentive programs and strategic partnership can be leveraged for access to more capital and better financing terms. Development of smaller scale mobile units and/or integration of the technologies in local pulp and paper mills would seem the most cost effective approach for Northern BC.

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ACKNOWLEDGEMENT

I would like to express my gratitude and appreciation to Dr. Jing Chen and Dr. Ronald Thring for accepting readily to supervise this work and for their patience, guidance and support all along this project. I would also like to acknowledge the entire administration, particularly Dana Helgason, Dr. Bob Ellis, Charles Schell and Mike Ivanof, as well as all the professors of the MBA program for their dedication to the program and for their kindness, support and encouragement. They contributed greatly in making this MBA experience an enjoyable one. Thanks are also extended to Michael Kerr for his assistance with the government funding mechanisms and to Dr. Elisabeth Croft and Dr. Ian Hartley for accepting to be in my examining committee. Thanks and appreciations are also extended to everyone in our cohort. Their fellowship was enriching and well appreciated.

I would also like to acknowledge my employer FP Innovations - Paprican Division for giving me the flexibility to attend all MBA classes and for allowing me free access to several facilities and services to get this work completed successfully. A special note goes to Vic Uloth, Richard Berry, Tom Browne, and to Ann Peters as well as my co-workers for their encouragement and continued support.

Last but not least, I am greatly indebted to my wife Alima and children Ismaël, Aisha and Fatima for their love and support throughout this programme and to the Lord for giving me the will and means to fulfill this undertaking. I am also thankful for all those whose names are not cited here but who, in one way or another have been supportive during this work.

DEDICATION

This report is dedicated to my wife Alima and children Ismaël, Aisha and Fatima whose ongoing encouragement, love and fellowship are constant source of inspiration and renewal to me.

Ibrahim Karidio

Chapter 1
INTRODUCTION

Bio-fuel and bio-product are terms that refer to biomass-derived processed fuels and chemicals, generated through conversion of the chemicals found in biomass (which is any living organic matter such as wood, corn, wheat, most forestry and agricultural products, etc) into other forms, and generally serving as replacements for natural gas and petroleum derived products currently in the market place. There are abundant supplies of wood residues, in every part of Canada and particularly in Northern British Columbia (BC), which are presently unused but can potentially be used as feedstock for bio-fuel and bio-chemical production. The total annual surplus wood residues available in Canada for alternate use was estimated in 1999 to be around 7.4 million bone dry tonnes (BDT) with about 30% coming from British Columbia (McCloy, 2003). Even with the increased use of wood residues in co-generation projects, surplus availability for British Columbia was forecasted to reach 1.5 million BDT by 2005 (McCloy, 2003).

In Northern British Columbia, there has been a tremendous increase in surplus wood residues as a result of the mountain pine beetle infestation and a resulting increase in the Annual Allowable Cut and the concomitant lumber production in the Prince George and Cariboo Forest Regions (McCloy, 2003). Despite the abundance of biomass feedstock in Northern BC and the existence of a mature forest products industry, the bio-fuel and bio-chemical industry is slow to develop. Several barriers exist which are limiting the development of a diversified and sustainable bio-fuel and bio-chemical industry in Canada in general and in Northern BC in particular. These barriers include the lack of capital, technological limitation, lack of environmental, taxation, and financial incentives, and lack of guaranty for long-term availability of wood residues.

The objectives of this study were to determine:

(1) The financing options (including strategic partnerships) that are available to develop and implement biofuel technologies in Northern BC.

(2) The incentives in place at the local, provincial and federal levels to assist and promote the development of the emerging bio-fuel and bio-chemical industry in Northern BC.

(3) The status and limitations of the major biofuel technologies that are emerging in the market place for conversion of wood to fuels and chemicals, including pelletization, fermentation, gasification, pyrolysis and fractionation.

(4) How much biomass is available in BC in general and in Northern BC in particular.

1. 1 IMPORTANCE OF THIS STUDY

The importance of this study is several folds:

(1) To identify the major technologies available currently at the market place for biofuel production.

(2) To identify the major companies that are active in the development of the biofuel technology (Canada wide)

(3) To identify the major companies that are commercially active in the production of bio-fuel

(4) To determine the major barriers (information, institutional and policy, financial, technical, economics, etc) to the development of a diversified bio-fuel industry in Northern BC.

(5) To determine the (federal, provincial and municipal) regulatory policies and incentive programmes available with respect to bio-fuel production and industrialisation.

(6) To determine the financing options available for companies who are already involved in the production of bio-fuel and for those who may be interested in entering this market.

1.2 METHODOLOGY

In this study we have used mainly exploratory/primary research data and secondary data sources to gather the required information to respond with confidence to the research question.

The exploratory research consisted primarily of email, telephone calls, attendance to conferences and workshops, and direct contact with relevant people of the governments and industry to garner information and guidance about government policies and incentive programmes available in Canada and BC to promote the development of the bio-fuel industry.

The secondary source of information consisted of a thorough review of the literature concerning all aspects of the topic: biomass and biofuel energy and products, biofuel production technologies, government regulatory policies and incentive programmes, financing options, biofuel technology companies, biofuel manufacturing industries in Northern BC, major forest products companies and oil and gas producers in Northern BC.

The aforementioned sources of information were used to conduct a review of the major bio-fuel and biochemical production technologies that are emerging in the market place. The technologies reviewed included wood pellets manufacturing, fermentation, gasification, pyrolysis and fractionation. A brief description of the challenges that each of the technology would need to overcome to reach commercial maturity was provided. The companies that are active in each technology category were also identified.

The financing options available for the bio-fuel industry were then investigated. This included the traditional financing options such as banks, stock exchange, venture capital and other less traditional methods such as incentive credits (taxation, fiscal mechanisms, environmental credits, etc) and strategic partnership with other industries in Northern BC such as oil and gas, pulp and paper and utility providers.

Chapter 2

AN OVERVIEW OF BIOMASS AND BIO-ENERGY SOURCES IN CANADA AND IN NORTHERN BC

2.1 SOURCES OF BIOMASS AND THEIR AVAILABILITY

Biomass refers to all living organic matters that are available on a renewable basis. In Canada, there are several abundant sources of biomass materials which may be grouped in four main categories: Biomass from cellulosic materials such as wood residues and straw; biomass from agricultural crops such as corn, wheat and canola; biomass from animal wastes (mainly farm animal manures); and biomass from industrial and municipal wastes (sludges, etc).

2.1.1 Biomass from Cellulosic Materials

Biomass from cellulosic materials comes from wood residues (in the form of chips, sawmill residues, wood wastes or forest residues) or from agricultural wastes (straw, hay, etc). There are abundant supplies of wood residues, in every part of Canada and particularly in Northern British Columbia, which are presently unused but can potentially be used as feedstock for bio-fuel and bio-chemical production. The total annual surplus wood residues available in Canada for alternate use was estimated in 1999 to be around 7.4 million bone dry tonnes (BDT) with about 30% coming from British Columbia (McCloy, 2003). Even with the increased use of wood residues in co-generation projects, surplus availability for British Columbia was forecasted to reach 1.5 million BDT by 2005 (McCloy, 2003). In Northern British Columbia, there has been a tremendous increase in surplus wood residues as a result of the mountain pine beetle infestation and a resulting increase in the Annual Allowable Cut and the concomitant lumber production in the Prince George and Cariboo Forest Regions (McCloy, 2003).

Despite the abundance of biomass feedstock in Northern BC and the existence of a mature forest products industry, bio-fuel and bio-chemical industry is slow to develop. Recently only the wood densification industry which produces wood pellets for both the domestic and European markets has seen a re-emergence of interest and investment.

2.1.2 Biomass from Agricultural crops: Corn, Grains and Oilseeds

The agricultural crops most suitable for biofuel production are the oilseeds for bio-diesel, corn and the starchy cereal/grain crops for bio-ethanol. In British Columbia, barley, oats and wheat are the most common grain crops (BC MA&L, 2007). While oats and barley are used mainly as animal feed, wheat is used both for human consumption and livestock feed. British Columbia produced in 2002, about 126,000 tonnes of barley and about 35,000 tonnes of wheat. Smaller amounts of rye are also produced. The Peace River region grows 85 to 90% of the grain crops grown in BC (BC MA&L, 2007). Special varieties have been adapted for the soil and temperature conditions there. There is also some production in the North Okanagan Valley, around Vanderhoof, around Creston, and in the Lower Mainland (BC MA&L, 2007). Canola represents 98% of the oilseeds produced in BC. However, canola production had declined in 2002 by more than 60% from the 2001 level to about 16,000 tonnes. This production level is almost insignificant compared to the national production rate. Canola is grown in the Peace area in BC with an occasional field grown elsewhere in the province. It is a cool season crop adapted to areas where cool night temperatures allow it to recover from hot days and dry weather. In addition to grains and oilseeds, BC also produces 454,000 tonnes of fodder corn and 18,000 tonnes of sweet corn which is about 5% of the Canadian production. Three-quarters of the corn grown in BC is used by the processing industry. Corn is grown commercially in the Okanagan Valley, the Lower Mainland and Vancouver Island. Corn is a hot weather crop; it cannot be seeded until after all danger of spring frost has passed and it starts to deteriorate with fall frost. In addition to the actual crops, agricultural residues such as straw and stover are also valuable biomass feedstocks for biofuel production. Using the same methodology as BIOCAP (2003), it is estimated in this study and summarized in Table 2.1 that 99,000 metric tonnes of agricultural residues were available in 2001 in BC and the same level should be annually available in BC.

Table 2.1: Agricultural crop production in British Columbia

	Area[1]		Crop Yield[1]		Crop Production[1]		Total Straw/ Stover[2]		Sustainably removable residues (SRR)[2]		Recoverable SRR		Total Amount of Residues avalaible	
	(X1000 ha)		(kg/ha)		(X1000 tonnes)		(X1000 tonnes)		(X1000 tonnes)		(X1000 tonnes)[2]		(X1000 tonnes)[2]	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
Wheat	30.3	12.9	2,600	2,700	78.8	34.8	102.4	45.3	81.9	36.2	57.4	31.7	28.7	15.8
Oats	22.3	26.3	2,300	2,100	51.3	55.2	51.3	55.2	41.0	44.2	28.7	38.7	14.4	19.3
Barley	36.4	48.6	2,900	2,600	105.6	126.4	105.6	126.4	84.4	101.1	59.1	88.5	29.6	44.2
Rye	1.6	0.4	2,500	2,800	4.0	1.1	4.0	1.1	3.2	0.9	2.2	0.8	1.1	0.4
Canola	30.4	14.2	1,400	1,100	42.6	15.6	42.6	15.6	34.0	12.5	23.8	10.9	23.8	10.9
Mixed Grains	0.8	1.6	2,800	2,400	2.2	3.8	2.2	3.8	1.8	3.1	1.3	2.7	0.6	1.3
Tame Hay	344	398.6	3,600	3,600	1238.4	1435.0	1238.4	1435.0	990.7	1148.0	693.5	1004.5	34.7	50.2
Fodder Corn	8.9	10.1	56,100	44,900	499.3	453.5	499.3	453.5	399.4	362.8	199.7	226.7	10.0	11.3
Dry Peas	4	398.6 (1.9)	2,000	1,800	8.0	3.5	8	3.5	6.4	2.8	4.5	2.5	0.2	0.1
Sweet corn	1.35	NA	13,294		18.0		18	0	14.4	0.0	7.2	0.0	7.2	0
Corn for grain	1.08	NA	50,000		54.2		54.2	0	43.4	0.0	21.7	0.0	21.68	0
Total	392.1	424.9			1866.7	1912.5	1866.7	1912.5	1493.4	1530.0	953.9	1248.1	99.3	74.4

[1]Source: Statistics Canada, Agriculture Division and FAST STATS 2004
[2]Our own estimates using the same methodology as BIOCAP (2003).

2.1.3 Biomass from Animal wastes (Farm animals' manure, etc)

In 1996, Canadian livestock produced an estimated 361 million kilograms of manure daily (Statistics Canada, 2007) which is over 132 billion kilograms of manure for the year. Of this amount of livestock's manure, 52% was produced by beef cattle, followed by dairy cows (19%), hogs (16%), calves (7%), poultry (3%), horses (3%), and sheep produced less than 1% (Statistics Canada, 2007).

There were five major regional clusters in Canada where manure production was concentrated at the highest level of over 2000 kilograms of manure per hectare of land (Statistics Canada, 2006 and 2007). These regional clusters are located in Central and Southern Alberta, Southern Manitoba, Southern Ontario, Southeastern Quebec and Prince Edward Island. Beyond these regional clusters, there were two other individual sub sub drainage areas (environmental geography units which are drainage areas for smaller watersheds) in this highest category: one is located in the Lower Fraser River area in Southern British Columbia, and another one is near Wolfville and Kentville, Nova Scotia (Statistics Canada, 2007). In British Columbia, about 42% of the cow herds are in the Caribou and the Peace regions (BC Cattlemen Association, 2007) and this, in spite of the harsh winter conditions and the topography of the two northern regions. Manure in these regions is normally left to rot or used as soil fertilizer. Although manure is a valuable fertilizer for crop production, it can also become a source of pollution if not managed properly. Some crops can absorb adequate nutrients from manure and natural sources without additional commercial fertilizers. Therefore, it may be advantageous to collect this manure and transform it using anaerobic digestion into biogas which can be used in individual farms for domestic use (heating, cooking and hot water) or sold as a fuel and this would provide substantial supplemental revenues to rural farmers. Using the same methodology as BIOCAP (2003), it is estimated in this report, about 6 million metric tonnes per year of recoverable manure in BC (Table 2.2). This manure, if collected could generate about 115 million m^3 of methane per year with a net heat value of more than 4 million Giga Joules (Table 2.2). At a natural gas price of \$8 per Giga Joule, this land fill gas would generate revenue of \$32 million per year. However, this revenue stream does not take into account the cost of collecting the manure and capital and operating cost of the digesters.

Table 2.2: Manure production and biogas potential in British Columbia (estimated based on StatCan Census 2001 data)

	Manure production	Number of animals	Average mass /animal	Manure animal/day	Manure animal/year	Manure Daily total	Manure Yearly total	Recoverable manure	Recoverable manure/ year	Biogas production factors	Biogas potential		Methane content	Methane Production	Methane Net Heat Value
	kg/day/1000 kg of animal		kg	kg	kg	t	1000*t	%	1000 t	m^3/day/kg animal	m^3/day	m^3/year	%	m^3/year	GJ/year
Dairy cows	80.0	71401	600	48.00	17520	3427	1251	75	938	0.0022276	95433	34832930	54	18809782	673815
beef cows	59.1	279927	500	29.55	10786	8272	3019	75	2264	0.0012556	175734	64142851	54	34637140	1240792
bulls	59.1	17215	750	44.33	16179	763	279	65	181	0.0012556	16211	5917003	54	3195181	114460
Heifers	59.1	112032	400	23.64	8629	2648	967	65	628	0.0012556	56266	20536931	54	11089943	397271
Steers	59.1	46851	400	23.64	8629	1108	404	65	263	0.0012556	23530	8588401	54	4637737	166136
Calves	59.1	287523	150	8.87	3236	2549	930	65	605	0.0012556	54151	19765023	54	10673112	382339
Swine (pigs: Boars, Sows, etc)	63.1	165816	90	5.68	2073	942	344	76	261	0.0015998	23875	8714406	58	5054356	181060
Poultry (except turkey)	70.3	18000778	1	0.07	26	1265	462	93	429	0.0029162	52493	19160002	60	11496001	411817
Turkey	43.6	819569	10	0.44	159	357	130	78	102	0.0029162	23900	8723480	60	5234088	187499
Sheep (Rams, Ewes and Wethers)	40.3	39315	60	2.42	883	95	35	33	11	0.0020251	4777	1743618	50	871809	31230
Lambs	40.3	43992	20	0.81	294	35	13	33	4	0.0020251	1782	650348	50	325174	11649
Goats	65.6	18759	40	2.62	958	49	18	33	6	0.0020251	1520	554640	50	277320	9934
Horses and Ponies	51.0	53366	450	22.95	8377	1225	447	75	335	0.0020251	48632	17750841	50	8875421	317941
Total		19956544			77747	22735	8298		6029		578303	211080475		1.152E+08	4125942

2.1.4 Biomass from Municipal and Industrial Solid Wastes

Approximately 750 kg of municipal solid waste (MSW) is generated per person each year in Canada and about 24% of this is recyclable (BIOCAP, 2003). The recyclable portion in BC (calculated in BIOCAP's report and based on limited information) was estimated at 30% which is 25% higher than the national average (of 24%). About 55% of the recyclable materials in MSW have biomass potential with an average carbon content of 27% (BIOCAP, 2003). This carbon content also represents about 8% of the total MSW amount collected in Canada.

In Prince George, the Foothills Boulevard Regional landfill (FBRL) manages 94% of solid wastes generated in the Fraser-Fort George Regional District which has a population of about 100,000 (that is the population of Prince George and surroundings). The waste stream at FBRL is classified into two general categories based on the source and type of waste material. Waste materials such as food waste, paper waste, packaging waste, yard & garden waste and manufacturing / processing waste generated in homes and at businesses, restaurants, schools, hospitals, light industries and other institutions are considered to be Municipal Solid Waste (MSW). The other stream is Demolition, Land Clearing and Construction Debris (DLC) that includes materials such as concrete, asphalt, lumber, stumps, and building materials generated from general construction activities. In 2005, 94,415 tonnes of solid waste (87% MSW and 13% DLC) materials was handled at this facility (FBRL 2005). 12,680 tonnes of material was recycled and 81,735 tonnes of material was buried at the site (FBRL, 2005). In addition to MSW landfilling, 100 tonnes of waste asbestos were also buried at the site (FBRL, 2005). The remaining lifespan of this landfill is estimated to be about thirteen years. A wide variety of waste reduction services are offered at this site. The most popular service is the yard & garden waste recycling program. Other services include multi-material recycling drop-depot bins, and a variety of household hazardous waste collection services including used oil, rechargeable batteries, used cell phones and diversion programs for problem materials such as tires and refillable propane bottles. Applying the same methodology as BIOCAP (2003), on the data from FBRL's multi-material recycling program, we estimated a carbon yield of 19,707 tonnes per year which have an energy potential of 704,728 GJ/year (Table 2.3) if the waste materials can be diverted from current use. This would represent a significant energy contribution for the regional district and would extend the lifespan of the landfill.

In 2002, the Regional District installed a landfill gas collection system in conjunction with a landfill capping project over a 5.5 ha area of the landfill (FBRL, 2005). The main purpose of the landfill gas (LFG) extraction system was to collect the landfill gas for beneficial use and to reduce greenhouse gas emissions associated with the methane component of the gas. Currently, twelve of the sixteen vertical extraction wells are producing recoverable concentrations of methane. The four closed wells are thought to be installed in old areas of the landfill where the rate of methane production has diminished significantly (FBRL, 2005). A centrifugal blower system provides a vacuum that draws landfill gas from the extraction well system and moves the gas through an enclosed flare where the gas is combusted at temperatures in excess of 870 degrees Celsius (FBRL, 2005). The flow rate of LFG ranges from 220 to 240 standard cubic feet per minute and is regularly adjusted by the operator depending upon methane concentrations to a target methane concentration of 45%.

Combustion of the landfill gas resulted in the reduction of greenhouse gases equivalent to 15,000 tonnes of CO_2. The potential energy value of the amount of gas collected in 2005 is sufficient to replace the natural gas requirement for 440 homes. However, so far the gas is not used productively (FBRL, 2005).

Table 2.3: Carbon content and energy potential from unused landfilled solid waste from Prince George's FBRL

Items brought to FBRL	Total amount	Amount recycled	Amount combustible		Moisture content	Amount combustible	Carbon Content	C yield	Energy Potential
	tonnes/year	tonnes / year	%	tonnes / year	%	oven dry tonnes/year	%	oven dry tonnes / year	GJ/year
Newsprint		62	100%	62	10%	56	44%	25	878
Mixed paper		59	100%	59	10%	53	44%	23	835
Card board		58	100%	58	10%	52	44%	23	821
Milk Jugs		3	100%	3	10%	3	61%	2	59
MSW buried	69500		85%	59075	23%	45783	40%	18313	654882
DLC buried	12235		30%	3671	10%	3303	40%	1321	47253
Total	**81735**	**182**		**62928**		**49250**		**19707**	**704728**

2.1.5 Municipal bio-solids

Another source of municipal biomass is the extracted solids materials from sewage and waste waters. This material is often referred to as biosolids or sewage sludge. Wastewater treatment facilities are used to remove excrement as well as particulate, organic, bacterial, chemical and toxic materials from residential and industrial effluent waters before these are returned to surface waters such as lakes and streams. In Canada, only 33% of wastewater treatment is at the highest or tertiary level (BIOCAP, 2003). All treatment levels remove the biosolids proportion, but may not inactivate the bacterial fraction or remove toxic chemicals (BIOCAP, 2003). As a consequence, disposal of biosolids is problematic. In most regions, the favoured approach is to spread the biosolids on agricultural land, where it acts as a fertile soil amendment. Sites are selected according to stringent criteria set out by provincial government environmental agencies; these criteria are intended to minimize contamination of surface or groundwater supplies, avoid nuisance odour complaints and select for lands where crops intended for animal consumption are grown (BIOCAP, 2003). In fact, areas where all the criteria may be adequately met are in short supply, so that spreading sites may be heavily loaded. As well, biosolids are often not adequately stabilized and may contain high levels of contaminates (BIOCAP, 2003).

Where disposal by land application has become a problem, disposal of biosolids in landfill is a favoured option. According to BIOCAP (2003), a better solution is to subject biosolids to fermentative processes, which would stabilize the bacterial component and permit the precipitation of "toxic" chemicals, and the production of a high-grade biogas that can be used for co-generation. The resulting sludge is biologically inert, has low odour, lower volume and it can be used as a soil amendment with less side effects (BIOCAP, 2003). This option can be economically beneficial for municipalities, as it can save them landfill costs (including cost of transport to site). Furthermore, if co-generation is adopted, it can help to offset the energy cost of treating the sludge. Unfortunately, the sale of sludge as fertilizer is not currently permitted in Canada (BIOCAP, 2003), otherwise that would have provided additional revenues. As with the production of MSWs, biosolids are produced with consistency and in greater concentrations where population density is highest. In non-urban areas, wastewater treatment tends to be simpler (primary) or non-existent (BIOCAP, 2003). About 9% of the Canadian population has no available treatment for sewage, although the bulk of this fraction is captured by septic systems (BIOCAP, 2003). The trend for increasing attention to the extent of wastewater treatment is expected to ensure an increasing volume of biosolids, which may be viewed as biomass suitable for energy production. Biosolids do not represent a huge biomass resource and energy potential through combustion is minimal. However, the fermentation treatment of biosolids to produce biogas can proved worthwhile and may provide additional potential for contribution to the municipal grid.

Chapter 3

BIOFUEL PRODUCTION TECHNOLOGIES

3.1 TYPES OF BIOFUELS

All biomass materials are valuable sources of energy. Sometimes it may take more effort and ingenuity to transform the stored energy in biomass materials into readily useable fuel. The fuel and energy derived from biomass are called biofuel and bioenergy, respectively. Depending on the intended use of biomass fuel, the feedstock (or biomass) may be used as it is for heating and cooking in residential setting; or it may be transformed into an easier to handle, more compact and denser solid fuel in the form of chips, pellets or briquettes; the feedstock may also be transformed into liquid fuels such as bio-oil, bio- ethanol or bio-diesel or transformed into gaseous fuels such as biogas/syngas, methane or hydrogen. The conversion pathways of biomass into these different types of fuels can be very complex as the desired final product changes from solid fuel to liquid fuel or to gaseous fuel. These biomass conversion pathways include technological processes that involve biological, thermal, mechanical and chemical conversion. The products from these processes have specific attributes that determine their use as end products.

3.1.1 Solid bio-fuels: wood chips, wood pellets and charcoal

Solid biofuels include wood and agricultural residues which are usually processed themo-mechanically to produce a denser fuel such as wood chips, sawdust, pellets and briquettes. Typically, wood chips, sawdust and other biomass residues are collected from saw mills and burned in wood waste boilers to produce heat and high pressure steam. The high pressure steam is used in a turbine to produce electricity and hot water. The process of burning fuel to produce steam and electricity is called co-generation. The technology used by burning directly biomass materials to generate thermal energy is called combustion and it is a well established, mature technology. In British Columbia, most of the industrial wood waste boilers are located in pulp and paper mills as there are other synergies that justify it. Otherwise, at the present time, the cost of electricity produced using biomass combustion in a stand-alone cogeneration system is higher than the one produced with hydro or with coal (NEB, 2006).

More recently, a few manufacturing companies have started to densify waste biomass residues for both domestic use and for markets in Europe. The densification process is typically for wood wastes or agricultural residues, where it is compacted in the form of briquettes, pellets or "logs" and sold as a domestic or industrial fuel. Briquettes or logs are generally formed by forcing dry sawdust or shavings though a split cylindrical die using a hydraulic ram. The exerted pressure, of approximately 1200 kg/cm^2, and the resultant heat generated bonds the wood particles into "logs" (FAO, 1990).

The production of pellets involves the reduction of wood waste to the size of sawdust, which is then dried to approximately 12% moisture content, before being extruded in specially adapted agricultural pellet mills to form pellets of 6 to 18 mm diameter and 30 mm long, with a density in the range of 950 to 1300 kg/m^3 (FAO, 1990). Drying of the furnish, prior to extrusion, is usually undertaken in rotating drum dryers, fired by approximately 15 to 20% of the plant's pellet production (FAO, 1990).

Pelletization produces a product with excellent handling and storage characteristics, and which has four times the energy concentration of raw wood thus greatly reducing transport cost and improving boiler efficiency (FAO, 1990). However, FAO (1990) found that the high capital investment needed to build a pellet plant and the additional costs required to operate it, could only prove economically attractive if the processed fuel was to be transported beyond 250 km from the source of the raw material (FAO, 1990). However, at today's fossil fuel prices combined with incentives for greenhouse gas emission reduction, pelletization may be viable even for on site-generated fuels.

The technology involved in compacting biomass materials into pellets, briquettes or logs is well established. In Prince George and areas, there are several wood pellets plants already operating (see list in Table 3.1). In addition TallOil Canada has also expressed its intention to build two pellet plants in the area; one plant is planned for the Vanderhoof area and the other one for the Prince George area. In 2005, Prince George areas had an annual wood pellet production capacity of 550,000 tons (Dunsford, 2006).

In addition to wood pellet, biomass material can also be processed to produce charcoal which may be used as a fuel for cooking. When the charcoal is activated, it is usually sold as a specialty chemical. The technology used to produce charcoal is a pyrolysis process which is a form of combustion in the absence of oxygen. There is no charcoal manufacturing plant in Northern BC.

Table 3.1: Wood pellets manufacturing plants in British Columbia
(Information compiled from data obtained in Wood and Coal (2007) and Wood Pellet Association (2007) websites.

Name of Company	Contact Information	Web site	Brand names
PFI Pellet Flame Ltd.*	12080 Willow Cale Forest Rd., Prince George, BC, V2N 4T7; (250) 963-7220	www.pelletflame.bc.ca	
Pinnacle Pellet Inc.**	4252 Dog Prairie Rd., Quesnel, BC , V2J 6K9 Contact: Craig Lodge — craig.lodge@pinnaclepellet.com	www.pinnaclepellet.com	Brand names: Pinnacle Pellet Fir wood pellets
Premium Pellet Ltd	Box 125, Vanderhoof, BC, V0J 3A0 Contact: Lloyd Larsen — mailus@premiumpellet.com	www.premiumpellet.com	
Armstrong Pellets Ltd	Box 280, Armstrong, BC, V0B 1B0 Contact: Roger Mushaluk — roger@armstrongpellets.com	www.armstrongpellets.com	Brand names: Armstrong Premium Wood Pellet Fuel
West Wood Fibre Products Inc.	201-705 Laval Cresent, Kamloops, BC, V2C 5P2 Contact: Jason Perris — jperris@westfibre.com		
Pacific BioEnergy Corporation.*	Suite 1508-999 W. Hastings St. , Vancouver, BC, V6C 2W2. Contact: Scott Folk — sfolk@pacificbioenergy.ca	www.pacificbioenergy.ca	
Tall Oil Canada ***	Box 12122; 555 W. Hastings St.; Vancouver, BC; V6B 4N6 Contact: Lennart Sandstom — lennart.sandstrom@talloil.se	www.talloil.com	
Princeton Co-Generation	Box 2440; Princeton, BC, V0X 1W0 Contact: Dean and Gary Johnston — dean@eagle-valley.com, gary@eagle-valley.com		Brand names: Eagle Valley wood pellets

* Pellet Flame and Pacific Bio are the same company.
** Pinnacle and Canfor have joint venture wood pellet plant in Houston, BC
*** Tall Oil Canada does not have any plant yet but is planning to open two plants: One in the Vanderhoof area and another one in the Prince George area.

3.1.2 Liquid bio-fuels: Ethanol, bio-oils and bio-diesel

With the increasing global demand in transportation fuels and the increasing public pressure on the governments of industrialized countries to find alternative fuels that will mitigate greenhouse gas emissions, many countries are actively trying to develop in the short and medium terms renewable liquid bio-fuels from biomass materials. The most attractive liquid bio-fuels are ethanol, biodiesel, methanol, dimethyl ether (DME), and ethyl tertiary butyl ether (ETBE) (Toro Chacon, 2004). Both ethanol (a type of alcohol) and biodiesel are commercially produced in significant quantities. Bio-ethanol is produced either from crops with high sugar contents such as sugar cane and beets, or from cereal with high starch content such as corn, wheat and barley.

In North America, corn is the predominant agricultural crop for ethanol production, whereas in Brazil sugar cane is the crop the most used. Bio-diesel can be produced from crops with high oil (fatty acid) content; that is, the oilseed crops such as canola, soybean, sunflower, and flaxseed. It can also be produced from animal fats, algae and recycled cooking grease/oil (Klass, 1998). In addition to agricultural crops, bio-ethanol can also be produced from cellulosic biomass materials using technologies such as fermentation, pyrolysis or gasification. After gasification or pyrolysis of the feedstock, further chemical reaction (Fischer-Tropsch) would be required to convert the products of gasification or pyrolysis into ethanol or diesel. The status of the technologies for these conversion pathways is discussed in Section 3.3.

3.1.3 Gaseous bio-fuels: Methane, Biogas/Syngas, Hydrogen, etc

In addition to being converted into liquid fuels which is most desirable as transportation fuel, biomass materials can also be converted in gaseous fuels such as methane, hydrogen or biogas (which is a mixture of carbon monoxide, carbon dioxide, hydrogen, methane, and other hydrocarbons) which could be used to displace natural gas in the short to medium term. Hydrogen can in the long term also be used as a transportation fuel.

Biomass materials such as animal manure or bio-solids from municipal wastes are usually processed biologically using anaerobic fermentation to produce methane. Methane can also be produced through the composting of organic material in landfills as it is done in the Foothills Boulevard Regional landfill in Prince George (FBRL, 2005). Wood and agricultural residues can also be converted into methane, hydrogen or biogas using the gasification technology.

In Northern BC, converting cellulosic biomass into liquid or gaseous bio-fuels would be most desirable as the feedstock is abundant; it does not compete with human and livestock food demand for grains and starch, and there is a mature forest products industry (including pulp and paper and wood products manufacturing) in the region that could add synergy in adopting any of these technologies. The fermentation of corn into ethanol and the processing of oilseeds into biodiesel could also be valuable options. However, there are several barriers that need to be overcome, these include the fact that these agricultural crops have already other well established markets and also the perception of the general public that the use of food products for biofuel production may cause food shortage or drive very high the price of food derived from these products. Other barriers are also summarized in Table 3.2.

3.2 BIO-FUEL PRODUCTION PATHWAYS AND TECHNOLOGIES

There are four distinct pathways for converting biomass into value-added bio-fuel: the thermo-mechanical pathways; the thermo-chemical pathways; the chemical conversion pathways and the biological /fermentation pathways.

The thermo-mechanical methods involve both heat treatment (drying) and mechanical processing (sizing and compacting) of the biomass material to produce essentially pellets and briquettes which are suitable for heating and cooking. This technology has reached a commercial maturity. It is also the simplest and the most inexpensive pathway for biofuel production.

The chemical conversion pathways make use of the technology of extraction and chemical reaction such as trans-esterification to convert fatty acids into bio-diesel.

The thermo-chemical pathways combine heat and chemical reaction engineering in the form of combustion, gasification, pyrolysis or other upgrading techniques such as supercritical conversion and hydrothermal upgrading to convert the biomass feedstock into heat, electricity or gaseous, liquid and solid fuels.

The biological conversion /fermentation pathways use microbiological action to convert the biomass material into usable fuel. Fermentation can be done in the presence of air (aerobic) or at the absence of air (anaerobic). Fermentation is a biological process in which enzymes produced by microorganisms catalyze chemical reactions that convert naturally occurring plant sugars into alcohol. Fuel grade ethanol is normally made through an existing and well understood fermentation process of agricultural crops such as beets, sugar cane, corn, wheat or barley. However, ethanol can also be made through fermentation of wood-based cellulose or hemicellulose.

Each of the above pathways can lead to distinct product streams and the technologies involved are at various degrees of commercialization depending on the feedstock that is considered.

3.3 STATUS OF BIOFUEL PRODUCTION TECHNOLOGIES

The technologies used to convert biomass materials to higher value fuels are not new but their application to certain types of biomass is recent. In this section, a review of the status of the application of these technologies in converting biomass feedstock into higher value fuels is presented. The status and barriers of the different biomass technologies are summarized in Table 3.2.

Table 3.2: Status of Biofuel production technologies

Technologies	Main Products	Feedstocks	Status	Barriers
		Thermochemical pathways		
Gasification	Syngas / Biogas Methane Hydrogen	Wood and agricultural residues	Commercial	Cost Gas cleanup Feed preparation
Pyrolysis	Char coal Bio-oil	Wood and agricultural residues	Small scale Mobile units Commercial	Small scale
Gasification or pyrolysis integrated with a Fischer Tropsch reactor	Ethanol Bio-Diesel	Wood and agricultural residues	Large scale Demonstration Near commercial	Technical High costs Competition against non renewable
Hydrothermal upgrading	Oxygenated	Wood and agricultural residues	R&D	Technical High costs Small scale
Supercritical conversion		Wood and agricultural residues	R&D	Technical High costs Small scale
		Fermentation pathways		
Anaerobic fermentation	Ethanol	Starch crops such as corn	Commercial	High cost
		Wood and agricultural residues	Research and development stage	High cost Technical
		Chemical pathways		
Trans-esterification	Biodiesel	Oil seeds Animal fat Waste vegetable oil	Commercial	Cost Separation techniques
		Wood extractives (from pulp mills)	R&D	Costs Technical
		Thermo-mechanical pathways		
Densification	Wood pellets or briquettes	Wood and agricultural residues	Mature technology Commercial	Feedstock availability Harvesting costs

3.3.1 Fermentation

Fermentation is a biological process in which enzymes produced by microorganisms are used to catalyze the chemical conversion of naturally occurring plant sugars into alcohol. Ethanol is the main product, but other types of alcohols can also be produced. In British Columbia, the process could be used with wood residues, agricultural residues, or with agricultural grain crops such corn, wheat and barley to produce fuel grade ethanol.

The fermentation process with six-carbon sugars such as those found in sugar cane or in starchy grain crops is well understood and is at a mature commercialization stage. However, fermentation of wood residues to produce ethanol, although done during World War I and World War II, is much more challenging and has yet to prove economical at the commercial scale (Klass, 1998). The challenge is due to the fact that although wood has high concentration (39-50% for hardwoods; 41-57% for softwoods) in six-carbon sugars such as glucose which is more easily convertible to ethanol, it also has substantial amount of five-carbon sugars, such as xylose (18-28% for hardwoods, 8-12% for softwoods) which are more difficult to convert into ethanol (Klass, 1998).

Wood is also made of hemicellulose (23-32%), cellulose (38-50%) and lignin (15-25%). Lignin is the binding agent which gives wood its consistency and hardness. Cellulose is the white spongy material which is used as pulp. Hemicellulose is easier to convert into ethanol than cellulose probably due to the nature of the sugars in them. Currently, researchers are looking at first extracting the hemicellulose portion of wood and to ferment it to produce ethanol and to leave behind the cellulose and lignin portions that can still be use to produce valuable products (Frederick, et al, 2006; Yoon et al., 2006; Amidon et al., 2006). This approach would be more suitable for the pulp and paper industry which already has uses for cellulose and lignin and is also looking at ways of diversifying its revenue streams.

Ethanol yield using fermentation depends on the type of feedstocks. With cellulosic biomass feedstocks, the yield is between 284 and 435 litres per bone dry ton (BDT) of biomass (INRS, 2006). The ethanol yield during corn fermentation is about 429.4 liters per BDT of biomass (BIOCAP, 2004). During the commercial fermentation of corn, in addition to ethanol, other high value products such as antibiotics, lysine, monosodium glutamate, gluconic acid, lactic acid, acetic acid and malic acid are also produced. These by-products could also be recovered and sold. That would help reduce the process cost. So far, there are several commercial corn to ethanol plants but cellulosic ethanol plants are only at the demonstration and pilot scale stage. The cost of production of ethanol through fermentation will be discussed in Chapter 4. A list of companies particularly active in the R&D and commercialization of bio-ethanol is included in Table I.1 of Appendix I and the lists of bio-ethanol plants in Canada and the US are shown in Appendices II and III.

3.3.2 Gasification

Gasification is the process of heating biomass with sub-stoichiometric (or insufficient) amount of oxygen. Gasification may be done with partial oxidation (burning) or indirect heating of the biomass. Depending on the characteristics desired for the final product, gasification may be conducted in pressurized or atmospheric conditions and it may be assisted with steam, air or oxygen. Typically biomass gasification is done at temperature greater than 600°C with higher temperature promoting gas yield. Gasification produces a synthetic gas also called syngas (or biogas or producer gas in certain cases) which is a mixture of several gases such as hydrogen, methane, carbon monoxide and other impurities.

The syngas can be used directly with minimum cleaning in a boiler or a kiln as a fuel to replace fossil fuel or after further purification, the syngas can be burned in a gas turbine to produce electricity or it can be converted using catalysts into value-added fuels and chemicals (diesels, dimethyl ether, methanol, ethanol, etc). There is also the possibility of separating and purifying certain gaseous components of the syngas such as hydrogen which can then be used as fuel or as chemicals.

Gasification is a conversion technology that can accommodate a wide range of feedstocks (wood wastes, agricultural residues, animal wastes, sludges, etc). Some gasification technologies can use coal or crude oil as well. An extensive listing of gasification projects installed around the world can be found at the Gasifier Inventory's web site: www.gasifiers.org. This web site also provides a listing of the technology suppliers. In Table I.2 of Appendix I, we have summarized the companies that are most active in developing and commercializing the biomass gasification technology for the purpose of producing valued added fuels and chemicals. The major challenges for biomass gasification reside in the feed preparation, syngas cleanup, the use of the syngas for chemical production, and the high cost of the technology.

3.3.3 Pyrolysis

Pyrolysis refers to the heating of biomass feedstocks in the absence of oxygen. There are two types of pyrolysis: Slow pyrolysis (also referred to as carbonization or liquefaction) and fast or flash pyrolysis. Slow pyrolysis is done slowly at temperatures between 300 and 350°C to produce predominantly char coal or viscous bio-oil. Fast or flash pyrolysis is done rapidly at higher temperatures between 400 and 650°C and some times even at much higher temperatures between 800 and 900°C to promote gas yield and minimize tars and char formation. The primary product of fast/flash pyrolysis is a less viscous bio-oil at a yield of 70-75% based on the starting weight of the biomass feedstock. Bio-oil is water soluble; it is storable and transportable, although corrosive and acidic (pH between 2 and 4). Bio-oil is denser than water with a density of 1.2 kg per liter; and has a high heating value of 16-19 GJ/tonne. In general bio-oil contains 15 to 30 weight-percent of water and about 30 weight-percent of oxygen on dry basis. The oil can be upgraded to reduce the oxygen content, but that has economic and energy penalties. Pyrolysis and upgrading technology are still largely in the pilot phase. Hydrothermal upgrading (HTU), originally developed by Shell, converts biomass at a high pressure and at moderate temperatures in water to biocrude. Biocrude contains far less oxygen than bio-oil produced through pyrolysis, but the process is still in a pre-pilot phase (Naber et al., 1997).

Bio-oil can be used directly as fuel for combustion or for modified turbines and diesel engines. It can also be used as blend for diesel fuel, or as a specialty chemical in the manufacturing of thirty chemical products including natural resins used in wood manufacturing (Oriented Strand Board (OSB) and plywood) and in polymer application

(Ensyn, 2007). It is also reported that a company working with the US National Renewable Energy Laboratory, has developed a process to convert pyrolysis oil to transportation grade fuels, to be used in place of or as additive to gasoline and diesel (INRS, 2006).

Pyrolysis companies have developed operating facilities with one in the US and several operating in Canada (INRS, 2006). By 2003, Ensyn has constructed six commercial pyrolysis reactors, including an 80 tonnes per day (tpd) facility in Renfrew, Ontario, and is reportedly pursuing a number of new opportunities in North America (Ensyn, 2007). Dynamotive has a 100 tpd operating commercial facility in West Lorne, Ontario, and is reportedly constructing a 200 tpd facility for a gas turbine demonstration (Dynamotive, 2007). Renewable Oil International has been focusing on the development of smaller modular units that can be constructed remotely, transported in container-size pieces, and quickly installed on site. Renewable Oil International was constructing a 15 tpd demonstration unit in Massachussetts (INRS, 2006). Ontario has also been testing on forestry residuals, a promising 50 tpd mobile pyrolysis unit (installed on five trucks) that would produce bio-oil for mill power boilers.

While pyrolysis has a long history in Europe and Canada, and in spite of the success of the demonstration and commercial units, the technology has yet to gain a widespread adoption. Several barriers including some technical limitations and competition against non renewable products which are manufactured at lower costs would need to be addressed in order to improve market acceptance of this technology. Companies active in the commercialization and R&D of biomass pyrolysis are listed in Table I.3 of Appendix I.

3.3.4 Biodiesel production technologies

Biodiesel is made by chemically transforming naturally occurring oil or fatty acids from plants or animal into methyl esters (biodiesel) and glycerin (a byproduct). The chemical process is known as transesterification and does not pose major difficulties when pure feedstocks are used. The major concern with biodiesel production is on yield improvement and on the extraction and chemical separation techniques that are required either as pretreatment of the feedstock or for purification of the biodiesel product. In addition, there is concern about disposal of two by-products: (1) the solid residues from crushing of the oilseeds feedstock to extract the oil and (2) the glycerin which is formed during the trans-esterification reaction. The other concerns about biodiesel fuels are the wide variability in properties. Both the European Union and the American Society for Testing and Materials (ASTM) have formulated standard specifications that all biodiesel fuels must meet (Toro Chacon, 2004). Other potential barriers for biodiesel commercialization are the availability of the biomass based feedstocks and the high production cost for biodiesel compared to petroleum based diesel. Biodiesel can be blended in any amount with petroleum based diesel fuel. B100 is the name for pure biodiesel, whereas B20 contains only 20% biodiesel and B10 only 10% biodiesel. Like petroleum based diesel fuel, biodiesel will need additives to keep it from freezing in extreme cold weather.

There are also kraft pulp mill by-products that are extractives from the wood (commonly called in the industry as "soap" and "talloil") that may also be suitable for biodiesel production. The use of these by-products for making biodiesel would be most ideal for kraft pulp and paper mills where greater synergy exists. The Canfor Pulp mills in Prince George can be ideal candidates for exploring this option, particularly if a partnership can be made between Canfor and Husky Oil which has a light oil refinery just beside the pulp mills. A list of biodiesel plants in Canada and in the USA is shown in Appendix IV.

3.3.5 Other technical issues with biomass fractionation

Fractionation refers to the separation of biomass into its constituent components such as cellulose, hemicellulose and lignin. The challenge with fractionation is to minimize the degradation and cross-contamination among the different fraction. The processes currently being employed include steam explosion, aqueous separation and hot water systems (INRS, 2006). In addition research is being conducted in several universities such as the University of Maine, the State University of New York and the Institute of Paper Science and Technology of the Georgia Institute of Technology that are trying acid extraction technique to extract the hemicellulose from the wood chip and to ferment it into ethanol. This process is most suitable for pulp and paper mills. Companies that are actively seeking to commercialize fractionation technologies are summarized in Table I.4 of Appendix I.

Chapter 4

Biofuel Economic Assessment

The high price of oil and gas and the environmental impacts caused by the emissions of greenhouse gases from the combustion of fossil fuels has created new incentives for re-assessing both the economic and environmental viability of advanced biofuel production technologies. While the environmental benefit for using well managed biofuel is becoming more accepted, the economic benefit of bio-fuel is more difficult to demonstrate in Canada where there is also abundant supply of seemingly cheaper substitutes (coal, natural gas, uranium, etc). However, if the real costs of externalities (pollution costs, greenhouse gas emissions costs, etc) were factored in the economic analysis for fossil fuels, biofuels would probably be more economical even at the current stage of development of some of technologies.

In this Chapter, instead of conducting an elaborate economic assessment, we will just review some of the economic issues involved with the production of liquid biofuel such as bioethanol and biodiesel.

4.1. ECONOMICS OF BIO-ETHANOL PRODUCTION TECHNOLOGIES

As explained in Chapter 2, bio-ethanol can be produced either by fermentation or by gasification. The fermentation method is most adapted for starchy agricultural crops such as corn, wheat and barley. The fermentation route is also being applied to cellulosic biomass material such as straw and wood residues. The gasification route for bioethanol production is particularly being developed for cellulosic biomass. So far, the cost of production of ethanol from corn using fermentation is estimated at US$0.24 per litre compared to a cost of US$0.40 per litre of ethanol produced by fermentation of straws (Frederick et al., 2006; Larson et al, 2006). However, in order to achieve these production costs, large scale plants would be required. A stand alone ethanol plant would need to have an annual ethanol production capacity of at least 25 million US gallon (or 94.6 million litres). Using current ethanol yields from corn fermentation as summarized in Table 4.1, it would require a plant capable of processing hourly about 28 BDT for 330 days every year. The size for the straw ethanol plant would be even bigger to almost 32-44 BDT/h. These production costs included the costs of collecting or of purchasing the feedstock; for corn stover, collection costs ranged from US$35 to US$46 per BDT and for corn the market price varies from US$1.94 to 3.28 per bushel or US$59-100 per BDT (NREL, 2000). In the NREL's 2000 study, a capital investment of 27.9 million dollars would be required and the total production costs for starch ethanol would be about 22 million per year or (US$ 0.23 per litre of ethanol). 38% of the capital investment went to the purchase of equipment for solid/sirup separation/drying, 19% was spent on distillation equipment and 16% on fermentation equipment. In the production costs 77% was incurred to purchase corn. Capital depreciation accounted only for 13% of the production cost.

Table 4.1: Ethanol yields and plant size requirements for the production of 94.6 million litres of ethanol per year using data from BIOCAP (2004) and NREL (2000).

Feedstocks	Ethanol yield in litres per BDT of feedstock	BDT of feedstock per hour
Corn	429.4	27.8
Cereal	470.6	25.4
Straw	261.2* to 363.5	32.9 - 43.75*

* Yield from NREL's 2000 study.

For the case of corn straw, NREL (2000) estimated production costs of $37.3 million with 44% of the production costs incurred to purchase the raw materials. Capital depreciation for the ligno-cellulosic process was 36.5%. It was not clear if this process has an added incentive in the US for rapid capital write-off. Due to the complexity of this process, NREL (2000) estimated a capital costs estimate of 136 million dollars (1999 dollars). The biggest single capital expenditures were for boiler/turbogenerator (28%); fermentation/saccharification and cellulase production 24%; feedstocks pretreatment/detoxification (22%).

If we take into account, the US' government subsidies for ethanol which are US$0.13/L and we use as market price for ethanol, the price forecasted by the Chicago Futures for December 2006 and which was about US$0.455/L, the profit margin for corn ethanol would be substantial (US$ 0.355/L) and for cellulose ethanol the profit margin would be about US$0.185 per litre (Agriculture Canada, December 2006). In Canada, the profit margin would be narrower as the planned subsidy is lower (CAN$0.10/L). The US government is hoping that by the expiration date of the biofuel subsidies (in 2010), the technology would have matured enough to self sustain itself without further subsidies.

Both starch and cellulose ethanol production processes generate by-products which can provide additional revenues. The biggest advantage would be to build these plants in pulp mill location where processes can be integrated to reduce costs. One major draw back for the fermentation of corn process is that it generates equal amounts of CO_2 and ethanol (NREL, 2000). This CO_2 can be captured and sold to an organization that specializes in the cleaning and pressurization of CO_2 (NREL, 2000) and for the capture to be relevant the amount of CO_2 generated has to be significant and a user must be nearby.

Although corn has been the main focus for starch based ethanol production, this can change in Western Canada where wheat is the primary feedstock. A major barrier for these processes is the availability of the feedstock at reasonable cost. It is clear that by building these huge plants, at one point of time the feedstock would need to be transported from far away to the plant and this would add significantly to the production costs. Although ethanol from corn is the major focus of the US Department of Agriculture (USDA), others predict that it would ultimately cause higher grain prices and disruption in the global food economy (Earth Policy Institute, 2007).

In Canada, with the federal government's commitment to have a 5% renewable content in Canadian transportation fuels by 2010, combined with the federal excise tax exemption of CAN$0.10 per litre of bioethanol/biodiesel, ethanol production is projected to increase to about 2.74 billion litres by 2010 from a current production level of 0.6-0.84 billion litres (Agriculture Canada, November 2006 and December 2006). If Canada were to meet its production target of 2.74 billion litres of ethanol, according to Agriculture Canada (Dec

2006), approximately 4.6 million tonnes of corn and 2.3 million tonnes of wheat will be required and it would results in the production of 2.1 million tonnes of the co-product dried distiller's grain (DDG), which is currently sold as protein meal for animals. The huge increase in the supply of DDG is expected to affect the animal feed market (Agriculture Canada, December 2006).

In Canada, IOGEN (a biofuel company based in Ottawa) is the dominant company for cellulosic ethanol production. It is planning to build a 400 million dollars plant and has a technology capable to reduce the costs of production.

Although cellulose ethanol is still very expensive, it is viewed by many as the future hope of biofuels, as it has the potential to improve energy yields while not impacting the market for food crops (Hammerschlag, 2006). Cellulose ethanol is the main focus for the US Department of Energy (USDOE). In addition to the studies on corn straw, additional studies were done on wood residues. These studies on wood cellulose conversion in to bioethanol were done in the context of a pulp mill biorefinery. Frederick et al (2006) presented during the 2006 Tappi Engineering Conference in Atlanta, work his group was conducting on Ethanol from Loblolly Pine. He indicated that there will be a significant market for wood based ethanol, since ethanol production from corn starch will not meet the US demand. Frederick et al. (2006) also conducted cost estimates for ethanol production based on extraction of 14% of the hemicellulose prior to pulping. He found that at constant pulp production rate with no loss of cellulose, the breakeven price for ethanol production would be between US$ 0.28 and US$0.47 per litre (or US$1.06 and US$1.78 per US gallon) if there is some loss of cellulose. The breakeven price estimates for 100% digester utilization with cellulose loss is US$0.42/L (or US$1.60 per US gallon). This costing was done assuming a price for Loblolly Pine wood at US$64/BDT. Currently the biggest cost is the cost of the extraction vessel which has to be so big to handle all the wood being pulp. The breakeven price for corn ethanol was US$ 0.23/L (or US$0.88/US gallon). Frederick (2006) concluded that there is a need to decrease cellulose loss and to improve the extraction and fermentation technologies. Other issues to evaluate, is the impact of hemicellulose extraction on pulp quality.

In addition to Frederik et al. (2006), Larson et al. (2006) also presented a comprehensive cost benefit analysis of gasification-based bio-refining at US Kraft pulp mills. They had looked at several market potentials and several bio-refinery designs. His pulp mill bio-refinery would produce 1,500-5,000 barrel of oil equivalent of ethanol per day and the capital cost would be between 250 million and 500 million US dollars (with an accuracy of plus or minus 30%). These costs would compare at 138 million US dollars for the Tomlinson recovery boiler and about 250 million US dollars for black liquor gasification with combined cycle. The high cost of the bio-refinery technology poses a serious financial risk; therefore it would require partnerships and greater integration with the pulp and paper mills to reduce the risks. Choren Beta has a plant in Germany that makes bio-diesel from gasification of biomass followed by Fisher Tropsch synthesis. During question period, the impact of wood bio-diesel on current diesel engine has been asked. It appears that Fischer Tropsch bio-diesel can be used with no problem.

For the case of Northern BC, an average Kraft mill producing 900 air dried tonnes of pulp per day, can potentially yield with an integrated biorefinery, an additional 118,000 litres of ethanol per day (assuming the same yield as in the NREL study and assuming only conversion of the hemicellulose portion of the wood chip). Based on some high yield cellulosic ethanol technologies (435 L/BDT according to IRNS, 2006), a potential daily ethanol production of 200,000 litres is possible. This can generate significant additional revenue for the pulp and paper mills.

4.2 ECONOMICS OF BIODIESEL

The current federal and provincial government initiatives on bioenergy which is mandating 5% addition of biodiesel in petroleum-based diesel fuel and fuel oil for heating would certainly spur biodiesel production in Canada which is so far insignificant. Canada consumes about 23.4 million tonnes (about 26 billion litres) of diesel annually and 46% of this is used as transportation fuel largely by heavy vehicles [BIOCAP, 2004]. The USA consumes around 178.4 million tonnes (or 198.2 billion litres) of diesel of which 65% was consumed as transportation fuel [BIOCAP, 2004]. The use of 5% bio-diesel in transportation diesel fuel alone would amount to 610 million litres of biodiesel per year in Canada at current consumption rate. According to BIOCAP (2004), to meet this demand, would require significant increase in oilseed production (at least 10%) and a 50% export diversion of animal fat and canola oil.

A proposed Canola based biodiesel plant proposed for Dawson Creek, BC, would cost about CAN$ 24 million to produce about 22 million litres per year at a yield of 393 L of biodiesel per tonne of Canola; this would require about 56,000 tonnes of canola (The Prince George Citizen, 2007). This is more canola than currently produced in the province.

Biodiesel from pulp mill extractives can be considered however, then the mill would need another fuel sources as currently these extractives are burned in the lime kilns or in the power boilers.

Klass (1999) has provided an economic comparison between diesel and biodiesel production. At the time, the biodiesel production was not competitive. In the US, financial incentives were added to stimulate production. Similar types of incentives combined with environmental credits would be needed in Canada to stimulate the commercial production of biodiesel.

4.3 ECONOMICS OF GASIFICATION

The economics of biomass gasification for power production is well established. However, it is still not competitive compared to traditional cogeneration system for power production. However, with added incentives, biomass gasification can help to reduce the use of natural gas combustion in pulp and paper mills. The major impetus for gasification is for the production of biofuels and chemicals (ethanol, methanol, bio-diesel, and hydrogen). It is argued that cellulose ethanol could be produced more cheaply with gasification than with fermentation (since with fermentation, a lot of carbon is also converted into CO_2).

With the rapid development of the biofuel industry, the sustainability of the supply chain and of the entire industry is in question. While some argue that integration of the biofuel production with pulp production would create synergy that would ensure sustainability (Lewis, 2006), others might argue that the competitive nature of the industry might make it unsustainable as noticed Chen (2006) "… competitiveness is intrinsically incompatible with sustainability." To maintain sustainability, some restrictions may need to be imposed on our energy consumption. However, if "we succeeded in maintaining a sustainable lifestyle", history proved Dr. Chen (2006) that "we will then eventually be failed by a society that is more aggressive and adventurous in developing energy consuming technologies".

Chapter 5

BIOFUEL FINANCING

On one hand, for a biofuel production facility to be economically viable, it often needs to be of a significant size to reap the benefits of economies of scale; on the other hand, large production facilities require significant capital investments which may require skilful financing arrangements. The capital intensive nature of the emerging biofuel technologies and the high risks associated with any new (unproven) technology require new financing options which include not only traditional and conventional methods but also strategic partnerships with governments and different industries in order to reduce the level of perceived risks and provide a testing ground for these technologies to mature and provide first mover advantage to the partners. In this chapter, we will review the financing options currently available and that can be used to develop a new biofuel economy in BC in general and in Northern BC in particular.

Before dealing with any financing aspect for a project or a company, it is important to assess the entire amount of capital required and at what cost this capital should be acquired. The required amount of capital should cover all major costs involved in the project. These costs would include (but not limited to) the capital costs for purchasing all equipment; the costs for engineering feasibility studies; the costs for constructing the plant; installation and start-up costs; operating and maintenance costs; costs for initial research and development which might be required to optimize the process; etc. Depending on the size and legal form of business (i.e., proprietorship, partnership or corporation) of the entity which needs the funds, the financing options can be very different. While most large companies can fund innovation projects internally, new technology start-ups must often obtain external financing (Schilling, 2005). Because technology start-ups often have both unproven technology and an unproven business concept (and sometimes an unproven management team), they often face a much higher cost of capital than larger competitors, and their options for obtaining capital can be very limited (Schilling, 2005). In general, during the first stages of start-up and growth, entrepreneurs may have to turn to friends, family, and personal debt (Schilling, 2005). At the same time, start-ups may also be able to obtain some initial funding in the forms of grants or loans through government agencies. If the idea and the management team seem promising enough, the entrepreneur can leverage initial funding agreements to facilitate partnerships or to tap to other investors such as "angel investors" and venture capitalists as both sources of funds and mentoring (Schilling, 2005). As new technology companies grow, become mature and prove themselves, they may be able to tap to bigger capital markets (stocks, etc). In the following sections, we will elaborate more on the different options explaining their advantages and potential limitations.

5.1. RAISING FUNDS USING FAMILY, FRIENDS OR CREDIT CARDS

Due to the risky nature of the new and often unproven technology and/or management, entrepreneurs must often rely on friends and family members that are willing to provide initial funding either in the form of a loan or an exchange for equity in the company. Alternatively, the entrepreneur may try to obtain debt financing from a local bank. Apparently, a large number of start-ups are actually funded with credit cards, resulting in very high interest rates. Funding requirements at this stage seldom exceed $50,000

(Schilling, 2005; Kerr; 2007). A list of the major banks can be found in the yellow pages of the telephone directory under the headings “Banks” and “Investment Advisory Services”.

5.2 RAISING FUNDS USING GOVERNMENTS INCENTIVE PROGRAMS

In Canada, there are federal and provincial governments’ programs in the forms of loans, grants and other financial incentives that are designed to foster entrepreneurship and innovation. A list of the federal government programs can be found on the website: www.strategis.ic.gc.ca. In addition to the federal government, additional funds can also be found at the provincial and local levels.

The effective use of all the incentive programmes that are being announced by the federal and provincial governments can significantly reduce development and start-up costs for a biofuel industry in Canada in general and in Northern BC in particular.

In general the incentive programmes tend to promote R&D as well as commercialization of promising technologies. The federal government’s Science Research & Experimental Development (SR&ED) program can provide to Canadian-controlled private corporations up to 35% in tax credit which is topped up in BC by the provincial government with an additional 10% credit. For other types of business organisation the amount of SR&ED tax credit is about 20% (Workshop at UNBC March 19, 2007).

Combining all of the potential incentives from several government portfolios can significantly reduce the development cost of biofuel technology as well as the cost for implementing this technology in the industry.

At the federal level, the following departments should be approached: Agriculture and Agri-food Canada, Natural Resources Canada, Environment Canada and Industry Canada; at the provincial level in BC the following ministries would be of interest: Ministry of Energy, Mines and Petroleum Resources; Ministry of Forests and Range; Ministry of Agriculture and Lands; Ministry of Economic Development; Ministry of Environment; Ministry of transportation; Ministry of Finance and the Ministry for small Business & Revenue. Major Crown corporations such as BC Hydro, BC Transit, Insurance Corporation of British Columbia (ICBC) and BC Rail may also be interested in supporting biofuel initiatives.

In general, assistance from local level government may be used to leverage more funding from the provincial government. The funding from the provincial government may also be used to leverage assistance from the federal government. The assistance programs from all levels of government can be used as leverage for amounts up to $500,000 (Kerr, 2007).

While the government's grants may not require any payback and the loan terms are very generous, there are also several serious limitations with the government's programmes (See Table 5.1).

Table 5.1: Summary of advantages and disadvantages of Canadian government programs (Kerr, 2007)

Advantages	Disadvantages
• Grants do not require payback. • Collaborative contributions may usually require only 50% support with no payback on the government's share. • Loans have very forgiving terms and are usually renegotiable. • Good way to lever funds and reduce bank risk. • Government employees usually want to help for success. • Some programs come with free advisory help; for example with IRAP you get money and free technology expertise at your fingertips.	• The process can be onerous to get an application in and it is not timely. • Process may involve a team of people that may not understand the particular technology. • Funding can dry up or may only be available at certain times • Funding can be based on quality of application and not on merit and sometimes funds can be divided among applications received. • Audits of fund use may be done for up to 5 years after the funding was offered. • Claim processes can be time consuming. One can spend a lot of time tracking and proving expenditure for cost incurred programs – ex. Time records and cheques being cashed. • Terms and conditions can limit your firm for the future – One needs to know where one is heading first before applying for government assistance.

5.2.1 Strategy Initiatives for the Development of a National Biofuel Incentive Program

Extensive consultations were conducted with various stakeholders at the federal and provincial levels to examine the benefits of, barriers to, and policy measures needed for, a vibrant Canadian biofuel industry. In additions to these consultations, several interest groups including the Canadian Renewable Fuels Association (CRFA), the Canadian Forest Innovation Council, the BC Biorefining Institute, BIOCAP Canada Foundation (BIOCAP) and the Canadian Bioenergy Corporation, have also produced comprehensive strategy reports (CFIC, 2006; BC Bioenergy December 8th & 15th, 2006) that can be used as guides for policy makers. It was hoped that these reports would fast track the development of a national initiative for reducing greenhouse gas emissions which could help the country to achieve competency in “green” technologies. These “green” technologies can be expected to be in huge demand as countries around the world try to reduce their green house gas emissions in order to fight global climate change.

Some of the policy suggestions in the stakeholders’ strategy reports are aimed at increasing domestic biofuel production as well as ensuring a strong Canadian markets for biofuels (Globe-Net, March 23, 2007). For this to occur, CRFA recommended:

- Tax credits for liquid biofuel production, instead of the existing excise tax exemption
- Programs to encourage farmers for equity investment in renewable fuels production facilities and to support emerging technologies
- Clear standards for renewable fuels to ensure quality and safety.

On the other hand, the Canadian Bioenergy Corporation, the largest distributor of biodiesel in western Canada, was advocating for a tax credit for petroleum distributors to encourage them to allow their pipelines to be used for moving the biodiesel to market. According to the Canadian Bioenergy Corporation, that incentive was the biggest factor in getting volumes of the alternative fuel flowing in the US (Pratt, 2006).

The policy initiatives of the Canadian Forest Innovation Council (CFIC) are particularly geared at transforming the forestry industry to become what is now called as the “Forestry Biorefinery” which will produce not only pulp and lumber products but also bioenergy and biochemicals. CFIC produced several white papers on the topics (CFIC, 2006). One of these white papers was written by Mabee & Saddler (2006) and it examined how transformative technologies (including advanced thermo-chemical and bio-conversion systems) could be used to expand bioenergy production in Canada, and maximize the economic and environmental benefits to the industry. CFIC also identified the key barriers for implementation of the transformative technologies required for bioenergy production as being the following:

- Technology scale-up issue to achieve commercial viability
- Cross-sectoral stakeholders engagement for co-product development
- Development of standard biofuel specification to ensure product homogeneity and quality
- Lack of better understanding of feedstock availability
- Lack of green procurement policy to generate market-pull
- Lack of quantification of relative economic value of Canada's forest biomass as a feedstock for biofuels.

At the time CFIC's recommendations for action were (CFIC, 2006):

- Establishment of a fibre centre to study the best use of Canada's cellulose fibres
- Establishment of a biorefinery pilot
- Amalgamation of Canada's three forestry research centres (Paprican, Forintek and Feric) into one single institute, (now called FP Innovations and became official in April the 2nd, 2007).

Other biorefinery strategy initiatives were later developed in BC, with Forintek being instrumental in the process for developing a BC Biorefinery strategy and Paprican and Papier leading the initiative for the development of a national biorefining research program (BC

Biorefining, Dec. 8^{th} and Dec. 15^{th}, 2006). The BC Bioenergy/Biorefining Initiative Group which is comprised of several stakeholders including (government departments, universities, research institutions, industry representatives, etc) came up with important suggestions such as (BC Biorefining, Dec 8^{th} and Dec 15^{th}, 2006):

- The need to link technology development with policy (tax system, public education, etc)
- Driver should be a business push which engages a technology pull, industry engagement is important.
- Importance to harness talents at BC's universities.
- The governance of a BC initiative hinges on the investors directing the research not simply advising.
- A role for First Nations was seen as highly desirable.
- The need for integrating feedstock systems to include forestry, agriculture, municipal solid waste and others.
- Importance to have collaboration with other provinces (Alberta), other industries (Oil & Gas) and other countries (USA and the European Union).
- Importance to have successful technology demonstration.
- Finding some mechanism for carbon exchange.

Most of these suggestions are expected to be included in the BC Bioenergy Strategy Report to be released later this year.

BIOCAP with the Canadian Agri-food Research Council (CARC) conducted also a comprehensive "assessment of the opportunities and challenges of a bio-based economy for Agriculture and food research in Canada" (CARC & BIOCAP, 2003).

The intensive work conducted by the various stakeholders for the rapid development of a vibrant biofuel economy in Canada, is starting to bear results. The federal and provincial governments are realizing the huge potential offered by the emerging biofuel technologies in helping the country reduce its greenhouse gas emissions while helping to diversify both the forestry and agriculture industries. The governments are also realizing that investment in the development of biofuel technology is necessary to help the country join the global race for leadership in green technology. In the past two months several major initiatives were announced by the federal government as well by several provincial governments including British Columbia.

5.2.2 Relevant Incentive Programmes at the Federal Level

Several initiatives were announced by the federal government in the last few months. These include policy initiatives as well as spending incentives that were summarized in the 2007 federal government's Budget delivered on March 19, 2007. In this budget, there were a number of spending initiatives that can have positive impact on the development of an emerging biofuel economy while helping at the same time to reduce green house gas emission. These financial incentives are summarized as follows (Federal Budget 2007; GLOBE-Net, Ottawa, March 19, 2007):

- Up to $1.5 billion over seven years as operating incentive/subsidies for producers of renewable fuels such as ethanol and biodiesel. Eligible producers would receive up to $0.10/L for renewable alternatives to gasoline and up to $0.20/L for renewable alternatives to diesel for the first three years, and a declining amount thereafter. Conditions will be imposed to ensure that the industry does not earn excessive profits, and incentives will not be provided when rates of return exceed 20 per cent, determined annually. Support for individual companies will be capped to ensure that both small players and large oil producers are able to receive funding.

- $500 million over seven years will be administered by Sustainable Development Technology Canada (SDTC) to support the construction of commercial production facilities for "next-generation renewable fuels", or cellulose-based fuels produced from agricultural and wood waste.

- $1.48 billion in 'ecoTrust' funding to help provinces launch projects to reduce greenhouse gas emissions and air pollution. $200 million of the ecotrust fund are allocated to BC's "Hydrogen Highway" projects that are relative to the construction of recharging stations for fuel cells to cut down on greenhouse gas emissions.

- Excise tax exemption for ethanol and biodiesel as of April 1, 2008. The removal of the excise tax and its replacement with a tax credit had been requested by biofuel producers.

- The extension of the "Accelerated Capital Cost Allowance for Clean Energy Generation (ACCA-CE)" to equipment acquired before 2020 and its expansion to renewable technology applications is a good incentive for projects that improve energy efficiency or use renewable energy such as biomass or biofuel.

- The phasing out of the tax break for oil sands developers, as well as the removal by 2015 of the accelerated capital cost allowance for general investment in the oil sands, could help indirectly the biofuel industry as these measures may increase gasoline price, thereby reducing the price differential between the two types of fuels.

- A rebate of up to $2,000 for the purchase of a new fuel-efficient vehicle, and a Green Levy on new fuel-inefficient vehicles may also help indirectly the biofuel industry by encouraging biofuel consumption.

There are policy initiatives that were also announced by the federal government; among these, are:

- Announcement last year that required that all gasoline sold in Canada have at least five percent ethanol content by 2010 and that all diesel fuel and heating oil sold in Canada have at least two percent biodiesel content by 2012.

- On April 1, 2007, a new Cabinet Directive on Streamlining Regulation will come into effect. The directive will attempt to focus resources on “larger, more significant regulatory proposals”, and will establish service standards for regulatory reviews, along with periodic reviews of the process. Based in part on a model employed by British Columbia, the budget also includes a plan to reduce the administrative and paper burden on businesses by 20 percent by November 2008, which could mean less regulatory filing requirements related to environmental impacts [GLOBE-Net, Ottawa, March 19, 2007].

- To shorten regulatory timelines for project proponents, the government will establish a Major Projects Management Office to provide a single window on the federal regulatory process for industry, and "improve overall accountability by monitoring and reporting on the performance of federal regulatory departments".

- Budget 2007 also announced new funding to increase staff in certain regulatory departments and agencies to reduce project review times. According to the government, these measures will cut in half the average regulatory review period for large natural resource projects, from four years to about two years.

- The federal government has also indicated it will issue its climate change plan, including regulations for industrial greenhouse gas emitters, by the end of March 2007, with specified targets and compliance mechanisms. The plan is expected to include emissions trading, and an environmental technology fund that will be supplied by those who exceed their limits. This regulation can become an important driver for technology development in the areas of carbon capture, carbon sequestration and advanced biofuel generation (GLOBE-Net, March 19, 2007).

5.2.3 Relevant Incentives Programmes in BC

The provincial government in BC is developing its own biofuel strategy. In February 2007, a bioenergy plan was revealed (The BC Energy Plan: a Vision for Clean Energy Leadership). The plan includes:

- A $25 million innovative clean energy fund to support projects that will show case new energy technology.
- An $89 million dollars investment in a hydrogen fuel cell bus fleet and fuelling infrastructure between Vancouver and Whistler for the 2010 Olympics as part of a broader fuel cell strategy. This can indirectly have a positive impact on hydrogen production from biomass.
- An order to BC hydro to make standing offer to purchase power from green energy projects and efficient cogeneration plants under 10MW. BC Hydro is supposed to pay rates at $71 per megawatt hour. The development of small cogeneration units is seen as being more economical for heat and electricity production in smaller communities.
- By 2010, the province will require that gasoline and diesel sold in BC include five percent biofuel (ethanol or biodiesel).
- The province also plans to use the vast amount of pine beetle wood to produce biofuels such as ethanol and biodiesel.
- A more detailed bioenergy strategy is expected to be released soon.

The BC bioenergy plan lacks specifics and details. It does not mention how to overcome cost barriers of using the massive amount of pine beetle killed timber and wood wastes;

it does not have any target set for how much energy the province plans to produce from the beetle killed timber and wood waste, or even when the province expects to start the biofuel production. There is also no timeline set for the proposal call to be made by BC Hydro for electricity generation from biomass. Finally there was no financial analysis in the bioenergy plan on how much it will cost the province or how much it would cost to accelerate it. It is hoped that some of these deficiencies in the BC 2007 Energy plan will be addressed in the Bioenergy Strategy Report to be released soon.

The major issue with both the federal and provincial funding initiatives is that these initiatives take a long time to implement and some time these funds may not even have money available by the time they get implemented.

5.3. FINANCING THROUGH STRATEGIC PARTNERSHIPS

Another source of finance for the capital and technology intensive biofuel industry is strategic partnership with appropriate stakeholders with critical or complementary competencies that can help to overcome barriers and create synergy. The strategic alliance can be either highly structured as in a joint-venture or just informal. Sometimes instead of partnering in every aspect of the business, part of the business or services may be licensed or outsourced. Licensing involves the selling of rights to use a particular technology or other resource from a licensor to a licensee. Licensing is a fast way of accessing or leveraging a technology, but offers little opportunity for the development of new capabilities (Schilling, Page 160, 2005). Outsourcing would enable a firm to rapidly access another firm's expertise, scale or other advantages. Firm might outsource particular activities so that they can avoid the fixed asset commitment of performing those activities in-house. For example instead of manufacturing biodiesel or bioethanol in-house, a company might outsource the manufacturing portion and just focus on the distribution of the finished product. A joint venture partnership between firms usually entails significant equity investment and often results in the creation of a new separate entity. Joint venture is usually designed to enable partners to share the costs and risks of a project and to have great potential for pooling or transferring capabilities between firms. In general, strategic partnership involves risk sharing that can increase financial investment and stimulate local private sector participation. For the partnership to be successful, a careful selection of the partners that have both a resource fit and a strategic fit must be done. The partnership would need clear and flexible monitoring and governance mechanisms to ensure that partners understand their rights and obligations, and have methods of evaluating and enforcing each partner's adherence to these rights and obligations (Schilling, 2005, Page 161). For the biofuel industry, there are several partnership scenarios that can help:

i) Partnership Between Forestry Companies and The Oil and Gas Industry

The forestry industry has experience with wood handling, processing and logistics. The oil and gas industry has experience in refinery, oil processing and distribution. The oil and gas companies also have the financial strength to invest in the biofuel industry without undue hardship. Furthermore, the oil and gas industry has already the infrastructure for transporting liquid and gaseous fuels. The liquid biofuel can be a complementary good to fossil fuel in the short and medium term, and a substitute product in the longer term. It may be highly valuable for the oil and gas industry to invest in what might be part of their value chain. The forestry companies, particularly, the pulp and paper industry have also a great knowledge of biomass and valuable experience with biomass handling and processing. Their facilities are ideal locations for producing biofuel and the technology can nicely be integrated with Kraft pulp processing. Capital cost and operating cost can significantly be reduced if an advanced biofuel plant were integrated with a Kraft pulp mill. This situation seems ideal for Northern BC and particularly for Prince George where both a major oil refinery such as Husky Oil coexists beside three major pulp and paper mills owned by Canfor. The concept of integrating biofuel production with pulp making is part of a larger initiative by the pulp and paper industry; and it is called the integrated pulp mill forest biorefinery. This forest biorefinery concept is not limited to Prince George alone. It can be suitable for most pulp and paper mills in Northern BC.

ii) Partnership Between Forestry, Farming and other Industries

Other industries in Northern BC such as mining industry or public utilities such as BC Hydro can benefit from investment in biofuel technology. As some of the technology may be more suitable for remote location and can help reduce green house gas emission.

iii) Partnership Between Technology Developers and Research Institutes, Higher Learning Institutions and Other Public Institutions.

The partnership may also involve institutions for higher learning (such as universities and colleges), research institutes (such as FP Innovations) and federal institutions that promote technology development such as Industry Canada, Agriculture and Agri-food Canada, Natural Resources Canada or the Ministry of Environment or provincial government institutions such as BC Ministries of Agriculture or that of Energy & Mines or the Ministry of Forests and Range. Part of the government funding may come to support research and development activities and these funding can be obtained through the Natural Sciences and Engineering Research Council (NSERC), the Industrial Research Assistance Program (IRAP), Sustainable Development Technology Canada (SDTC) or Natural Resources Canada (NRCan). The protocol for funding by these institutions can be found on their websites also listed in Appendix V.

Partnership can also be done by putting together local assets and talents. In Northern BC, the Northern Development Initiative Trust (Northern Trust) can be a valuable partner for facilitating financing for promising biofuel industry which has the support of the communities. While on normal circumstances, Northern Trust does not loan or grant money to private businesses; on a case per case basis it can provide investment loans for biofuel initiatives with strong community backing. Northern Trust website is shown in Appendix V.

iv) Inter-Provincial Partnership

This can be done between British Columbia and Alberta for example. While BC is a forestry rich province with abundance of biomass materials, the province of Alberta, has strong expertise in petrochemical technology, and it has a surplus cash flow. Alberta also has large amounts of agricultural residues to dispose of and it may also soon have to deal with the mountain pine beetle infestation. Therefore, one would expect Alberta to be interested in finding alternative solutions for reducing its greenhouse gas emissions as well as finding way to diversify its economy. A partnership between Northern BC and Alberta would create synergy for the development of a biofuel economy in the two provinces.

v) International Partnership

Collaborations with international partners in the USA and in the European Union could also be beneficial for BC and Northern BC. The EU has been investing in research and development of biofuel technologies for long time and they can be valuable partners and potential market for surplus biofuel products. The USA has been investing heavily recently in developing advance biofuel technology as a means to reduce their dependency on imported oil and also as an alternative solution to curbing their greenhouse gas emissions. The majority of the funding for biofuel technology in the USA is through the US Department of Energy and the Department of Agriculture. Other financing options in the US may be found on the Small Business Administration website shown in Appendix V. These US government fundings would require that the work be conducted in collaboration with a recognized American University, research laboratory or company. It is important to check with the institutions involved what are the restrictions and limitations on the grants before even applying.

5.4 RAISING FUNDS USING CONVENTIONAL FINANCING METHODS

In conventional finance, capital is raised through a combination of debt/loan and equity. The debt to equity ratio is a major indicator of the financial health of a company. This measure would therefore tend to be quite large for emerging technologies and for company which are growing. The cost of raising this capital is function of the relative proportion of debt and equity required. This cost is usually referred as the weighted average cost of capital and its definition can be found in most finance text books.

5.4.1 Equity Investment

Equity can be procured from internal sources or from external investors in public or private markets. Equity investors and lenders view and analyze investment projects very differently. Equity investors analyze investments from a risk-return trade-off with an emphasis on the expected investment return. They are usually willing to take high risk with the prospect of a higher return. There are two specific types of equity investors called "Angel Investors" and "Venture Capitalists".

5.4.1.1 Angel Investors

Angel investors are wealthy individuals who have been successful in business and who would fund projects as private investors without utilizing a venture capital limited partnership structure (Schilling, 2005). They invest for the thrill of entrepreneurship and sometimes for the opportunity of mentoring start-up companies. "Angels" typically fund projects that are one million dollars or less. The returns Angels make on their successful investments far exceed what they lose on the bad ones. Angels are usually not listed in public directories, but are identified through professional networks (Schilling, 2005). A large number of start-ups obtain "seed stage" (before there is a real product or the company is organized) financing from angels investors. In the US, the average investment per angel investor is between 350,000 and 700, 000 dollars and about 50,000 projects were funded in 2000 by angels (Schilling, 2005).

5.4.1.2 Venture Capitalists

For projects that require more than one million dollars, entrepreneurs often turn to a specific group of equity investors called venture capitalists (Schilling, 2005). They are financial investors who make high-risk, equity investment in entrepreneurial businesses deemed capable of rapid growth and high investment returns. They purchase a significant fraction of company and take an active policy role in management. Their goal is to liquidate their investment in five to six years when the company goes public or sells out to another firm.

Venture capital firms routinely consider as many as hundred candidates for every investment made and expect to suffer a number of failures for each investment success. In return, they expect winners to return five to ten times their initial investment (Higgins 2004). There are two types of venture capitalists: wealthy individuals often referred to as "angels" (discussed in section 5.4.1.1) and professional venture capital companies. Most venture capital firms employ an unusual form of organization known as a private equity partnership (Higgins, 2004). Instead of using the conventional public company form, private equity partnerships are privately owned limited partnerships with a specified life of ten years or less (Higgins, 2004). Acting as general partner, a venture capital firm raises a pool of money from institutional investors, such as pension funds, college endowments, and insurance companies, who become the limited partners. As limited partners the institutional investors enjoy the same limited liability protections afforded by the corporate shareholders. The venture capital firm then invests the money, manages the portfolio of start-ups, liquidates the portfolio, and returns the proceeds to the limited partners. In return, the venture capital firm charges the limited partners an annual management fee of 1 to 2% of their original investment, plus what is known as a carried interest, typically equal to 20% of any capital appreciation on portfolio companies. The amount of money invested by venture capitalists has grown exponentially during the last decade and is still growing. Part of that growth is due to a special group of venture capitalists called the strategic investors. Strategic investors are operating companies, frequently potential competitors that make significant equity investments in start-ups as a way to gain access to promising new products and technology (Higgins, 2004). Some strategic investors have come to view venture investing as an alternative form of research and development. Rather than developing all new products in-house, they sprinkle money across a number of promising start-ups, expecting to acquire any that prove successful (Higgins, 2004). Other special situations attracting private equity money are leveraged buyouts, rollup acquisitions, and distressed firms – often referred to as "vulture investing" (Higgins, 2004). In Northern BC, most major chartered banks have investment banking division or subsidiaries that provide venture capital. In addition to the major banks, the Bank of Development of Canada (BDC), Canaccord Capital Corporation (Canaccord) and Export-Canada provide venture capital support for certain types of business investment. In addition to the major chartered banks, Canaccord and BDC, information about venture capital groups can also be found with following:

- The Chamber of commerce in most major cities (Prince George, Vancouver, etc)
- The City's Economic Development offices such as the Community Futures Development Corporation of Fraser Fort George, the Aboriginal Business Development Centres, etc.
- Corporate lawyers and major accounting firms
- The finance or business administration departments of most major universities such

as the University of Northern British Columbia (UNBC), the University of British Columbia (UBC), Simon Fraser University (SFU), etc

- The Yellow Pages of the telephone directory (Vancouver, Prince George, etc)
- The Canadian Venture Capital and Private Equity Association
- The US National Venture Capital Association
- Networking

In 2002, in the USA, the average venture capital deal was almost 10.5 million dollars, and the vast majority of those deals were in the biotechnology, computer hardware and software, and wireless telecommunications industries (Schilling, 2005).

5.4.2 Debt / Loan Investment

Loans can be obtained from family, friends and angels or through public markets in terms of bonds or through private placements with banks or with other institutional lenders. The loan agreements (covenants) can be structured in so many different ways and it is important to properly negotiate those covenants.

5.4.2.1 Institutional Lenders

While in one hand venture capitalists seek high risk, high return investments, most lenders, on the other hand, tend to be far more risk averse and are not in the venture capital business. The debt contract is a fixed obligation and the lender does not profit, beyond a certain level, from project (or firm) success. Up to the limit of unacceptable risk, lenders adjust debt interest rates and terms for default risk (e.g., higher interest rates on riskier loans). As a result of credit rationing, however, lenders will simply not take some risks. If a project (or firm) is likely to default or come close to default in any single year, lenders will often not supply a loan. Therefore, unlike equity investors, lenders typically analyze a project (or firm) from a worst-case perspective (Kahn and Stoft, 1989). The major lending institutions in Canada include the chartered banks, investment banks, and other depository institutions – trust companies, credit unions, investment dealers, insurance companies, pension funds and mutual funds (Ross et al, 2005). The difference between the different financial institutions can be found in Page 18 of Ross et al. (2005). Another major lender and provider of venture capital, is the Bank of development of Canada (BDC) which is a financial institution wholly owned by the Government of Canada. BDC plays a leadership role in delivering financial and consulting services to Canadian small and medium-sized businesses, with a particular focus on the technology and export sectors of the economy (BDC, 2007).

In general the cost of debt with major lending institutions for a start-up of unproven technology can expect to be five to ten percentage points above bank of Canada risk free premium.

5.5 FINANCING OF THE CAPITAL RAISED

As mentioned in Section 4, investment capitals are raised as a combination of debt and equity which both need financing. Major debts such as those required to develop the biofuel industry can only be afforded by large corporations which may chose to finance them either as projects or as corporation. The two financing methods differ primarily in how the debt is structured.

5.5.1 Project Financing

In project financing lenders look primarily to the cash flow and assets of a specific project for repayment rather than to the assets or credit of the promoter of the facility. The strength of the underlying contractual relationships among various parties is essential in project financing. Support for a loan in project financing would have to come in large part from the revenues associated with the product biofuel purchase agreement. Therefore, long-term biofuel purchase commitments that, at least partially, guarantees a revenue stream, would be essential, especially for high capital-cost technologies such as biofuel production facilities. An unpredictable or unspecified revenue stream is a risk that most project financing lenders are unwilling to take. Debt is frequently less costly than equity (Brealey and Myers, 1991). As such, there is a tendency for developers to maximize debt leverage (i.e., the percent of debt used to finance a project) under project financing. This tendency is limited, in part, by debt service coverage requirements. In the case of non-utility power generators, debt is most often obtained via the private placement market, often from commercial banks or institutional lenders, although publicly placed debt has also been used (Wiser & Pickle, March 1997). Equity was usually acquired from internal sources (i.e., from the developer and/or its parent corporation) or from third-party investors (institutional investors, subsidiaries, etc.).

5.5.2 Corporate financing

In corporate financing, lenders look to the entire corporate balance sheet for repayment. Corporate financing (often called internal or balance-sheet financing) therefore lacks the degree of asset-specificity found in project financing (Wiser and Pickle, March 1997). The primary requirement made by lenders in corporate financing is a restriction on the issuing of debt beyond certain limits (Smith and Warner, 1979). Additional debt can hurt bondholders and other lenders because it reduces the ability of a firm to pay interest on existing debt. The use of corporate financing to supply the capital needs of individual projects is common for most corporations.

5.5.3 The Difference Between the Two Financing Options

Wiser and Pickle, (March 1997) compared the two types of financing options in the context of power generation using renewable energy, and they concluded that project financing has several advantages to corporate financing. Loans are generally non-recourse (sometimes limited-recourse) to the parent company and therefore do not have a substantial impact on the company's balance sheet or credit worthiness (Wiser & Pickle, March 1997). As a result, small- and medium-sized developers are free to pursue several projects simultaneously without large negative company-wide impacts. In addition, the reduced market risks and the non-recourse nature of debt in project financing allow higher debt to equity ratios, which can result in reduced financing costs (Wiser & Pickle, March 1997). Nevitt (1983) and Brown (1994) identify a number of negative aspects of project financing compared to corporate financing, including the large transaction costs of arranging the various contracts, high legal fees, higher debt costs, and a greater array of restrictive loan covenants.

Chapter 6

SUMMARY: A SOLUTION FOR NORTHERN BC

With the Pine Beetle infestation which is affecting an estimated 8 million hectares of forest land in Central and Northern British Columbia, there is an abundance of biomass material which has already lost its timber value but can be used for biofuel production. With a well thought out strategy, this tragedy can be used to diversify Northern BC's economy which currently is predominantly based on forestry. This can be the opportunity for starting a vibrant and profitable new economy based on renewable biofuel.

Northern BC already has a well developed forestry industry with several pulp and paper manufacturing companies in addition to the saw mills and other wood processing industries. The area has oil and gas experience. There is also a light oil refinery in Prince George just beside three major pulp and paper mills which can produce close to 3500 air dried tonnes of kraft pulp per day. With an integrated forest bio-refinery in the pulp and paper mills, Prince George's pulp mills could generate between 156 and 265 million litres of ethanol per year (assuming 340 days of operation) with no disruption in pulp production. The capital investment required would be between US$1.05/L and US$1.84 L depending on the size of the plant. The high investment costs for the bio-refinery could be mitigated by having several partners including the oil and gas industry and the governments (both federal and provincial). Several incentive programmes were announced by both levels of government and one would expect more to be announced within the BC Bioenergy Strategy initiatives.

In addition to the pulp mill bio-refinery, other emerging, smaller scale biofuel industries and technologies would need to be promoted in Northern BC. The mobile (type) pyrolysis unit being experimented in Ontario should be tried in Northern BC. Smaller scale gasification units could be tried for rural areas, particularly for power generation.

Although so far untapped, land fill gases also offer an opportunity for further exploration. As indicated by the Foothills Boulevard Regional Landfill annual report, methane gas collected at the landfill can be used to produce the annual energy requirement for 440 homes. Further studies are needed to investigate the additional investment costs required to either sell this gas to natural gas distributors or to use it for on-site electricity generation.

There are a number of barriers that can hamper the development of an advanced biofuel industry in Prince George. Among these are high capital costs, financing of new technology and, technological challenges. High capital costs could be offset by using appropriate incentives; financing could be leveraged through public/private partnerships, and local talents and assets could help mitigate the technological challenges, while helping the university to develop an expertise in bio-refining and bio-energy.

Prince George has the ability to position itself as a leader in the new bio-fuel economy by proactively addressing these issues.

Chapter 7

CONCLUSION

In spite of the abundance of biomass feedstock in Northern British Columbia (BC) and the existence of a mature forest products industry, biofuel education and industry are slow to develop. Several barriers, including lack of awareness, lack of capital, lack of incentives, lack of guarantee for long-term availability of feedstock, and technological limitation are impeding the development of this industry.

This study uses both primary and secondary sources of information, as well as exploratory research to evaluate:

1. The nature of biomass feedstock available in BC and in Northern BC
2. The status of the technologies that are emerging in the market place for conversion of these feedstocks into fuels and chemicals.
3. The incentives in place at the provincial and federal levels to assist and promote the development of a bio-fuel industry in Northern BC.
4. The options that are available and can be used to finance these technologies in Northern British Columbia.

It is found that:

- British Columbia has a wide variety of biomass feedstocks. However, wood and wood residues are the most predominant sources of biomass. The province was forecasted to have 1.5 million bone dry tonnes of surplus wood residues in 2005

(McCloy, 2003) and this surplus wood residues did not even include the beetle killed wood.

- British Columbia does not produce very much Canola (only 16,000 tonnes in 2001) and 75% of the corn produced in BC is used up by the food processing industry. However, British Columbia produces annually an estimated 99,000 tonnes of agricultural residues and six million tonnes of recoverable manure. The manure alone if collected could generate about 115 million m^3 of methane per year with a net heat value of more than 4 million Giga Joules (GJ). Assuming a natural gas price of $8/GJ, this amount of methane would generate $32 million of annual gross revenue. This revenue stream does not take into account the cost of collecting the manure and capital and operating cost of the digesters. Although not addressed in this report, it would be certainly desirable to evaluate the net revenue stream this renewable fuel can generate, rather than just the gross amount.
- At the Foothills Boulevard Regional Landfill, the regional district has installed a landfill gas collection system that collects enough methane gas to replace the natural gas requirement for 440 homes (FBRL, 2005). Although, the system has been in place since 2002, so far the gas is not being used as a source of energy. Even though burning of the methane was helping to reduce greenhouse gas emission by 15,000 tonnes of CO_2 equivalent (FBRL, 2005), the potential for energy usage remains untapped.
- Biosolids in Prince George do not represent a huge biomass resource and energy potential through combustion is minimal. However, the fermentation treatment of

biosolids can prove worthwhile and may provide additional potential for contribution to the municipal energy grid.

- There are several biofuel production technologies. Some are at a mature commercial stage while others are further away. The mature technologies are wood pellet manufacturing; biomass combustion for power generation, fermentation to produce bio-ethanol from cereal crops, and trans-esterification to produce bio-diesel from waste oil or from oilseeds. The technologies at near-commercial stage include fermentation of cellulose and hemicellulose to produce ethanol, gasification, and pyrolysis to produce biofuels and biochemicals. Presently the major barriers for the demonstration of these technologies are their high capital costs and difficulty in financing new technologies.
- There are several ways to finance these new technologies. In addition to conventional financing methods, government grants and loans and tapping angel investors and venture capitalists could prove very useful. The political climate is resulting in a multitude of incentive programmes at all levels of government. In addition, strategic partnerships with complementary partners could help to mitigate the risks.
- With a mature forest industry, the presence of an oil and gas industry, the presence of research oriented university, and the proximity of Alberta, the concept of pulp mill bio-refinery seems viable and timely for Northern BC

To take advantage of the huge opportunity in the new biomass based economy, Prince George could take a leadership role in developing a roadmap which focuses mainly on the North and provides guidance for the provincial bioenergy strategy. A centre of research focusing on bio-refining opportunities for the North would be a useful complement and would assist Prince George in achieving its goals of civic responsibility and economic growth.

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APPENDIX I

Companies Active in the commercialization and R&D of biomass Technologies

Table I.1: Companies Active in the commercialization and R&D of biomass fermentation

Companies	Address	Contact	Activity/ Claim
Bioengineering Resources Inc or BRI Energy LLC	1650 East Emmaus Road Fayetteville, AR 72701	William Bruce, President Phone: (479) 521-2745 Internet: www.brienergy.com	• Claim: A breakthrough to produce cellulose based ethanol. • Planning to have a commercial facility in 2007.
Celunol Corporation (Formerly BC International Corp)	980 Washington Street Dedham, Massachussetts 02026 USA	Michael Dennis, President & CEO Phone: (781) 461-5700 Internet: www.celunol.com	• Claim: A patented process to make cellulose based ethanol. • Constructing a pilot facility near Jennings, Louisiana. • Planning a commercial facility at the same location
Iogen	300 Hunt Club Road East Ottawa, Ontario K1V 1C1 Canada	Brian Foody, President Phone: (613) 733-9830 Internet: www.iogen.ca	• Focus mainly on switch grass and wheat straws • Has a large scale ($40 million) demonstration facility in Ottawa, Ontario • Claim: Can use hardwood as feedstock.
Mascoma Corporation	161 First Street Second Floor East Cambridge, Massachussetts 02142 USA	Colin South, CEO Phone: (617) 234-0099 Internet: www.mascoma.com.	• Cellulosic ethanol • Planning to construct a facility in 2007.
Xethanol Corporation	1185 Avenue of the Americas, 20th floor New York, NY 10036 USA	Christopher D.Arnault-Taylor, Chairman & CEO Internet: www.xethanol.com Phone: (646) 723-4000	• Indicated intention to purchase a major manufacturing facility from the pharmaceutical company Pfizer to use for ethanol production.
C2 Biofuels	Atlanta, GA	Roger Reisert	• Planning to build a wood to ethanol pilot facility in Georgia, USA, in 2007. • Partnering with Georgia Tech and the University of Georgia on developing the process and designing the plant.

Table I.2: Some of the Companies active in the commercialization and R&D of biomass gasification for biofuel production. For a complete listing consult: www.gasifiers.org

	Address	**Contact numbers**
Biomass Energy Concepts	850 Washington Road St Mary's, PA 15857 USA	www.becllcusa.com Phone: (814) 834-4470 Email: areinc@alltel.net
Carbona Corporation	2611 Marshfiel Road Vallejo, CA 94591 USA	Jim Patel, President Phone: (707) 553-9800 Email: carbona@carbona.us
Choren Industries GmbH	Frauensteiner Strasse Sq. 09599 Freiburg, Germany	Tom Blades, Managing Director and CEO Phone: 49 (0) 3731 26 62 0 www.choren.com
Enerkem Tecnologies Inc.	615 Boulevard Rene-Levesque West Suite 1220 Montreal, QC H3B 1P5 Canada	Phone: 514 875-0284 www.enerkem.com
EnerWaste International Corp.	Tom Dutcher, President P.O. Box 1194 Bellingham, WA 98227	Phone: (360) 738-1254 www.enerwatse.com
Global Concepts Inc.	1712 Pedregoso Place, SE Albuquerque, NM 87123 USA	Phone: (505) 294-5068 Email: globalc@peoplepc.com
Grand Teton Enterprises	5721 S. Mt. Vernon Spokane, WA 99223	Phone: (509) 939-6044 www.grandtetonentreprises.com
Interstate Waste technologies	17 Mystic Lane Malvern, PA 19355	Phone: (610) 644-1665 www.interstatewastetechnologies.com
Thermogenics, Inc.	7100-F Second Street NW Albuquerque, NM 87107 USA	Tom Taylor, President Phone: (505) 463-8422 www.thermogenics.com
Nexterra	Nexterra Energy Corp. Suite 950 - 650 West Georgia Street PO Box 11582 Vancouver BC V6B 4N8 Canada	Phone: (604) 637-2501 Fax: (604) 637-2506 Email: jrhone@nexterra.ca www.nexterra.ca
Vidir Machine Inc	Vidir Machine Inc Box 700 R0C 0A0 Arborg Canada	Raymond Dueck Phone: 204-364-2442 Fax: 204364-2454 email: Raymond@Vidir.com www.vidir.com
Kemestrie's Inc – BIOSYN	4245 Garlock Sherbrooke, Quebec, J1L 2C8 Canada	Nicolas Abatzoglou Phone : (819) 569-4888 Fax : (819) 569-8411 kem@interlinx.qc.ca

Table I.3: Companies active in the commercialization and R&D of biomass pyrolysis

	Address	Contact
DynaMotive Energy Systems Corporation	Angus Corporate Centre 1700 West 75th Avenue, Suite 230 Vancouver, BC V6P 6G2 Canada	Andrew Kingston, President & CEO Internet www.dynamotive.com Phone: (604) 267-6000
Ensyn Corporation	400 West 9th Street Wilmington, Delaware, USA	David Boulard Internet: www.ensyn.com Phone: (302) 425-3740
JND Group Limited (HQ)	Thrumpton Lane Retford, Nottinghamshire DN22 7AN England, UK	Internet: www.jnd.co.uk Phone: +44 (0) 1777-706-777
Renewable Oil International	3115 Northington Court P.O. Box 26 Florence, AL 35630, USA	Phillip C, Badger, President & Chief manager Internet: www.renewableoil.com Phone: (256) 740-5636

Table I.4: Companies actively seeking to commercialize fractionation technologies

Companies	Address	Contact
Biofine Renewables LLC	300 Bear Hill Road Waltham, MA 02541	Phone: (781) 6584-8331; Contact: Steve Fitzpatrick, President
Purevision Technologies, Inc.	511 McKinley Avenue Fort Lupton, CO 80621	Phone: (303) 857-4530 Contact: Ed Lehrburger, President & CEO

APPENDIX II
LIST OF CANADIAN FACILITIES THAT PRODUCE BIO-ETHANOL

http://www.ethanolmarketplace.com/plant/list/1

Accessed March 14, 2007

Company	Location	Capacity	Feedstock
Alberta.			
API Grain Processors	Red Deer, Alberta	26 million litres	Wheat
British Columbia			
Okanagan Biofuels Inc	Kelowna, BC		Wheat
Manitoba			
Mohawk Oil, Canada, Ltd.	Minnedosa, Manitoba	10 million litres	Wheat
Ontario			
Metalore Resources, Inc.	Ontario		Wheat
Commercial Alcohols, Inc.	Chatham, Ontario	150 million litres	Corn
Commercial Alcohols, Inc.	Chatham, Ontario		Corn
Seaway Grain Processors, Inc.	Cornwall, Ontario		Corn
Iogen	Ottawa, Ontario	3 million litres	Agricultural residues
Suncor Energy Products Ltd	Sarnia, Ontario		Corn
Commercial Alcohols, Inc.	Tiverton, Ontario	23 million litres	Corn
Quebec			
Tembec	Temiscaming, Quebec	17 million litres	Forestry
Commercial Alcohols, Inc.	Varennes, Quebec		Corn
Saskatchewan			
Pound-Maker Adventures, Ltd.	Lanigan, Saskatchewan	12 million litres	Wheat
Husky Oil Operations Ltd	Lloydminster, Saskatchewan		Wheat
Novamerica BioEnergy Corp	Weyburn, Saskatchewan		Wheat

APPENDIX III
LIST OF FACILITIES IN THE USA THAT PRODUCE BIO-ETHANOL

http://www.ethanolmarketplace.com/plant/list/1
Accessed March 14, 2007
Capacity in million US gallons per year

Company	Location	Capacity	Feedstock
	AZ		
Pinal Energy, LLC	Maricopa, AZ		Corn
	CA		
Golden Cheese Company of CA*	Corona, CA	5	Cheese whey
Phoenix Biofuels	Goshen, CA	25	Corn
Pacific Ethanol	Madera, CA		Corn
Parallel Products	R. Cucamonga, CA		
	CO		
Merrick / Coors	Golden, CO	1.5	Waste beer
Sterling Ethanol, LLC	Sterling, CO	42	Corn
Front Range Energy, LLC	Windsor, CO		Corn
	GA		
Wind Gap Farms	Baconton, GA	0.4	Brewery waste
	IA		
US BioEnergy Corp.	Albert City, IA		Corn
Otter Creek Ethanol, LLC*	Ashton, IA	55	Corn
Xethanol BioFuels, LLC	Blairstown, IA	5	Corn
Archer Daniels Midland	Cedar Rapids, IA		Corn
VeraSun Energy Corporation	Charles City, IA		Corn
Archer Daniels Midland	Clinton, IA		Corn
Tall Corn Ethanol, LLC*	Coon Rapids, IA	49	Corn
Amaizing Energy, LLC*	Denison, IA	40	Corn
Cargill, Inc.	Eddyville, IA	35	Corn
Voyager Ethanol, LLC	Emmetsburg, IA	52	Corn
Hawkeye Renewables, LLC	Fairbank, IA		Corn
VeraSun Energy Corporation	Ft. Dodge, IA		Corn
Quad-County Corn Processors*	Galva, IA	27	Corn
Corn, LP*	Goldfield, IA	50	Corn
Frontier Ethanol, LLC	Gowrie, IA		Corn
Iowa Ethanol, LLC*	Hanlontown, IA	50	Corn
Permeate Refining	Hopkinton, IA	1.5	Sugar / Starches
Hawkeye Renewables, LLC	Iowa Falls, IA		Corn
Horizon Ethanol, LLC	Jewell, IA	100	Corn
Midwest Grain Processors	Lakota, IA	95	Corn
Little Sioux Corn Processors, LP*	Marcus, IA	52	Corn
Golden Grain Energy, LLC*	Mason City, IA	40	Corn
Grain Processing Corp.	Muscatine, IA	20	Corn

Lincolnway Energy, LLC	Nevada, IA		Corn
Green Plains Renewable Energy	Shenandoah, IA		Corn
Siouxland Energy & Livestock Coop*	Sioux Center, IA	25	Corn
Pine Lake Corn Processors, LLC*	Steamboat Rock, IA	20	Corn
Big River Resources*	West Burlington, IA	40	Corn
IL			
Archer Daniels Midland	Decatur, IL		Corn
Adkins Energy, LLC	Lena, IL	40	Corn
Lincolnland Agri-Energy, LLC	Palestine, IL	48	Corn
Aventine Renewable Energy, LLC	Pekin, IL	100	Corn
MGP Ingredients, Inc.	Pekin, IL		Corn/wheat starch
Archer Daniels Midland	Peoria, IL		Corn
Illinois River Energy, LLC	Rochelle, IL		Corn
IN			
ASAlliances Biofuels, LLC	Linden, IN		Corn
Central Indiana Ethanol, LLC	Marion, IN		Corn
Iroquois Bio-Energy Company, LLC	Rensselaer, IN		Corn
New Energy Corp.	South Bend, IN	102	Corn
KS			
MGP Ingredients, Inc.	Atchison, KS		Corn/wheat starch
Western Plains Energy, LLC	Campus, KS	45	Corn
Abengoa Bioenergy Corp.	Colwich, KS	25	Corn/milo
Reeve Agri-Energy	Garden City, KS	12	Corn/milo
East Kansas Agri-Energy, LLC*	Garnett, KS	35	Corn
ESE Alcohol Inc.	Leoti, KS	1.5	Seed corn
Prairie Horizon Agri-Energy, LLC	Phillipsburg, KS		Corn
U.S. Energy Partners, LLC	Russell, KS	48	Milo/wheat
KY			
Commonwealth Agri-Energy, LLC*	Hopkinsville, KY	24	Corn
Parallel Products	Louisville, KY		Beverage waste
MI			
The Andersons Albion Ethanol LLC	Albion, MI		Corn
Michigan Ethanol, LLC	Caro, MI	50	Corn
US Bioenergy Corp.	Lake Odessa, MI		Corn
Midwest Grain Processors	Riga, MI		Corn
MN			
Agra Resources Coop. D.b.a. EXOL*	Albert Lea, MN	40	Corn
Bushmills Ethanol, Inc.*	Altwater, MN		Corn

Chippewa Valley Ethanol Co.*	Benson, MN	45	Corn
Ethanol2000, LLP*	Bingham Lake, MN	32	Corn
Minnesota Energy*	Buffalo Lake, MN	18	Corn
Al-Corn Clean Fuel*	Claremont, MN	35	Corn
Granite Falls Energy, LLC	Granite Falls, MN	45	Corn
Heron Lake BioEnergy, LLC	Heron Lake, MN		Corn
Northstar Ethanol, LLC	Lake Crystal, MN	52	Corn
Central MN Ethanol Coop*	Little Falls, MN	21.5	Corn
Agri-Energy, LLC*	Luverne, MN	21	Corn
Archer Daniels Midland	Marshall, MN		Corn
Land O' Lakes*	Melrose, MN	2.6	Cheese whey
DENCO, LLC*	Morris, MN	21.5	Corn
Pro-Corn, LLC*	Preston, MN	42	Corn
Corn Plus, LLP	Winnebago, MN	44	Corn
Heartland Corn Products*	Winthrop, MN	36	Corn
MO			
Golden Triangle Energy, LLC*	Craig, MO	20	Corn
Missouri Ethanol	Laddonia, MO		Corn
Northeast Missouri Grain, LLC*	Macon, MO	45	Corn
Mid-Missouri Energy, Inc.*	Malta Bend, MO	45	Corn
ND			
Alchem Ltd. LLLP	Grafton, ND	10.5	Corn
Red Trail Energy, LLC	Richardton, ND		Corn
Archer Daniels Midland	Wallhalla, ND		Corn/ barley
NE			
ASAlliances Biofuels, LLC	Albion, NE		Corn
Aventine Renewable Energy, LLC	Aurora, NE	50	Corn
Cargill, Inc.	Blair, NE	85	Corn
Platte Valley Fuel Ethanol, LLC	Central City, NE	40	Corn
Archer Daniels Midland	Columbus, NE		Corn
Advanced Bioenergy	Fairmont, NE		Corn
AGP*	Hastings, NE	52	Corn
Chief Ethanol	Hastings, NE	62	Corn
Siouxland Ethanol, LLC	Jackson, NE		Corn
Cornhusker Energy Lexington, LLC	Lexington, NE		Corn
Mid America Agri Products/Wheatland	Madrid, NE		Corn
E3 Biofuels	Mead, NE		Corn
KAAPA Ethanol, LLC*	Minden, NE	40	Corn
Val-E Ethanol, LLC	Ord, NE		Corn

Husker Ag, LLC*	Plainview, NE	26.5	Corn
Abengoa Bioenergy Corp.	Ravenna, NE		Corn/ milo
Midwest Renewable Energy, LLC	Sutherland, NE	17.5	Corn
Trenton Agri Products, LLC	Trenton, NE	35	Corn
Abengoa Bioenergy Corp.	York, NE	55	Corn/ milo
NM			
Abengoa Bioenergy Corp.	Portales, NM	30	Corn/ milo
OH			
Liquid Resources of Ohio	Medina, OH	3	Waste beverage
SD			
Heartland Grain Fuels, LP	Aberdeen, SD	9	Corn
VeraSun Energy Corporation	Aurora, SD		Corn
Northern Lights Ethanol, LLC	Big Stone City, SD	50	Corn
Great Plains Ethanol, LLC*	Chancellor, SD	50	Corn
James Valley Ethanol, LLC	Groton, SD	50	Corn
Sioux River Ethanol, LLC	Hudson, SD	55	Corn
Heartland Grain Fuels, LP*	Huron, SD	12	Corn
Prairie Ethanol, LLC	Loomis, SD		Corn
Redfield Energy, LLC	Redfield, SD		Corn
North Country Ethanol, LLC*	Rosholt, SD	20	Corn
Broin Enterprises, Inc.	Scotland, SD	9	Corn
Glacial Lakes Energy, LLC*	Watertown, SD	50	Corn
Dakota Ethanol, LLC*	Wentworth, SD	50	Corn
TN			
Tate & Lyle	Loudon, TN	67	Corn
TX			
Panhandle Energies of Dumas, LP	Dumas, TX		Corn/ grain sorghum
WI			
Western Wisconsin Renewable Energy, LLC*	Boyceville, WI		Corn
United WI Grain Producers, LLC*	Friesland, WI	49	Corn
Badger State Ethanol, LLC*	Monroe, WI	48	Corn
Utica Energy, LLC	Oshkosh, WI	48	Corn
Central Wisconsin Alcohol	Plover, WI	4	Seed corn
ACE Ethanol, LLC	Stanley, WI	39	Corn
WY			
Wyoming Ethanol	Torrington, WY	5	Corn

APPENDIX IV
PROPOSED BIODIESEL PLANT LIST

COMPILED BY BIODIESEL MAGAZINE

http://www.biodieselmagazine.com/article.jsp?article_id=943&q=&page=all

Accessed on March 14, 2007

Biodiesel Magazine's second edition of its annual Proposed Biodiesel Plant List indicates some interesting trends, most notably the obvious—growth. It's apparent this industry is itching to explode with expansion.

by Anduin Kirkbride McElroy, Holly Jessen, Nicholas Zeman, Ron Kotrba and Dave Nilles

Biodiesel Magazine's Proposed Biodiesel Plant List has become an annual undertaking for the publication's editorial team, and the project's name—bland as it may be—is pretty much a fixture. This year, however, the list's name just doesn't capture what it represents, which is a whole lot of production capacity on the drawing board. With downright eye-opening figures of 65 would-be plants representing an astronomical 1.46 billion (billion … with a "B") gallons annually, a more appropriate title for the information presented on the next 19 pages might have been, "Biodiesel: By the Numbers."

According to the Spring 2006 U.S. & Canada Biodiesel Plant Map, there is approximately 400 MMgy of capacity on line today with another 320 MMgy under construction. Taken in the context of the proposed plants presented here, the industry is looking at the potential for more than 2 billion gallons of annual capacity. However, it can be surmised that several of the projects listed here will not come to fruition. In fact, it may come down to a virtual race to see which plants get on line first.

Biodiesel Magazine started off with more than 175 proposed projects that were narrowed down to a final tally of 65. Of those listed, one can draw several conclusions about the direction of the industry.

First, let's state the obvious—the biodiesel industry is moving ahead at a breakneck pace. It seems almost anyone with seed money and a dream is attempting to throw their proverbial hat into the biodiesel ring.

Plant size is also increasing, perhaps showing a slight maturation of the industry. Last year's proposed list featured 36 plants averaging 14 MMgy. This year's list features 65 plants averaging 22.4 MMgy.

The list also shows that, unlike a majority of U.S. ethanol plants, biodiesel projects are less tied to agricultural regions of the country. That has been, and continues to be, a strong selling point to policy makers. However, although biodiesel projects are popping up in at least 29 states, Iowa continues to dominate the renewable fuels landscape. The state leads this list with six proposed projects totaling 280 MMgy of production.

BQ-9000 accreditation was another important issue discussed by representatives of proposed plants. Most projects reps said the voluntary accreditation program was vital. It's reassuring to see the importance placed on quality assurance.

Avenues for glycerin disposal are becoming a larger concern. Several projects have proposed innovative solutions for the biodiesel coproduct. Some plants plan on using the glycerin to fire power plants. One proposed plant, Fry Away Fuels in Coates, Minn., is planning to blend glycerin with coffee grounds and sawdust, which will then be fired in wood-burning boilers. Other facilities are looking at ways to introduce glycerin into cattle feed.

Again, it's important to stress the criteria used to compile this list. Our staff attempted to contact every proposed plant—between concept and construction—that we became aware of through other news sources or by word of mouth. Each project listed here was verified by a reliable source, whether a direct project representative, a government official or someone else connected to the project.

For various reasons, some proposed plants chose not to be included. Others proved impossible to reach. Still others undoubtedly remain flying below our radar. If you don't see your project listed here, give us a call. We'd love to hear from you.

As with last year's list, this isn't intended to be an all-encompassing inventory of every proposed biodiesel project in the United States and Canada—it's merely a snapshot of what is happening in the industry right now.

Also, to make the list more manageable, only plants slated to produce 1 MMgy or greater are included.

The list is organized by regions: Pacific, Mountain, North Central-West, South Central-West, North Central-East, South Central-East, New England, Middle Atlantic, South Atlantic and Canada. For starters, let's head West.

Pacific

Energy Alternative Solutions Inc.
Location: Watsonville, California
Target groundbreaking: July 2006
Feedstock: virgin vegetable oils/yellow grease
Capacity: 1 MMgy
Process technology: Pacific Biodiesel
Synopsis: With financing and permitting in place, the company is preparing to break ground July 1, according to Senior Vice President Bernie Weiss. The company is awaiting final engineering for the batch process plant. It is also scheduling the arrival of the tanks and assembly crew. An August production start is planned. Weiss says the glycerin would be sold to local power plants for electrical generation.

Bio Friendly Fuel Partners
Location: San Francisco, California
Target groundbreaking: summer 2006
Feedstock: multi-feedstock
Capacity: 20 MMgy
Process technology: undeclared
Synopsis: President Eric Johnson tells Biodiesel Magazine the company is still narrowing down potential sites within northern California. He says is has been doing research since 2004. A feasibility study has been completed and the project is in the financial phase.

Baker Commodities
Location: Vernon, California
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 15 MMgy

Process technology: Superior Process Technologies
Synopsis: This project is located in a suburb of Los Angeles. Baker Commodities' Fred Wellons says the plant would be expandable to 30 MMgy.

Pacific AgriEnergy LLC
Location: eastern Washington
Target groundbreaking: 2006
Feedstock: virgin vegetable oils
Capacity: 10 MMgy
Process technology: undeclared
Synopsis: This facility will be breaking ground this year, according to Project Manager Dwight Robanske. It will be using oil from locally grown crops such as brassica, canola, rapeseed and mustard. Initial capacity would be 10 MMgy, with expansion possible at a later date.

Palouse Bio LLC
Location: Spokane Valley, Washington
Target groundbreaking: 2006
Feedstock: mustard oil/canola oil/rapeseed oil
Capacity: 5 MMgy
Process technology: undeclared
Synopsis: Five ag co-ops are planning a zero-discharge biodiesel facility, as well as an oilseed crushing plant. Both plants will be collocated with one of the co-op's facilities. Production should start within nine months from the start of construction, says spokesman Jim Armstrong. The group received a $2 million low-interest loan from the state of Washington, and is currently engaged in permitting and engineering. Glycerin would be used in an on-site cogeneration plant.

Unnamed
Location: Walla Walla, Washington
Target groundbreaking: June 2006
Feedstock: multi-feedstock
Capacity: 63 MMgy
Process technology: Lurgi PSI
Synopsis: Chem-Con Corp. will soon break ground and plans to begin production February 2007. CEO Jay Greig says the zero-discharge plant, which would include a pre-cleaning, bleaching and degumming pretreatment process, would enable the plant to use virtually any feedstock. However, it would rely mainly on soy, canola and palm oils. The publicly traded company has obtained funding through equity investments. A combination of debt and equity will finance construction.

Baker Commodities
Location: Tacoma, Washington
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 10 MMgy
Process technology: Superior Process Technologies
Synopsis: This project is probably the furthest along of Baker Commodities' three proposed plants. Property for this facility has been purchased near Tacoma.

Mountain

American Agri-Diesel
Location: La Junta, Colorado

Target groundbreaking: undeclared
Feedstock: soy oil/canola oil
Capacity: 25 MMgy
Process technology: undeclared
Synopsis: American Agri-Diesel is currently building a 2 MMgy to 6 MMgy pilot biodiesel plant in Burlington, Colo., according to Steve Aslagon, low emissions program manager. Once that project has "proven" itself, the company will make a final decision on whether to move forward with it. If the project advances as planned, it would likely be completed and on line in 2007. Once operational, the group plans to become BQ-9000 accredited.

Phillips County Biodiesel Project
Location: Phillips County, Colorado
Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 1 MMgy
Process technology: undeclared
Synopsis: A group interested in building a biodiesel plant in Phillips County, Colo., hopes to get started building in about a year, according to Bob Melander, director of the Rocky Mountain Farmers Union Cooperative Development Center.

Sustainable Systems LLC
Location: Culbertson, Montana
Target groundbreaking: undeclared
Feedstock: virgin vegetable oils
Capacity: 15 MMgy
Process technology: undeclared
Synopsis: Sustainable Systems operates an oilseed crushing facility at the site of this proposed plant, according to Paul Miller, the company's president. The biodiesel project is in the permitting and engineering phase. At press time, Sustainable Systems was evaluating process technology providers and a general contractor for the continuous-flow facility.

Greater Montana BioEnergy LLC
Location: Havre, Montana
Target groundbreaking: undeclared
Feedstock: canola oil
Capacity: 10 MMgy
Process technology: undeclared
Synopsis: At press time, a site survey was being conducted, according to James Lambert, president and COO of Agro Technologies International. Agro Management Group, which focuses on research and development for bio-lubricants, now wants to enter biofuels production. The biodiesel plant has a projected first-year capacity of 2 MMgy with plans to increase to 10 MMgy by its third year of production. The company hopes to move forward with construction as soon as June, with production commencing in December.

Wyoming Biodiesel Co.
Location: northeast Wyoming
Target groundbreaking: fall 2006
Feedstock: undeclared
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: Wyoming Biodiesel Co., a wholly owned subsidiary of Energy Fuel Dynamics LLC, is

working toward a plant possibly near Gillette, Wyo., according to Business Development Manager Jim Kintz. At press time, soy and canola oil were being considered as potential feedstocks. Kintz said permitting was nearly complete, funding was being solidified and negotiations were underway for glycerin off-take contracts.

Wyoming Ag Marketing LLC
Location: Riverton, Wyoming
Target groundbreaking: undeclared
Feedstock: virgin vegetable oils
Capacity: 1 MMgy
Process technology: undeclared
Synopsis: A grain storage facility east of Riverton, has been selected as the plant's proposed site. The facility would use canola, camelina and sunflower oils as feedstock. The Rocky Mountain Farmers Union Cooperative Development Center is helping advance the project.

North Central-West
Magic City Biodiesel LLC
Location: Minot, North Dakota
Target groundbreaking: June 2006
Feedstock: canola oil
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: Magic City Biodiesel LLC is a wholly owned subsidiary of the holding company Dakota Skies Biodiesel LLC, according to COO Skip Hauth. A German company, Uhde, is the general contractor and is working with Dakota Skies to select the process technology provider. The facility is expected to produce biodiesel that meets or exceeds European specifications by July 2007 (see Feedstock feature on page 56).

Marble Rock Biodiesel
Location: Marble Rock, Iowa
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: This facility would use a continuous-flow operation. Glycerin marketing plans are as yet undetermined, according to spokesman Steve Bodensteiner.

Raccoon Valley Biodiesel
Location: Storm Lake, Iowa
Target groundbreaking: October 2006
Feedstock: soy oil
Capacity: 50 MMgy
Process technology: Engineering Automation and Design Inc.
Synopsis: According to spokesman Terry Argotsinger, the plant site would include an all-renewable fuels filling station.

PowerShift Biofuels of Iowa
Location: Fairfield, Iowa
Target groundbreaking: summer 2006
Feedstock: soy oil/canola oil
Capacity: 60 MMgy

Process technology: undeclared
Synopsis: PowerShift Energy Co. Inc. and NewGen Technologies, a subsidiary of ReFuel America, are working on this project, according to Dan Leach, PowerShift CEO. At press time, the companies were waiting on the results of environmental reviews and expected to break ground in June. The anticipated completion date is summer 2007. The group is planning an additional five projects located throughout the United States with a collective production capacity of 300 MMgy. However, further details weren't available at press time.

Iowa Renewable Energy
Location: Washington, Iowa
Target groundbreaking: June 2006
Feedstock: soy oil/animal fats
Capacity: 50 MMgy
Process technology: Renewable Energy Group
Synopsis: Project Manager Pamela Dunbar says the equity drive is complete. Off-take marketing and procurement agreements are being negotiated.

Southern Iowa Bioenergy LLC
Location: Lamoni, Iowa
Target groundbreaking: summer 2006
Feedstock: multi-feedstock
Capacity: 30 MMgy
Process technology: Renewable Energy Group
Synopsis: Southern Iowa Administrative Assistant Rose Saxton says while no specific groundbreaking has been set, the group hopes to start construction as early as this summer.

Hawkeye Bioenergy
Location: Camanche, Iowa
Target groundbreaking: August 2006
Feedstock: multi-feedstock
Capacity: 60 MMgy
Process technology: Bratney Companies
Synopsis: A feasibility study and business plans have been completed. Hawkeye's Mike Meyer says the company is undecided on plans for the plant's pharmaceutical-grade glycerin.

Fry Away Fuels
Location: Coates, Minnesota
Target groundbreaking: undeclared
Feedstock: recycled grease/virgin sunflower, rapeseed and mustard oils
Capacity: 1 MMgy
Process technology: undeclared
Synopsis: According to Fry Away's Kai Curry, the company is securing more private equity. The facility, which is planned to expand to 5 MMgy, would blend its glycerin with compacted coffee grounds and sawdust, which will then be used to fire wood-burning boilers.

Rock Hill Biodiesel
Location: Trenton, Missouri
Target groundbreaking: undeclared
Feedstock: yellow grease/soy oil
Capacity: 3 MMgy
Process technology: Greenline Industries

Synopsis: Rock Hill's John Robbins says this modular plant could double in size within three years of starting production.

Unnamed
Location: Marshall, Missouri
Target groundbreaking: undeclared
Feedstock: soy oil/animal fats
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: Roy Marshall, member of Marshall's economic development council, says a general contractor has been interviewed and a process technology firm has been selected, although it wasn't disclosed at press time.

Heartland Biodiesel
Location: Rock Port, Missouri
Target groundbreaking: undeclared
Feedstock: soy oil/animal fats
Capacity: 30 MMgy
Process technology: Renewable Energy Group
Synopsis: At press time, Heartland was preparing for its equity drive. The plant site has access to a Burlington Northern Santa Fe mainline and is located near several major soy crushing facilities. Spokesman Stan Griffin says West Central of Ralston, Iowa, would manage the project.

Northeast Nebraska Biodiesel
Location: Scribner, Nebraska
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 5 MMgy
Process technology: TechnoChem International
Synopsis: Fundraising is ongoing for this project, which would primarily use soy oil. Backup generators and steam boilers would be powered with biodiesel, allowing the facility to power itself. Spokesman Robert Byrnes says the company is developing cattle feed options for the plant's glycerin.

Mobius BioFuels
Location: Fremont, Nebraska
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 10 MMgy
Process technology: undeclared
Synopsis: Mobius spokesman Bob Buscher Jr. says a technology provider is being sought for this modular project. The plant would be expandable to 30 MMgy. A feasibility study is complete, and a feedstock procurement plan is being finalized.

South Central West
Earth Biofuels
Location: New Orleans, Louisiana
Target groundbreaking: summer 2006
Feedstock: multi-feedstock
Capacity: 20 MMgy
Process technology: Earth Biofuels Technology Co.
Synopsis: Earth Biofuels' CEO Tommy Johnson says this project, which hopes to break ground soon,

would be located near an ethanol plant.

Earth Biofuels
Location: Muskogee, Oklahoma
Target groundbreaking: late summer 2006
Feedstock: multi-feedstock
Capacity: 50 MMgy
Process technology: Earth Biofuels Technology Co.
Synopsis: This project would be co-located with an ethanol plant to take advantage of transportation, labor, energy and other pooled resources, according to Earth Biofuels CEO Tommy Johnson. The plant would primarily use soy oil as a feedstock.

Redland Industries Inc.
Location: Guymon, Oklahoma
Target groundbreaking: June 2006
Feedstock: multi-feedstock
Capacity: 30 MMgy
Process technology: Redland Industries
Synopsis: With a strong financial partner with access to international capital, this project is waiting to finalize the financial transfers, says Redland Industries' spokesman Kent Powell. The plant design provides a high-volume, continuous-flow modular system. BQ-9000 accreditation would be sought upon production. A significant expansion is planned to begin in late 2006 following start-up.

GeoGreen Fuels LLC
Location: Gonzales, Texas
Target groundbreaking: May 2006
Feedstock: soy oil
Capacity: 3 MMgy
Process technology: undeclared
Synopsis: The Gonzales facility is expected to produce ASTM-spec fuel by August 2006, according to GeoGreen's Kathryn Kartchner. The plant would use a continuous-flow process unit with Active Ion waterless technology and real-time automated control.

TexCom Inc.
Location: Seabrook, Texas
Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 35 MMgy
Process technology: Lurgi PSI
Synopsis: At press time, TexCom's Jay Charles said groundbreaking on the project—which may operate under a different name—was imminent.

North Central East
Blackhawk Biofuels LLC
Location: Freeport, Illinois
Target groundbreaking: late 2006/early 2007
Feedstock: soy oil
Capacity: 30 MMgy
Process technology: Renewable Energy Group
Synopsis: Blackhawk Biofuels has an option on a 49-acre site near Freeport, Ill., according to Chairman Ron Mapes. The project is initializing permitting and financing. Soy oil would be the

primary feedstock, while rendered animal fats and corn oil are also under consideration.

Unnamed
Location: Knox County, Illinois
Target groundbreaking: undeclared
Feedstock: undeclared
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: A group of local farmers and businesspeople have been leading an effort to bring a biodiesel plant to the area for 18 months, according to Larry Larson, director of Knox County Solid Waste. Currently, organizers are trying to catch the interest of investors to back the proposal. The soybean-growing region also has a pork processing facility nearby.

National Trail Biodiesel Group
Location: Newton, Illinois
Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: A feasibility study and business plans are complete. An equity drive is slated to be completed by June, says spokesman Dick Grogg. National Trail Biodiesel plans to pursue BQ-9000 accreditation once operational.

Delta Biofuels
Location: Danville, Illinois
Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: This developing project may be located adjacent to a Bunge soybean crushing facility, says spokesman Gene Holmes.

Indiana Clean Energy LLC
Location: Frankfort, Indiana
Target groundbreaking: summer 2006
Feedstock: soy oil
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: Indiana Clean Energy LLC has an option to buy a piece of land located next to one of three possible feedstock suppliers, according to CFO Mark Bunner. The project is beginning the financing process. Permit applications have been submitted.

Unnamed
Location: Ecorse, Michigan
Target groundbreaking: undeclared
Feedstock: soy oil/canola oil
Capacity: 15 MMgy to 20 MMgy
Process technology: undeclared
Synopsis: Currently, plans are to erect a pilot biodiesel plant producing approximately 400,000 gallons annually, according to Edward Trager, COO of Ender LLC. The plant, which would use batch processors, should be operational this fall. After that, the larger facility would be built in Ecorse. At

press time, Ender LLC was in discussion with a group about a joint venture on the project. The company hopes the larger plant is operational by August 2007.

Unnamed
Location: Saginaw, Michigan
Target groundbreaking: undeclared
Feedstock: soy oil/canola oil
Capacity: 15 MMgy to 20 MMgy
Process technology: undeclared
Synopsis: Another Ender LLC project, this plant is expected to develop similar to the Ecorse, Mich., project. Following a 400,000-gallon-per-year project, a 15 MMgy to 20 MMgy plant would be built.

Unnamed
Location: Detroit, Michigan
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 4 MMgy to 6 MMgy
Process technology: Biodiesel Industries Inc.
Synopsis: Biodiesel Industries Inc., which already operates multiple facilities in the United States, has purchased property to build another plant, according to Jake Stewart, vice president of corporate development. The project is in the construction planning phase with site preparation and permitting underway. This project is a collaboration with NextEnergy, DaimlerChrysler and other major automotive manufacturers and suppliers.

Michigan Biofuels LLC
Location: Belleville, Michigan
Target groundbreaking: July 2006
Feedstock: soy oil
Capacity: 10 MMgy
Process technology: Michigan Biofuels LLC
Synopsis: At press time, groundbreaking was closing in on Michigan Biofuels' plant, which is anticipated to start up in November 2006. Financing and permitting is underway, according to President Patrick Sullivan.

Unnamed
Location: Adrian, Michigan
Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 20 MMgy
Process technology: undeclared
Synopsis: After leading the push for the Great Lakes Ethanol plant (later bought by Midwest Grain Processors), local individuals began pushing for a biodiesel project, according to David Munson, president of the Lenawee Chamber of Economic Development. Biofuels Industries Group has selected a 20-acre site in an industrial area of the city, according to spokesman Michael Horowitz. At press time, the group was awaiting a ruling regarding property tax exemptions.

American Biodiesel LLC
Location: Toledo, Ohio
Target groundbreaking: June 2006
Feedstock: soy oil
Capacity: 30 MMgy

Process technology: undeclared
Synopsis: At press time, work was being done on permitting and the final financing package, according to Ric Lesinski, vice president of marketing and sales. The company was working on finalizing a contract with Minneapolis-based Crown Iron Works Co.

South Central East
Alternative Liquid Fuel Industries
Location: McArthur, Ohio
Target groundbreaking: June 2006
Feedstock: multi-feedstock
Capacity: 1 MMgy
Process technology: undeclared
Synopsis: At press time, the group was changing from a limited liability company to an incorporated company. Alternative Liquid Fuel Industries President Michael Noll says the plant would be expanded to up to 50 MMgy. Noll is working with a university to develop value-added products from the plant's glycerin.

North Prairie Productions LLC
Location: south-central Wisconsin
Target groundbreaking: fall 2006
Feedstock: multi-feedstock
Capacity: 30 MMgy
Process technology: Desmet Ballestra
Synopsis: A handful of sites have been identified as possibilities, according to President Mike Robinson. Financing was in progress at press time. Soy oil and corn oil would be the plant's primary feedstocks. Production at the facility could begin by August 2007.

Owensboro Grain Biodiesel
Location: Owensboro, Kentucky
Target groundbreaking: mid-May 2006
Feedstock: soy oil
Capacity: 50 MMgy
Process technology: undeclared
Synopsis: Permits are approved, and everything else is in place for a mid-May groundbreaking, according to spokesman John Wright. The plant would be built on a greenfield site adjacent to the company's vegetable oil refinery located on the Ohio River. Crude glycerin marketing agreements are finalized. Biodiesel off-take agreements are ongoing. Wright says Owensboro would use a proven European technology and pursue BQ-9000 accreditation once operational.

Earth Biofuels
Location: Greenville, Mississippi
Target groundbreaking: June 2006
Feedstock: multi-feedstock
Capacity: 20 MMgy
Process technology: Earth Biofuels Technology Co.
Synopsis: CEO Tommy Johnson tells Biodiesel Magazine that the engineer for this project is expected on-site by late May. The plant would primarily use soy oil as a feedstock. Bunge operates an oilseed processing facility nearby.

Southern Biodiesel LLC
Location: central Mississippi

Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: Tim Coursey, head of this project, says he is in the midst of a strategic site location assessment study. He intends to purchase a turnkey operation with continuous-flow processing but says there's a six-month lead time to get the process equipment on-site once it has been ordered.

Delta Biofuels
Location: Marks, Mississippi
Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 30 MMgy
Process technology: undeclared
Synopsis: The makeup of investors is changing, but the project is still moving forward, according to Gene Holmes, Delta Biofuels spokesman. The company plans at least two large biodiesel facilities. This project may be adjacent to a Bunge oilseed processing facility.

Memphis Biofuels LLC
Location: Memphis, Tennessee
Target groundbreaking: June 2006
Feedstock: multi-feedstock
Capacity: 36 MMgy
Process technology: undeclared
Synopsis: Located at a former Proctor & Gamble plant, the animal feed company of Cochran Corp. now specializes in vegetable oil byproducts there. The biodiesel plant would be on the same 17-acre site where Brandon Sheley, senior vice president of Cochran Corp., says most equipment needed for biodiesel production is already in place. Breaking ground in June, the plant is expected to be fully producing by August 2006. More than 1 million gallons of storage exists on-site, with another 500,000 gallons to be built. Memphis Biofuels, which would primarily use soy oil, plans to apply for BQ-9000 accreditation.

New England

Greenleaf Biofuels LLC
Location: New Haven, Connecticut
Target groundbreaking: late 2006
Feedstock: undeclared
Capacity: 5 MMgy
Process technology: undeclared
Synopsis: President Gus Kellogg created Greenleaf more than 18 months ago as a B100 distributor. After working to create a consumer market, Kellogg is now searching for a biodiesel plant site capable of handling a facility up to 30 MMgy. He is also analyzing the feasibility of using domestic soy oil or importing feedstock.

Northeast BioEnergy LLC
Location: Limestone, Maine
Target groundbreaking: 2007
Feedstock: canola oil/palm oil
Capacity: 40 MMgy
Process technology: undeclared

Synopsis: Loring BioEnergy LLC is researching the feasibility of using B100 to power the 55-megawatt turbine in its electrical cogeneration plant. If deemed feasible, the facility would require 40 MMgy of biodiesel just to run the turbine. The facility would import the fuel until there is enough local feedstock to supply a biodiesel facility.

Maine Biodiesel LLC
Location: Rumford, Maine
Target groundbreaking: 2007
Feedstock: crude tall oil
Capacity: undeclared
Process technology: SC Fuels LLC
Synopsis: SC Fuels LLC, Frontier Energy LLC, the Fractionation Development Center (FDC) and a local paper mill have partnered in this innovative biodiesel project. They are currently evaluating technologies to convert crude tall oil (a byproduct of the kraft pulping process) to biodiesel, according to the FDC's Todd Ploanowicz.

Unnamed
Location: Houlton, Maine
Target groundbreaking: October 2006
Feedstock: soy oil
Capacity: 5 MMgy
Process technology: undeclared
Synopsis: The Houlton Band of Maliseet Indians has completed a feasibility study and is very near completion of the business plan, according to project representative Peter Sexton. The tribe would own the majority of the business, and is currently looking for other private investors. It hopes to transition to locally produced canola oil. The tribe is also conducting a USDA-funded pilot study on canola.

Baker Commodities
Location: Billerica, Massachusetts
Target groundbreaking: undeclared
Feedstock: multi-feedstock
Capacity: 10 MMgy
Process technology: Superior Process Technologies
Synopsis: Baker Commodities' Fred Wellons says it may be 18 months before his company begins producing biodiesel.

Northeast Biodiesel Co. LLC
Location: Greenfield, Massachusetts
Target groundbreaking: summer 2006
Feedstock: waste vegetable oil/yellow grease
Capacity: 10 MMgy
Process technology: undeclared
Synopsis: Larry Union, president and CEO, hopes that construction will start this summer, followed by production start-up in late fall. He says groundbreaking depends on finalizing several contracts and acquiring equity.

Middle Atlantic

Unnamed
Location: New Jersey

Target groundbreaking: undeclared
Feedstock: soy oil
Capacity: 15 MMgy to 20 MMgy
Process technology: BioEnergy of Colorado
Synopsis: BioEnergy of Colorado, which already operates two biodiesel plants near Denver, is looking East, according to President Tom Davanzo. While a site hasn't been selected yet, the New Jersey project could be operational in 2007.

North American Biofuels Co.
Location: New Jersey
Target groundbreaking: 2006
Feedstock: trap grease
Capacity: undeclared
Process technology: undeclared
Synopsis: North American Biofuels already operates a pilot plant in Long Island, N.Y. The company is looking at five potential sites in urban areas of New Jersey. Proposals for two projects have been passed to the state's Department of Environmental Protection.

Tri-State Biodiesel Inc.
Location: New York, New York
Target groundbreaking: August 2006
Feedstock: waste vegetable oil
Capacity: 5 MMgy
Process technology: undeclared
Synopsis: This project could be completed by spring 2007. The plant's biodiesel would be marketed locally, according to CEO Brent Baker.

Philadelphia Fry-o-Diesel LLC
Location: Philadelphia, Pennsylvania
Target groundbreaking: spring 2007
Feedstock: trap grease
Capacity: 2 MMgy to 3 MMgy
Process technology: Philadelphia Fry-o-Diesel LLC
Synopsis: The company is a subsidiary of The Energy Cooperative in Philadelphia. It has been running a pilot plant to develop technology to convert trap grease to ASTM-compliant biodiesel. Fry-o-Diesel is designing a commercial facility, which it projects to be operational by late 2007.

Lake Erie Biofuels
Location: Erie, Pennsylvania
Target groundbreaking: August 2006
Feedstock: multi-feedstock
Capacity: 45 MMgy
Process technology: undeclared
Synopsis: This project, which has been under development since mid-2005, is slated to be operational by August 2007.

Enviro Biodiesel
Location: Rouseville, Pennsylvania
Target groundbreaking: summer 2006
Feedstock: soy oil
Capacity: 45 MMgy

Process technology: Bratney Companies
Synopsis: This project was in the midst of obtaining permits at press time. The site, located four miles north of Rouseville, is a former Pennzoil oil refinery located on the Norfolk Southern Railroad. Construction on the brownfield site is expected to take 10 months.

South Atlantic

GreenWing Biodiesel
Location: central Florida
Target groundbreaking: 2006
Feedstock: multi-feedstock
Capacity: 50 MMgy
Process technology: undeclared
Synopsis: This project is unique in that much of the biodiesel would be converted to hydrogen for fuel cells. The biodiesel project, which would use proprietary technology, could be under construction later this year, according to spokesman Ralph Brill.
Earth Biofuels
Location: Cordele, Georgia
Target groundbreaking: June 2006
Feedstock: multi-feedstock
Capacity: 10 MMgy
Process technology: Earth Biofuels Technology Co.
Synopsis: Earth Biofuels CEO Tommy Johnson says this project is a joint venture with a local limited liability corporation. The plant would be expandable upon completion. The primary feedstock will be soy oil. Johnson also mentions ongoing work with the University of Georgia's Agricultural Extension looking at other economically competitive, locally produced feedstocks.

BioMass Energy Services Inc.
Location: Cordele, Georgia
Target groundbreaking: May 2006
Feedstock: soy oil
Capacity: 5 MMgy
Process technology: NexGen
Synopsis: The plant is on course to be operational within four months of construction, according to spokesman Randy Parker. At press time, groundbreaking was slated for mid-May.

Canada

West Coast Biodiesel Ltd.
Location: Vancouver, British Columbia
Target groundbreaking: undeclared
Feedstock: yellow grease
Capacity: up to 50 million liters (13 MMgy)
Process technology: BioDiesel International
Synopsis: Canadian rendering company West Coast Reduction Ltd. is proposing this project. According to West Coast's Grant Saar, the facility is nearing construction. Saar says West Coast is already western Canada's largest distributor of biodiesel.

APPENDIX V
List of Websites of Some Potential Financing Partnerships

Institutions	Website addresses
Natural Sciences and Engineering Research Council (NSERC)	www.nserc.ca
Industrial Research Assistance Program (IRAP)	www.irap.ca
Natural Resources Canada (NRCan)	www.nrcan.gc.ca
Northern Development Initiative Trust (Northern Trust)	www.ndtitrust.ca
Small Business Administration (SBA)	www.sba.gov/index.html
Canaccord Capital Corporation (Canaccord)	www.canaccord.com
Bank of development of Canada (BDC)	www.bdc.ca
• The Canadian Venture Capital and Private Equity Association (CVCA)	www.cvca.ca
• The US National Venture Capital Association (NVCA)	www.nvca.org