BC BIODIESEL FEEDSTOCK ASSESSMENT STUDY

Prepared For:

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EXECUTIVE SUMMARY

In 2002, the transportation sector in Canada accounted for approximately 28 percent of secondary energy use in Canada and about 34 percent of related greenhouse gas (GHG) emissions.

GHG emissions from the transportation sector increased by 22 percent from 1990 to 2002, consistent with the increase in energy use. The change in GHG intensity of transportation energy use was negligible because the fuel mix continues to be based almost entirely on fossil fuels. One alternative to fossil fuel use in the transportation sector that could change the GHG intensity of the transportation sector is biodiesel.

Biodiesel is an alternative fuel that can be made from any fat or vegetable oil. It can be used in any diesel engine with few or no modifications. It can be blended with diesel at any level (for example a 20% blend is known as B20) or used in its pure form (B100). Biodiesel is made primarily through a chemical process called transesterification whereby the glycerine is removed from the fat or vegetable oil. Biodiesel is thus an ester, if methanol is used in the production process it is a methyl ester and if ethanol is used it is an ethyl ester. Since it is made from plant or animal oils it is a renewable fuel.

The Federal Government has included a production goal of 500 million litres of biodiesel by 2010 in its Climate Change Action plan. They have also established an $11.9 million fund that will support research and provide incentives for industrial-scale biodiesel pilot plants, and support demonstrations of its effectiveness to encourage broader use of biodiesel.

One key aspect of meeting the 500 million litre target is the identification of sufficient feedstock to convert into biodiesel. Feedstock availability is quite diverse across Canada with different regions not only producing different feedstocks but also having varying supply and demand balances. The objective of this work is to investigate these feedstock issues for the Province of British Columbia.

The specific goals of this work are therefore:

- First, to identify total volumes and types of potential British Columbia feedstock available annually to produce biodiesel (methyl ester), including identifying potential of feedstock imports and exports.
- Secondly, to identify whether British Columbia has sufficient (volume, type, availability, price) domestic biodiesel feedstock to supply a viable domestic biodiesel industry in the short and long-term, and to identify how feedstock imports and exports impact the industry.
- Finally, to evaluate other issues that might arise with some of the specific feedstocks.

Six classes of biodiesel feedstocks have been considered in this report. In five of the six cases the product is currently being sold for some application. Only in the case of trucked liquid wastes (brown grease) is the feedstock being disposed of. These non-marketed volumes are very limited. In many cases there are also imports and exports of the feedstocks. The findings are summarized in the following table. The volumes of some of the materials can fluctuate significantly from year to year. Mean values are presented below.

Table ES- 1 British Columbia Feedstock Summary

Feedstock	BC Production	Imports	Exports
	tonnes	tonnes	tonnes
Vegetable Oils	0	60,000	200,000
Animal Fats	5,000	2,000	120,000
Used Cooking Oil	13,000	Included above	0
Marine Oils	4,000	25,000	1,000
Tall Oils	7,500	0	0
Brown Grease	500	0	0
Total	30,000	87,000	320,000

The Port of Vancouver reported that exports of oils and fats range from 300,000 to 700,000 tonnes per year. This is higher than is calculated here but some fats from rendering operations in Alberta and Saskatchewan are also exported and while some of this material is obviously counted as being exported from BC in the Industry Canada database some may be exported from the port but included in the export volumes of Alberta and Saskatchewan origin in the database. This would account for the difference.

The volume of BC produced feedstocks are quite small compared to the potential market demand in the province and compared to the quantity of potential feedstock that moves through the province before being exported. It should also be noted that about 60% of the BC production is probably controlled by West Coast Reduction. Only the tall oil, brown grease, and a small amount of the used cooking oils, animal fats and marine oils are being produced by other companies.

The used cooking oils and the marine oils have existing domestic markets. The brown grease is currently disposed of and the tall oil is burned without separating the fatty acids (that could be used for biodiesel production) from the rosin.

The potential for biodiesel production in BC from BC feedstocks is very limited therefore. Any BC biodiesel production must rely on the canola oil or animal fats that move through the province on their way to overseas markets or on imported feedstocks.

While BC has the most favourable tax climate in Canada for biodiesel use the use of canola oil as a biodiesel production feedstock will require a large plant and even with that the economic returns are marginal when the long term average canola oil price is used and sold against the current diesel fuel price. The economics of biodiesel production in BC are much more favourable when animal fats are used for the feedstocks. Not only are the rates of return better but small plants can produce acceptable rates of return.

Tall oil is an interesting biodiesel feedstock. The low value currently being generated by the tall oil makes it a financially attractive feedstock even in small plants. It has some potentially attractive co-products but the long term supply of tall oil is uncertain due to the impact of the mountain pine beetle on the pine tree resource.

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1. INTRODUCTION

In 2002, the transportation sector in Canada accounted for approximately 28 percent of secondary energy use in Canada and about 34 percent of related greenhouse gas (GHG) emissions.

GHG emissions from the transportation sector increased by 22 percent from 1990 to 2002, consistent with the increase in energy use. The change in GHG intensity of transportation energy use was negligible because the fuel mix continues to be based almost entirely on fossil fuels. One alternative to fossil fuel use in the transportation sector that could change the GHG intensity of the transportation sector is biodiesel.

Biodiesel is an alternative fuel that can be made from any fat or vegetable oil. It can be used in any diesel engine with few or no modifications. It can be blended with diesel at any level (for example a 20% blend is known as B20) or used in its pure form (B100). Biodiesel is made primarily through a chemical process called transesterification whereby the glycerine is removed from the fat or vegetable oil. Biodiesel is thus an ester, if methanol is used in the production process it is a methyl ester and if ethanol is used it is an ethyl ester. Since it is made from plant or animal oils it is a renewable fuel.

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One key aspect of meeting the 500 million litre target is the identification of sufficient feedstock to convert into biodiesel. Feedstock availability is quite diverse across Canada with different regions not only producing different feedstocks but also having varying supply and demand balances. The objective of this work is to investigate these feedstock issues for the Province of British Columbia.

There is some conflicting information on the availability of biodiesel feedstocks in BC. The WISE Energy report suggested that up to 125 million litres of biodiesel could be produced with BC feedstocks, whereas the $(S\&T)^2$ report for NRCan found that less than 45 million litres could be produced from BC feedstocks. Not only are there significant differences between these two values but they also represent maximum volumes and most of this material is already being used somewhere.

The specific goals of this work are therefore:

- First, to identify total volumes and types of potential British Columbia feedstock available annually to produce biodiesel (methyl ester), including identifying potential of feedstock imports and exports.
- Secondly, to identify whether British Columbia has sufficient (volume, type, availability, price) domestic biodiesel feedstock to supply a viable domestic biodiesel industry in the short and long-term, and to identify how feedstock imports and exports impact the industry.
- Finally, to evaluate other issues that might arise with some of the specific feedstocks.

The approach to undertaking the work has been to identify all potential feedstocks and the amount of that material generated in the province. This has included vegetable oils grown, animal fats produced at slaughter facilities, estimates of waste cooking grease generated, marine oils produced by fish processors, tall oil produced by pulp mills, and brown grease from municipal sewage treatment systems. Where possible this has been done on a regional basis by dividing the province into regions.

In most cases the feedstock resource needs to be processed before it is suitable for production of biodiesel. The existing processors in BC have been identified by feedstock and where appropriate by region.

These processors have markets for the products that are produced and these will be identified by sector, and location, where possible. Those potential feedstocks that are not being recovered or are being disposed of as waste will also be identified at this stage.

From these three steps of identifying the resources, the existing processors, and the ultimate destination of the processed goods we have been able to identify the overall supply and disposition of potential domestic biodiesel feedstocks in BC. This included the material being exported from the province.

It is also important to be able identify the import potential, either from other provinces in Canada, from the United States or from overseas. Some material is already moving in and out of the province and the volumes have been identified, as have trends in terms of volume changes of the different feedstock materials. Imports studied included animal fats, yellow grease and vegetable oils. Canada does import all of these materials and the amounts imported into BC will be determined.

The next stage will be identify how much of this material could be diverted from existing markets for biodiesel production and what would be required to make that diversion economically attractive. That will allow the identification of a maximum feedstock potential using BC produced feedstocks.

There are other important issues that have been addressed including:

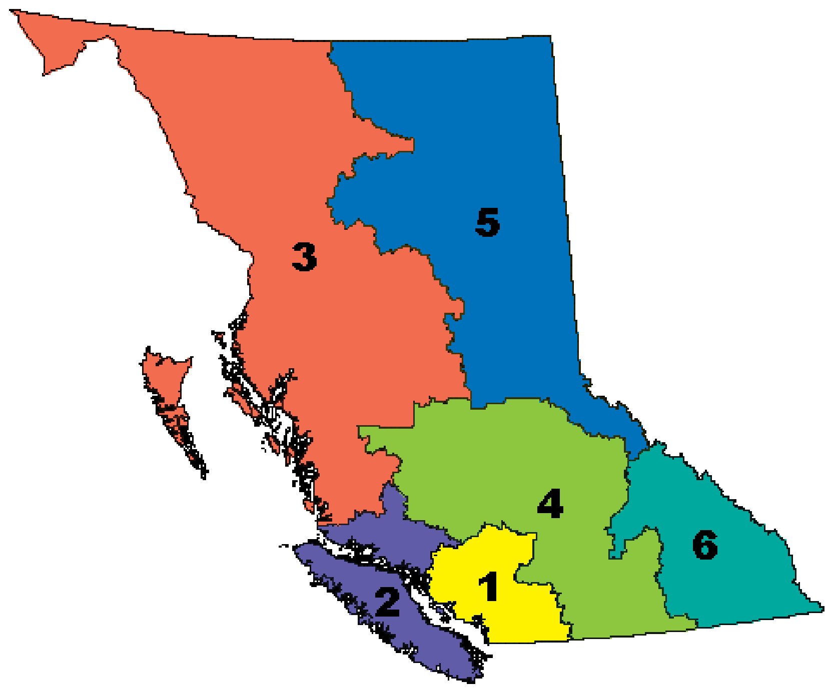
- Viability of using Animal Fats from specified risk material
- Any research/technology required to make any BC feedstocks cost effective
- Economic viability of using each of the potential feedstocks
- What feedstock is currently being used for biodiesel production in BC and why? Is there a feedstock preference from buyers?
- What are the challenges/pros/cons with each of the feedstock options, e.g. sulphur content, cold flow properties, cost, geographic location, etc
- Investigate whether different feedstocks offer different co-product opportunities/issues.

Public sources of information have been used wherever possible and augmented with data from selected interviews with sector participants. The public data is transparent and traceable. Data sources have included Statistics Canada, Industry Canada, Canadian Food Inspection Agency, and The US Department of Commerce.

1.1 British Columbia Regional Information

Some of the information on BC feedstocks can be identified regionally. The province has been divided into six regions for this study as shown in the following figure. When possible the feedstock resource has been identified on a regional basis.

Figure 1-1 British Columbia Regions



The six regions and their populations (2001 Census) are identified in the following table. The majority of the population is located in the southwest quadrant of the province.

Table 1-1 British Columbia Regional Information

Identification	Name	Population	% of Population
1	Lower Mainland	2,302,890	58.9%
2	Vancouver Island	664,355	17.0%
3	North Coast	108,522	2.8%
4	Caribou-Okanogan	514,325	13.2%
5	North East	156,117	4.0%
6	Kootenays	161,529	4.1%
Total		3,907,738	100.0%

1.2 British Columbia Diesel Markets

The market for diesel fuels in BC is summarized for the year 2004 (the last for which a full year of data is available) in the following table (Statistics Canada, 2006).

Table 1-2 British Columbia Diesel Fuel Markets

Type	Litres	% of Distillate Sales
Stove oil and kerosene	22,500,000	0.6%
Low sulphur diesel	2,101,400,000	56.8%
Regular sulphur diesel	1,372,000,000	37.1%
Light fuel oil	206,300,000	5.6%
Total Light Distillate	3,702,200,000	100.0%

Transportation fuels dominate the applications of distillate fuels in the province accounting for over 90% of the light distillate market. About 60% of the diesel market is low sulphur (mostly on road applications) and 40% is regular sulphur off road applications. It is likely that the diesel fuel market is not proportional to population since the off road market is probably dominated by the forestry, mining and oil and gas industrial sectors although no detailed data on sector use is available on a regional basis.

The potential biodiesel markets in BC are identified in the following table for various possible biodiesel blend levels. The actual biodiesel markets will of course depend on the uptake of the fuel in the market place.

Table 1-3 Potential British Columbia Biodiesel Markets

	B2 (Litres)	B5 (Litres)	B10 (Litres)	B20 (Litres)
Low sulphur diesel	42,028,000	105,070,000	210,140,000	420,280,000
Regular sulphur diesel	27,440,000	68,600,000	137,200,000	274,400,000
Light fuel oil	4,126,000	10,315,000	20,630,000	41,260,000
Total	74,044,000	185,110,000	370,220,000	740,440,000

1.3 Biodiesel Feedstocks

There are a number of potential biodiesel feedstocks available in BC. These include vegetable oils, animal fats, used cooking oils, marine oils, pulp mill tall oils, and other materials such as trap grease. The production, supply and disposition of these materials are discussed in the following sections of the report.

Feedstocks are typically marketed on a weight basis. One tonne of feedstock oil will produce from 1,100 to 1,130 litres of biodiesel depending on the feedstock and production process used. The feedstock requirements to meet the potential biodiesel demand identified in the previous table are summarized in the following table. The required feedstocks could range from less than 40,000 tonnes per year to as high as 675,000 tonnes.

Table 1-4 Feedstock Requirements for Potential British Columbia Biodiesel Demand

	B2	B5	B10	B20
	tonnes	tonnes	tonnes	tonnes
Low sulphur diesel	38,200	95,500	191,000	382,100
Regular sulphur diesel	24,900	62,400	124,700	249,500
Light fuel oil	3,800	9,400	18,800	37,500
Total	67,300	168,300	336,600	673,100

Biodiesel production in BC is currently limited to very small operations. Some of these are community or co-operative operations and others are for profit. All of the current producers keep a low profile and the material that is being produced is unlikely to have been tested to ensure that it meets the quality specifications of CGSB or ASTM. The primary feedstock being used is used cooking oil. The volume being produced is likely in the tens of thousands of litres per year range.

There is some biodiesel being imported into BC from the United States and Eastern Canada. Generally this material does meet the quality levels set by CGSB and ASTM. This material is being actively marketed by a number of companies and petroleum distributors. The companies that are publicly offering biodiesel are summarized in the following table (BC Biofleet).

Table 1-5 Biodiesel Suppliers in British Columbia

Supplier	Comments
4 Refuel (Minitankers)	Fuel Distributor
Agri-green Biodiesel Inc.	Potential Producer
Canadian Bioenergy Corporation	Potential Producer
Cascadia Biofuels Inc.	Fuel Distributor
Ecofuels Canada Inc.	Fuel Distributor
Proquip Onsite Refuelling Ltd.	Fuel Distributor
Recycling Alternative	
Super Save Fuels	Fuel Distributor
West Coast Biodiesel	Potential Producer

2. VEGETABLE OILS

Canola, flaxseed, and soybeans make up 95% of total oilseed production in Canada. Canola and flaxseed are mostly grown in western Canada, while soybean production is concentrated in eastern Canada. Oil is also found in small quantities in cereal grains including corn and wheat. The oil content in corn is approximately 4% although none is grown and processed in British Columbia and the oil content of wheat is only about 1 to 1.5%; this is too low for practical extraction and only a small amount of wheat is grown and processed in BC. The oilseeds crops are therefore the primary vegetable crops of interest in British Columbia.

Before oilseeds can be used for biodiesel production they must be processed to extract the oil from the seed. There are no commercial oilseed processors in British Columbia. Biodiesel production from oilseeds in BC would therefore require either the establishment of a local crushers or the use of vegetable oils produced in other regions. Both options will be considered.

2.1 SUPPLY

Canola is grown in the Peace River (part of the north east region shown in the previous section) region of the province. Canola represents over 98% of the oilseeds grown in BC and thus represents the only potential BC grown vegetable oil feedstock for biodiesel.

There are oil seeds that are produced in the rest of Canada that move through BC on their way to market and BC imports some non-canola oil seeds for various applications.

There is a similar situation with processed vegetable oils, Canadian oils can move through BC on their way to foreign markets and BC imports a variety of vegetable oils.

All of these possible supply options are discussed below.

2.1.1 Local Production

The historical acreage and production of canola is shown in the following table (Canola Council of Canada). The estimated oil yield is based on 40% of the oilseed weight.

Table 2-1 British Columbia Canola Production

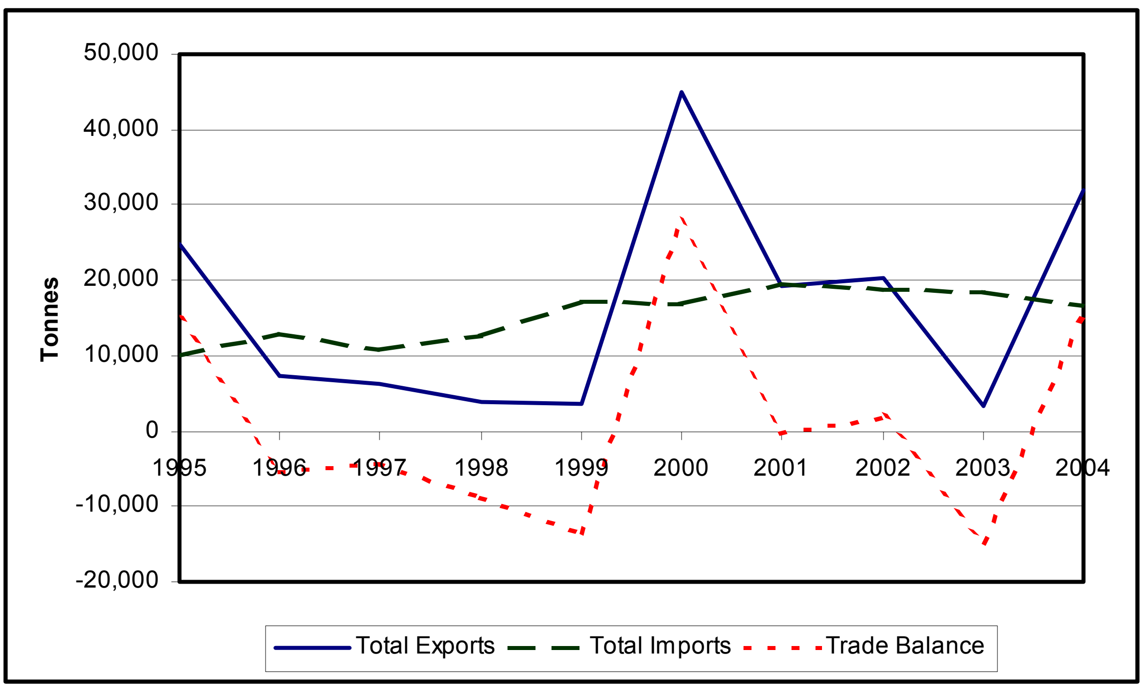
	Acreage	Production	Oilseed Yield	Estimated Oil Yield
	hectares	tonnes	tonnes/ha	tonnes
1996	16,194	19,100	1.18	7,640
1997	22,267	22,700	1.02	9,080
1998	40,486	61,200	1.51	24,480
1999	40,486	62,400	1.54	24,960
2000	32,389	55,200	1.70	22,080
2001	24,291	34,000	1.40	13,600
2002	16,194	18,100	1.12	7,240
2003	28,340	38,600	1.36	15,440
2004	25,101	43,800	1.74	17,520
2005	30,364	63,500	2.09	25,400

The canola production in BC is quite variable with large swings in both the land planted and the crop yield. The potential oil production has varied from 7,000 to 25,000 tonnes in the past decade. This could produce 7.7 to 28 million litres of biodiesel in the unlikely event that all of it was converted to biodiesel in BC. As noted above, there is no BC capacity to convert these oilseeds into canola oil at the present time.

2.1.2 Imports

BC imports other vegetable oil seeds for various purposes. Industry Canada maintains an on-line database for international trade (http://strategis.gc.ca/sc_mrkti/tdst/engdoc/tr_homep.html) that can be accessed by Harmonized System (HS) code. This allows the tracking of a large number of commodities by dollar value. This system allows the identification of imports of soybeans, linseed, sunflower seeds and all other vegetable seeds combined. The system only provides the value of the trade and not the quantity. As a first approximation of quantity the canola seed price for each year has been assumed to be the same as the average for all other oilseeds. The information on imports, exports and trade balance for the non-canola oilseeds is shown in the following figure.

Figure 2-1 Estimated Non Canola Oilseed Trade Balance for British Columbia



The trade in non-canola oil seeds is not that significant with imports being an estimated 20,000 tonnes at the peak. The export quantities vary significantly from year to year and BC can be a net importer or a net exporter of oil seeds. It is assumed that exports would in turn be imported from the United States, as there is essentially no BC production of any of these materials.

2.2 Disposition

Since there is no commercial processor of oilseeds in the province of BC all of the produced oilseeds must be either exported, or used as animal feed. The total supply of domestic seeds and imported seeds is quite low.

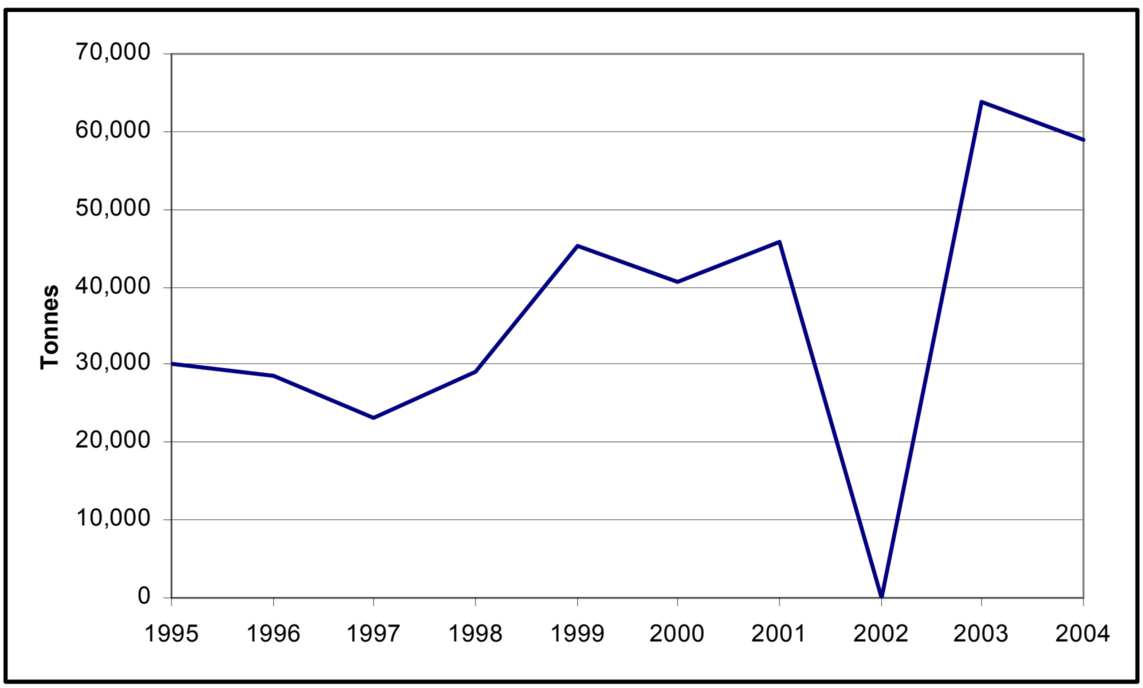
2.2.1 Oil Seeds

All of the production of canola in the province is either exported to overseas markets or shipped to Alberta for crushing there. According the BC Ministry of Agriculture and Land, in 2001 about half of the BC production of canola was trucked to the nearest processor where it was crushed for oil. This plant was located in the Alberta Peace region at Sexsmith. This plant ceased operation in 2002. The balance of production is moved by rail to Vancouver where it is loaded onto ships mostly destined for Japan, but some also goes to Korea, China and Mexico.

The practice of shipping some canola to Alberta for crushing and exporting the rest still remains in place although the amounts change every year. Good quality seed is generally sent to Fort Saskatchewan and lower grade seed goes to the crusher in Lethbridge (Glasier).

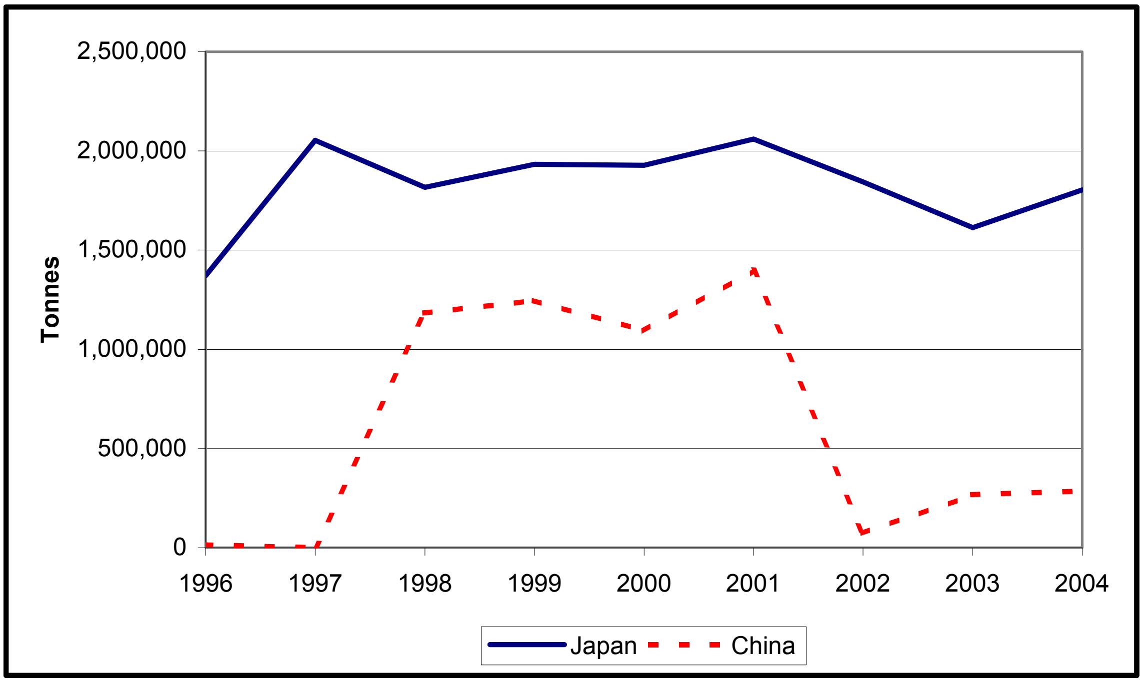
The canola seed exported from BC according to the Industry Canada trade database is shown in the following figure. These figures are not exactly the same as the canola production data available from the Canola Council of Canada. Variations could arise from stock carryover from year to year and from producers delivering product to an elevator in the adjoining province. Nevertheless it is apparent that a large portion of the BC produced canola is exported as canola seed most years. In years with poor crops such as 2002, the exports dropped to zero.

Figure 2-2 Canola Seed Exports – British Columbia Origin



There are also large volumes of canola seeds produced in the Prairie Provinces that move through BC to export markets. These volumes are two orders of magnitude higher than BC produced canola exports. It is theoretically possible that this material could be crushed in BC rather than being crushed overseas but it is highly unlikely that this would happen as the exports markets are generally looking for both the oil and protein meals. Japan also has preferential tariffs for whole seeds over the crushed products.

Figure 2-3 Canola Seed Exports – Prairie Origin



The potential use of oilseeds for crushing into oil for biodiesel production in BC is primarily dependent on oilseeds that would be imported into BC from the prairies rather than on any local oilseed production. The oil in this exported seed is generally between 600,000 and 800,000 tonnes per year. This is more than enough to meet the potential biodiesel demand even at the 20% blend level.

The Wise report on biodiesel production in BC also concluded that there was limited opportunity for biodiesel production from locally grown feedstocks at the present time.

2.2.2 Vegetable Oils

Vegetable oils are not produced in British Columbia but they are both shipped through BC on their way to export markets and they are imported from other countries. The United States is the largest importer of Canadian canola oil and they can take from 50 to 80% of the Canadian production depending on the year (Industry Canada). It is likely that much of this material would be shipped by rail from the crushing plants to the customers and would not pass through BC. Other foreign customers will receive canola oil by ship and most of this will be shipped through BC ports. There are three facilities at the Port of Vancouver that handle edible oils and fats, West Coast Reduction, Neptune Terminals, and Vancouver Wharves. The port is forecasting a 0.4% annual reduction in edible oil volumes through to 2020 (Vancouver Port Authority, Port Plan).

The following table summarizes the main overseas export customers in recent years.

Table 2-2 Overseas Buyers of Canadian Canola Oil

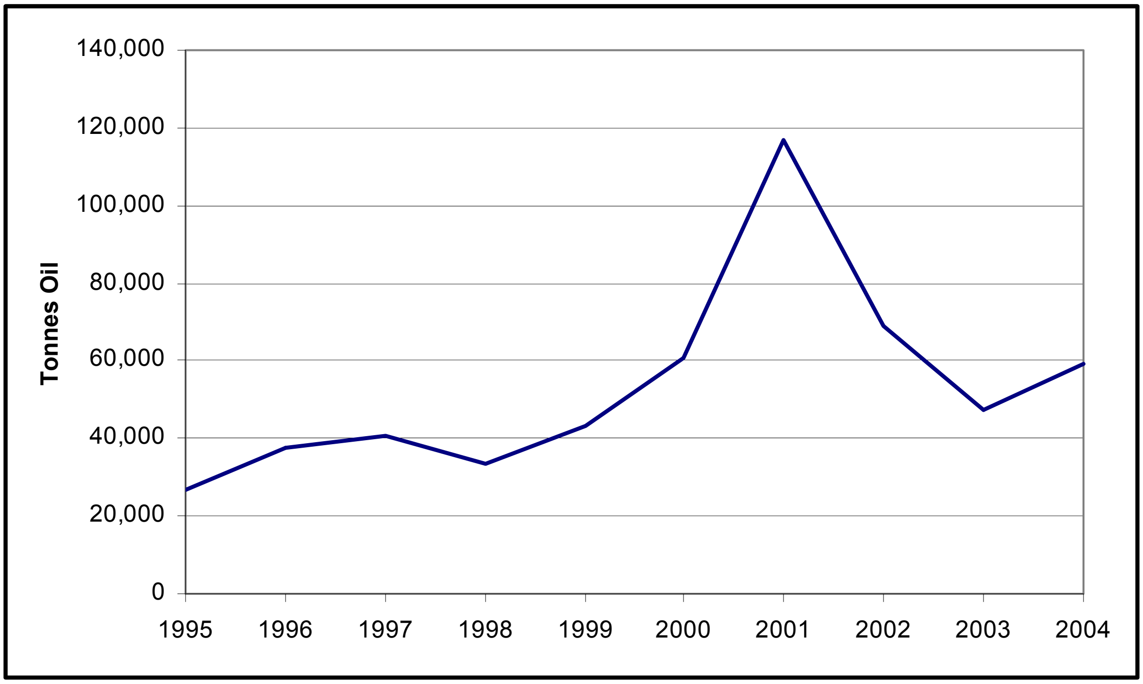
	2002	2003	2004	2005
	tonnes	tonnes	tonnes	tonnes
Japan	5,145	45,421	16,994	27,212
Mexico	1,601	1,034	26,000	21,963
China	13,152	77,175	130,406	12,929
Taiwan	22,961	10,036	19,352	9,307
Korea, South	41,661	71,495	11,551	9,265
Singapore	1,453	6,630	6,863	3,277
Venezuela	0	0	0	2,711
Colombia	104	377	1,811	2,182
Netherlands	6,443	0	124	940
United Arab Emirates	705	575	1,081	907
Kuwait	210	255	547	739
Philippines	918	653	1,520	683
U.S. Minor Outlying Islands	0	0	0	679
Vietnam	42	169	5,189	555
New Zealand	218	210	434	270
Other	16,157	51,157	12,252	717
Total	110,770	265,187	234,124	94,336

There are large variations in the quantities being imported by the various countries from year to year. This would indicate that customers are very price sensitive with little product or supplier loyalty. This would also suggest that at the right price a significant portion of these exports could be diverted to domestic biodiesel production.

In 2006 it is estimated that there is up to 120,000 tonnes of Canadian canola oil being exported to Europe for biodiesel production (F.O. Lichts). Considering the historical levels of canola oil shipments this is a very significant volume. There is little reason why this material could not be used for biodiesel production in BC rather than in Europe.

Vegetable oil imports into BC are much smaller than the level of canola oil exports in most years. These imports are estimated and summarized in the following figure. The Industry Canada trade data has been used and converted to a quantity basis by using the canola oil export price for the vegetable oil imports. Most years less than 60,000 tonnes of oils are imported. Soybean oil and olive oil dominate the imports but some palm oil is also imported.

Figure 2-4 Vegetable Oil Imports - British Columbia



The Port of Vancouver is the only port facility in BC that imports and exports fats and oils. They provide statistics for imports and exports as well as exports for the category that includes animal and vegetable oils. Their statistics are summarized in the following table. Their information is generally consistent with the other sources considering that some oil imports could arrive by rail from the United States or other parts of Canada or in smaller containers that would not be included in the Port of Vancouver data.

Table 2-3 Port of Vancouver Traffic – Animal and Vegetable Oils, Fats and Waxes

	2001	2002	2003	2004
	1,000 tonnes	1,000 tonnes	1,000 tonnes	1,000 tonnes
Inbound and Outbound	539	343	573	710
Outbound	497	320	548	686
Calculated inbound	42	23	50	24

This data is certainly consistent with the export trade data. The total volume of vegetable oils and animal fats is higher than export data for canola oil.

2.3 Availability for Biodiesel

British Columbia is not a significant producer of oilseeds and there is no oilseed crushing in the province. There are however, large amounts of both canola seeds and canola oil that are shipped through the province on their way to overseas export markets. Oilseed imports into BC are not significant and most years are close to the level of exports, indicating that the material may be US product that is being exported from BC ports.

The diversion of canola seeds to biodiesel production would require the establishment of a crushing facility in BC. This is an unlikely development as most crushers are located close to the raw materials and not necessarily close to the market.

Vegetable oil imports are on the order of 60,000 tonnes per year and are dominated by soyoil and olive oil. This material is most likely used for food processing in BC or western Canada. A small amount of palm oil is also imported. While the quantities of imported oils are not particularly significant it does demonstrate that oil imports are feasible and if the price were right then oil imports could be used for biodiesel production.

Vegetable oil exports from BC ports are significant. The volumes and customers vary year to year but the average level of overseas exports over the past five years has been 185,000 tonnes. The apparent lack of customer loyalty as demonstrated by large year-to-year changes in customers and volumes may indicate that a significant diversion of this material could be made to supply a local biodiesel industry. There are reports that some canola oil has been moving to Europe recently to be processed into biodiesel in Europe.

It may be possible to use 100,000 tonnes of canola oil that is currently being exported through BC for biodiesel production in BC. This assumes that this same material is not being used in the Prairie Provinces for biodiesel. Vegetable oil imports are another potential source of feedstock. The three export terminals should be capable of being modified to handle large quantities of feedstock imports should the demand arise.

The price of canola oil is among the highest of the potential biodiesel feedstocks. A long-term average price for canola oil in BC for conversion to biodiesel is approximately $750/tonne or 68 cpl for feedstock alone. The historical canola oil price in Vancouver is shown in the following figure.

Figure 2-5 Vancouver Canola Oil Price

2.4 TECHNICAL ISSUES WITH FEEDSTOCK

Canola oil is the dominant feedstock for biodiesel production in the world today. It is the primary feedstock used in Europe (called rapeseed oil there). The feedstock has a low level of free fatty acids and produces a biodiesel with the best cold weather properties of the feedstocks available. The cold weather properties and the cetane of the fuel are generally inversely related, the higher cetane biodiesels have the poorest cold weather properties and the fuels with the best cold weather properties have the lowest cetane. The cetane of the biodiesel produced from canola (~50) is the lowest of the common feedstocks but it is still higher than the cetane of the diesel fuel sold in British Columbia (low 40s). The biodiesel thus does provide a cetane increase when it is used in low-level blends.

Imported vegetable oil feedstocks could vary in quality and properties. Palm oil would produce biodiesel with relatively poor cold weather properties but high cetane levels. Soybean oil biodiesel would have properties in between canola and palm oil as shown in the following table.

Table 2-4 Vegetable Oil Biodiesel Fuel Properties

Feedstock	Cetane	Cloud Point (°C)
Canola	50-55	-3
Soy Oil	48-52	2
Palm Oil	60-65	15
Corn Oil	50-55	-4
Sunflower Oil	50-55	-1

3. ANIMAL FATS

Animal fats are another source of feedstock for biodiesel. Like oilseeds they too need to be processed before they can be used in the biodiesel production process. The fat contained in animal carcases, the fat from slaughter facilities, and other sources must be rendered to separate it from the solid high protein material. The supply chain thus encompasses the livestock producers, the slaughterhouses, the renderers, and finally the biodiesel producers. This section considers all of these steps in the supply chain. It will be apparent that the number of establishments in each portion of the supply chain decreases as one moves along the supply chain from the farm to the renderer.

3.1 SUPPLY

Animal fats could be sourced from local BC production and slaughter of animals or from animal fats that are imported from other provinces or countries. The two sources are discussed below.

3.1.1 Local Production

Statistics Canada reports on the production and disposition of animals in a series of reports (Statistics Canada, 2005, 2006b, 2006c, 2006d). The information on livestock is summarized in the following table. The 2005 poultry data is not yet available.

Table 3-1 Livestock Production and Slaughter - British Columbia

	2001	2002	2003	2004	2005
Cattle born, 1000 head	389.6	373.5	379.3	350.3	322.1
Cattle Slaughtered in BC, 1000 head	50.0	53.2	48.5	66.1	92.8
Hogs born, 1000 head	334.0	326.4	366.3	355.7	347.5
Hogs Slaughtered, 1000 head	258.3	264.4	264.8	265.0	238.4
Sheep born, 1000 head	56.0	56.6	56.7	50.4	51.3
Sheep Slaughtered, 1000 head	83.7	77.1	81.7	84.9	89.9
Poultry production, 1000 kg	158,515	164,100	165,971	136,030	n.a.

These animals are raised on a large number of individual farms. The numbers of farms raising each type of animal are summarized in the following table (Agricultural Census, 2001).

Table 3-2 Number of Farms in British Columbia Raising Animals

Animal Processes	Number of Farms
Cattle	5,295
Swine	153
Sheep	461
Poultry	977

It is apparent that there is considerable inter-provincial trade in live animals as the number of cattle and hogs slaughtered in BC are less than those born and raised here and in the case of sheep there are more animals slaughtered than born.

Most meat (and thus fat production) is produced in slaughter facilities that are federally inspected. The numbers of federally inspected slaughter facilities in BC according to species are summarized in the following table.

Table 3-3 Number of Federally Inspected Slaughter Facilities - British Columbia

Animal Processes	Number of Facilities
Cattle	4
Swine	2
Sheep	2
Poultry	9

De La Torre Ugarte et al (1999) presented data on the generation of animal fats based on the slaughter weights of animals. The factors that can be derived from their data show that total Animal Fats (edible and inedible) generation from calves, cattle and sheep is about 58 kg per 1000 kg of live weight, for pork the lard generation is 43 kg per thousand kg of live weight and for chickens the factor is 17 kg of fat per 1000 kg of chickens. These factors are useful in estimating the feedstock availability in a specific region. Dieterichs (2006) provided additional information in a recent presentation. The two sources of information are compared in the following table. While the hog data is similar there are significant differences for cattle and poultry. It will be assumed that the average live weights for cattle are 520 kg, for hogs 120 kg, and for sheep 55 kg.

Table 3-4 Animal Fat Generation Rates

	De La Torre	Dieterichs	Assumed Rates for BC
	kg fat/head	kg fat/head	kg fat/head
Cattle	26.3	36 – 43	35
Hogs	4.9	4 - 6	5
Poultry	1.7% live weight	6.5% live weight	1.7%
Sheep	12.75%	-	7

The animal fat produced in the province is estimated from the fat generation factors and the weight of animals slaughtered in BC. These calculations are summarized in the following table. The 2005 poultry data is not yet available.

Table 3-5 Animal Fats Produced - British Columbia

	2001	2002	2003	2004	2005
Cattle	1,750	1,860	1,700	2,310	3,250
Hogs	1,290	1,320	1,320	1,330	1,190
Sheep	590	540	570	590	630
Poultry	2,690	2,790	2,820	2,310	n.a.
Total	6,320	6,510	6,410	6,540	n.a.

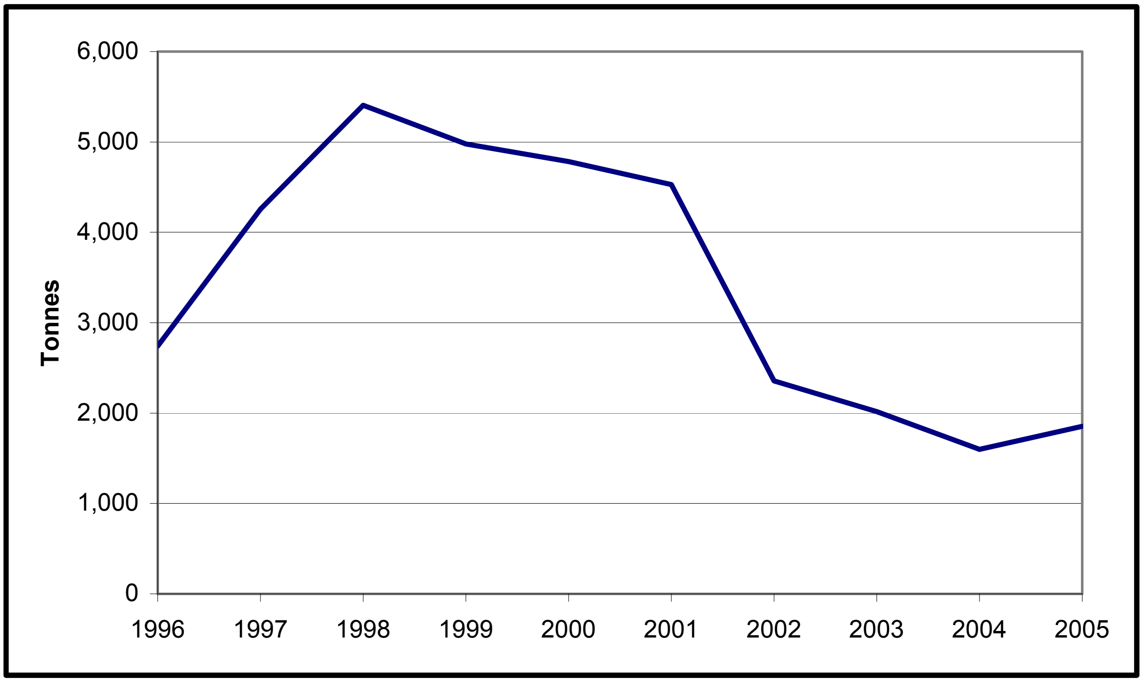
The animal fat production rate in BC has been quite stable in recent years based on the slaughter rate and the per animal generation factors. The total quantity has been about 6,500 tonnes per year. This material must still be rendered before it can be considered a biodiesel feedstock; nevertheless the total generation of animal fats in BC is quite low compared to the potential biodiesel requirements in the province.

The WISE report has about twice the animal fats being produced in BC (12,447 tonnes) than is calculated here. There is insufficient information available in the WISE report to determine how their values were derived.

3.1.2 Imports

There are small quantities of animal fats imported in BC each year from the United States. The value of these imports is reported by Industry Canada and has ranged from one to four million dollars per year. The FAO reports both the volume of animal fats exported and imported and the value for many countries. This data is not segregated by province though. Using the Industry Canada provincial values and the calculated per unit values from the FAO data for Canada the quantity of animal fats imported from the United States is shown in the following table. In recent years the quantity has been about 2,000 tonnes per year.

Figure 3-1 Animal Fat Imports – British Columbia



West Coast Reduction does have some operations in the US Pacific North West so it is most likely that this imported animal fat is predominantly their material.

The total of local supply and imports is about 8,500 tonnes per year. This is raw animal fat that must be processed by a renderer to separate it from the rest of the animal carcass and make it suitable material to be used as a biodiesel feedstock. The rendering step of the animal fat supply chain is described in the following section.

3.2 Disposition

BC has one large rendering company with two facilities, one in Nanaimo and one in Vancouver. The Nanaimo facility is dedicated to processing fish waste and operates 4 to 6 months per year. The Vancouver facility is now dedicated to poultry, fish, and pork wastes. All ruminant wastes are now shipped to their facility in Calgary (Investment Agriculture Foundation of British Columbia, 2005). Approximately 16,000 tonnes of ruminant wastes are moved out of the province annually for rendering in Alberta. This waste material contains water (~50%), meat and bone meal (~25%) and fat (~25%). This estimate of material trucked is therefore roughly consistent with the previous estimate of fat available from cattle in BC.

There is a third small rendering plant (Lawrence Meat Packing Co. Ltd.) associated with a slaughterhouse in Dawson Creek. They slaughter cattle and hogs and render the carcasses on a batch basis. The animal fat produced is sold to brokers for use in animal feeds.

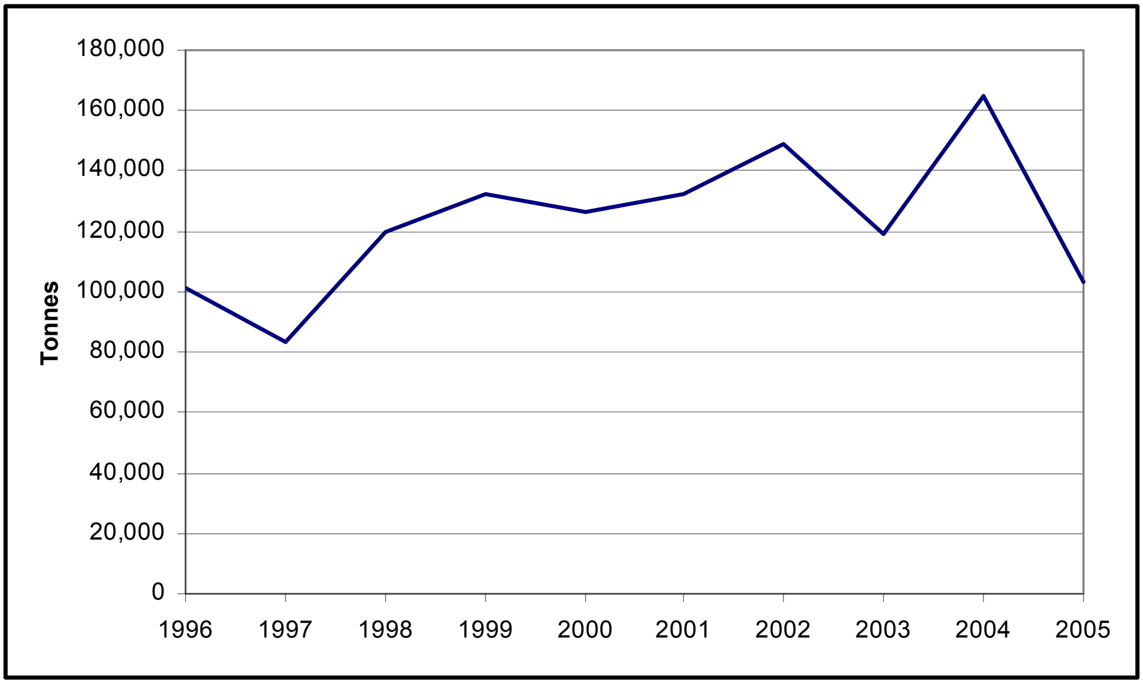
The estimated processed animal fat that is produced in BC is shown in the following table. The cattle have been removed from the fat production values above since they are no longer rendered in the province. The imported animal fat has been added. The quantity of animal fats now available is about 6,000 tonnes per year. Almost all of this material is produced by the Vancouver operation of West Coast Reduction and is thus available in the Lower Mainland region irrespective of where the animals were initially raised.

Table 3-6 Processed Animal Fat Produced - British Columbia

	2001	2002	2003	2004	2005
Cattle	-	-	-	-	-
Hogs	1,290	1,320	1,320	1,330	1,190
Sheep	590	540	570	590	630
Poultry	2,690	2,790	2,820	2,310	n.a.
Imports	4,527	2,357	2,015	1,597	1,853
Total	9,097	7,007	6,725	5,827	n.a.

Animal fat is also exported from BC. Industry Canada reports the dollar value of the exports and using the FAO data to extract the per unit value of animal fat exports from Canada the quantity of animal fat exported can be determined. This information is estimated as shown in the following figure.

Figure 3-2 Animal Fat Exports - British Columbia



Animal fat exports are estimated at 100,000 to 150,000 tonnes per year. The destination countries in 2005 included Japan, South Korea, Nicaragua, El Salvador, Mexico, Guatemala, and Peru.

The exports are larger than the production in BC and the gap is filled by animal fat produced in West Coast Reduction facilities in Alberta and Saskatchewan and moved to Vancouver for export.

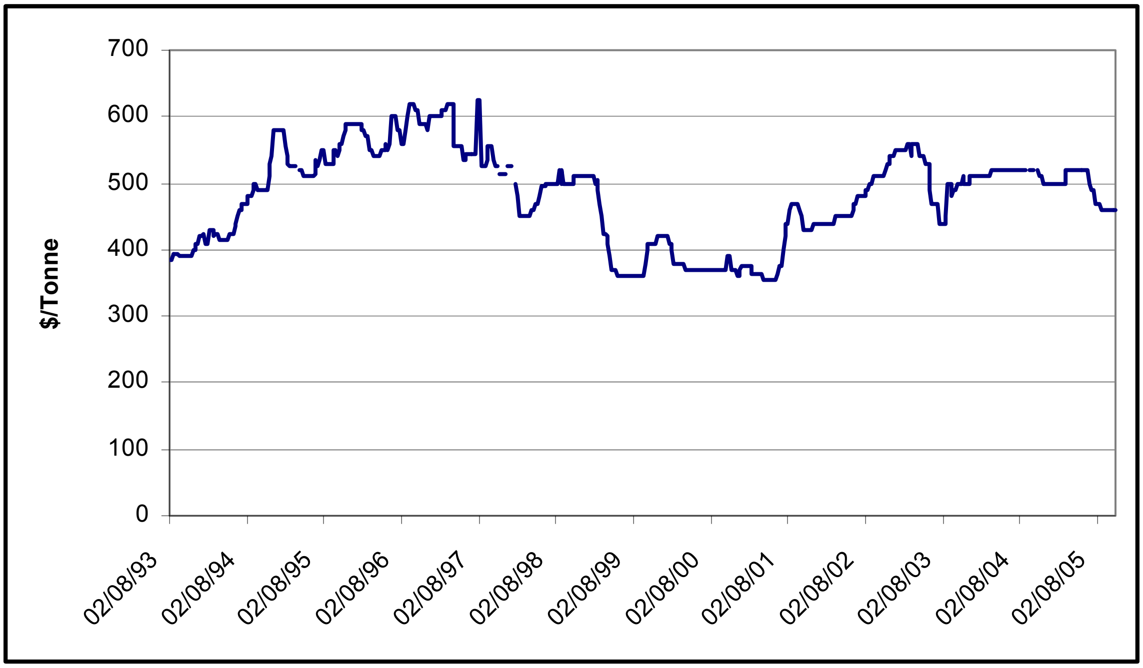
3.3 AVAILABILITY FOR BIODIESEL

The availability of animal fat for biodiesel production will be determined by West Coast Reduction, which has the largest rendering facility in the province. While the BC produced animal fat is limited to about 4,500 tonnes per year it is augmented by imports of animal fat from West Coast Reduction facilities in Alberta and Saskatchewan. It appears that at least 100,000 to 150,000 tonnes of animal fat is exported from BC annually. In some years even more can be exported.

The animal fat supply chain has moved from hundreds of farms to tens of slaughter facilities to essentially one primary renderer in the province. The use of animal fat for biodiesel production in BC will be largely influenced by the actions of West Coast Reduction. West Coast could decide to use a portion of this material for their own biodiesel production or, if the price is attractive they could sell the material to another prospective biodiesel producer in the province.

Animal fat prices are reported by Agriculture and Agri-Food Canada for a number of locations in Canada. The reported prices for Vancouver are shown in the following figure. The long-term average price is $480/tonne. This equates to a biodiesel feedstock price of 44 cpl.

Figure 3-3 Vancouver Animal Fat Prices



3.4 TECHNICAL ISSUES WITH FEEDSTOCK

Animal fats can have higher levels of free fatty acids than vegetable oils. They are most likely to be processed to biodiesel in multi-feedstock facilities. These facilities use a two-stage process to deal first with the free fatty acids and then with the triglycerides.

Biodiesel produced from animal fats does have good cetane properties (>60) but the cold weather properties are at the low end of the range of potential biodiesel feedstocks (cloud point 15 to 20 °C).

4. USED COOKING OILS

Used cooking oils are generated from a wide variety of small cooking operations in restaurants and food processing businesses, and from a few large operations such as potato processing plants that produce a pre-cooked product. E.g. pre-fried French fries and other potato products. In some locations it can also be derived from private households.

4.1 SUPPLY

Used cooking oils cannot be used directly for biodiesel production. They contain water, particulates and other contaminants that must be removed prior to being converted to biodiesel. A waste management company, West Coast Reduction in the lower mainland and other operators such as McLeod's in the interior, typically collects the used cooking oils but some other companies offer the service as well. Historically a renderer has undertaken the product upgrading to make a material suitable for biodiesel production but recently some of the collected material has been used for biodiesel production in the small operations identified earlier.

Very small biodiesel producers are also collecting some small quantities of used cooking oils. Restaurants will make the material available to biodiesel producers if the restaurant can reduce their operating costs without experiencing any problems with unreliable pick-ups or housekeeping issues. The biodiesel producers will have to remove the water and other contaminants prior to making biodiesel. Failure to do so could result in the production of off spec biodiesel.

4.1.1 Local Production

The production of used cooking oils is highly correlated to population. The approach taken to estimating the volumes of recycled oils available has been to determine the appropriate per capita production rates and then to apply those factors to the provincial populations.

There are a variety of per capita production rates that can be found in the literature. Many of the more recent estimates are in a relatively narrow range. The data that was identified in the literature is summarized in the following table. Some of the references have made their assumptions based on the US Department of Commerce data. This data represents the amount of oil collected and some of the higher estimates may include material produced but not collected.

Table 4-1 Recycled Cooking Oil Generation Rates

Author	Year	Yellow Grease
		kg/person
Duffield, USDA	1998	4.3
Wiltsee	1998	4.1
US DOC	2002	4.4
Implementation & Advisory Group	2002	5.1
Darling International	2002	6.4
Dieterichs	2006	4.5

The estimates of yellow grease for each of the regions of the province are shown in the following table. A generation rate of 4.1 kg per person is used. WISE used a value of 4.6 kg/person to arrive at their estimates of used cooking oil production in BC.

Table 4-2 Recycled Cooking Oils Produced - British Columbia

Identification	Name	Population	Cooking Oil, tonnes
1	Lower Mainland	2,302,890	9,442
2	Vancouver Island	664,355	2,724
3	North Coast	108,522	445
4	Caribou-Okanogan	514,325	2,109
5	North East	156,117	640
6	Kootenays	161,529	662
Total		3,907,738	16,022

This material is generated at literally thousands of facilities throughout the province. Most of the material is collected by West Coast Reduction and is processed in their Vancouver facility. The collection rate is probably high and it will be assumed that 80% of this material is collected for a total availability of about 13,000 tonnes per year.

4.1.2 Imports

Imports of used cooking oils would be included in the same customs classifications that are used to track animal fats. If any material were being imported it would therefore have been accounted for in the previous section.

4.2 DISPOSITION

Processed used cooking oil is often called yellow grease. It has a higher free fatty acid content than some of the rendered animal fats. It is often used as animal feed. There are no exports of the material. All of the material processed by West Coast Reduction is used for animal feed. Other collectors also use the material for animal feed and in a few instances some is being used as a biodiesel feedstock.

4.3 AVAILABILITY FOR BIODIESEL

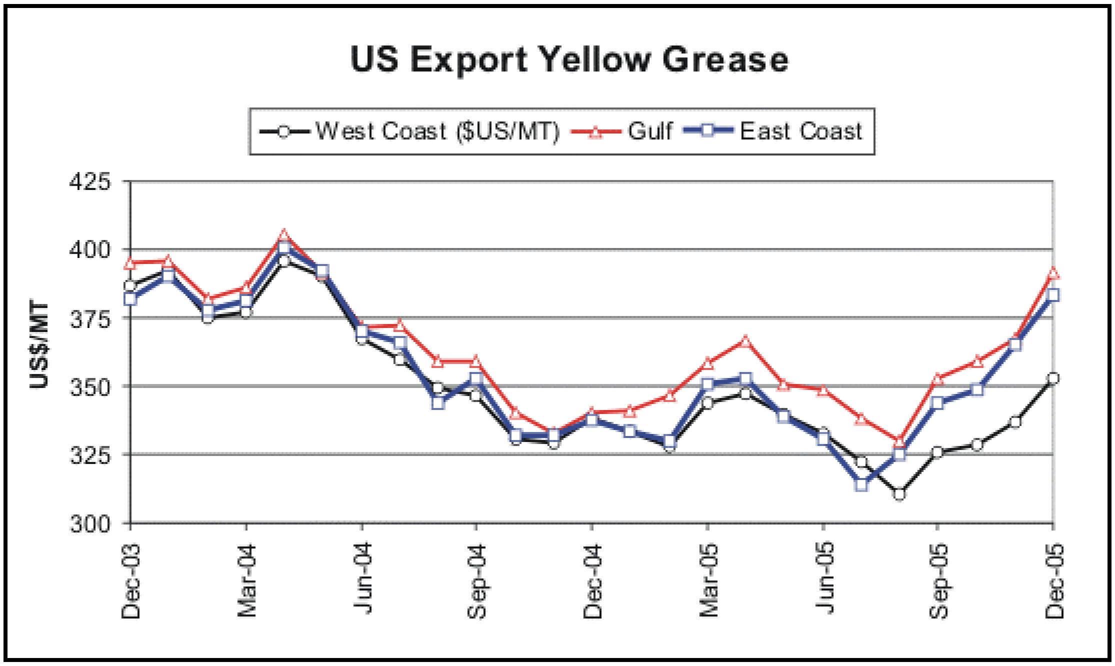
About one half of the cooking oil will be moved through the West Coast Reduction system during collection or processing, the ultimate disposition of the material is determined by their market demands. Small amounts of the material could be removed from that supply chain at the point of generation, i.e. the restaurants and food processors.

This material has often been identified by small community based biodiesel advocates as a source of free or low cost feedstock. This ignores the collection and upgrading costs that are associated with this material. The long-term sustainability of these small biodiesel producers is also questionable. They tend to be higher cost operations without the laboratory capabilities to ensure a product that meets the required quality specifications

The practical availability of used cooking oils for a commercial biodiesel processor is limited due to the relatively low volume and the dominance of a single company in the supply chain. The availability is also small compared to the potential demand for biodiesel in BC.

Yellow grease prices for British Columbia are not publicly available. The following figure has the historical export prices for yellow grease on the US west coast. The current price of yellow grease in the Pacific Northwest is about $275/tonne (Can) (Jacobsen). Prices are higher in Los Angeles at about $330/tonne.

Figure 4-1 Yellow Grease Export Prices



4.4 TECHNICAL ISSUES WITH FEEDSTOCK

Used cooking oils usually have high levels of free fatty acids and thus need to be processed in a multi-feedstock plant. The term "multi-feedstock plant" is used by the industry to denote a facility that is capable of handling feedstocks with either a high free fatty acid content (like used cooking oil) or a low free fatty acid level (like canola oil). Plants that can process high free fatty acid feedstocks can almost always handle low free fatty acid material. Used cooking oils can have other contaminants that can be problematic in producing on-spec biodiesel. These include sulphur and potentially some metals. Not all multi-feedstock plants are designed to deal with these issues. These feedstocks usually require finished product processing, such as distillation, in addition to dealing with the free fatty acid content.

The properties of biodiesel produced from used cooking oils can vary depending on the type of cooking oil initially used. Most often the properties are between those of vegetable oil biodiesel and animal fat biodiesel. This includes cetane and cold weather properties.

5. MARINE OILS

The global annual catch of fish and shellfish is about 90 million tonnes. Of this total, 27 million tonnes is caught to produce fishmeal and fish oil as opposed to human food (Fishmeal Information Network). With about 6 million tonnes of trimmings from food fish processing this produces a total of 33 million tonnes of fresh raw fish used to produce fishmeal and fish oil. Raw fish has a very high moisture content so the products of the fish reduction industry are currently approximately 6.2 million tonnes of fishmeal and 1.2 million tonnes of oil each year. There are some 400 dedicated factories around the world. The main producing and exporting countries are Peru, Chile, Iceland, Denmark and Norway.

Unlike fishmeal, the yield of fish oil per tonne of raw fish processed can vary widely. Depending on the species being processed, the time of year, the general condition of the fish and the efficiency of the recovery process, oil yield rates can vary from lows of just 2% to highs of 16%. Globally, average yield rates typically range between 3 and 5%. Of the 1.0 to 1.25 million tonnes of fish oil produced each year, 55 to 70% of it is currently used in the production of aquaculture feeds (Barlow). Only 10% of the fish oil is used for industrial applications. The remainder is used for edible and pharmaceutical applications. Fishmeal and fish oil production have been mostly static for the past decade and the industry believes it has reached a plateau. The availability of fish oil for biodiesel production may therefore be limited.

5.1 SUPPLY

British Columbia has a large and active marine fishery. There is both a wild commercial fishing industry and an aquaculture industry. The commercial fisheries include the harvesting of more than 80 different species of finfish, shellfish, and marine plants from both freshwater and marine environments. In 2004, the landed value of the salmon, groundfish, shellfish and herring fisheries combined was $389.9 million.

Aquaculture is also significant contributor to the provincial economy, and most aquaculture jobs are located in coastal communities. With its climate, good water quality and sheltered bays, British Columbia's coastline is well suited for both finfish and shellfish aquaculture. In 2004, the farmgate value of the salmon, shellfish and trout sectors combined was $228.1 million. Farmed salmon is B.C.'s largest agricultural export product.

5.1.1 Local Production

The WISE report on biodiesel claimed that fish oil produced in BC ranged between 13 and 53 million litres per year and that the source of the information was the BC Ministry of Agriculture, Food and Fisheries. The $(S\&T)^2$ report did not estimate the fish oil production but just referenced the WISE data and the level of imported fish oil in Canada.

The total fish harvest in recent years in BC is summarized in the following table (BC Ministry of Agriculture and Lands, 2005).

Table 5-1 British Columbia Seafood Harvest

	2002	2003	2004
	tonnes	tonnes	tonnes
Wild Salmon	33,300	38,400	25,500
Farmed Salmon	84,300	72,700	61,800
Other farmed fish	100	200	200
Herring	27,300	29,500	24,400
Groundfish			
Hake	56,900	69,200	124,900
Rockfish	22,200	21,700	20,000
Other	35,600	37,100	36,000
Shellfish	27,800	30,200	30,900
Other	5,800	8,300	12,600
Total	293,300	307,300	336,300

Much of this harvest is sold as food and is not rendered to produce fishmeal and fish oil. A large portion of the herring and the hake is typically processed to produce fish oil and fishmeal. The government of BC does record the quantity of fish oil produced but does not release the information if there are less than three companies producing the product. In recent years there have not been enough companies producing fish oil to release the data.

Fish waste is rendered at the West Coast Reduction facilities in Nanaimo and Vancouver and a small amount is produced at the Canfisco processing facility in Prince Rupert. The Nanaimo facility is dedicated to fish waste and operates during the hake fishery from June to October. West Coast Reduction picks up hake by-product from several fish-processing plants on Vancouver Island. The plant is capable of handling 22.5 metric tons of raw materials an hour. For every ton of raw material, the plant produces about 160 kilograms of fishmeal and 20 kilograms of oil (Alfa Laval). This data would suggest that a maximum of 1,620 tonnes of fish oil is produced in a season (less than 2 million litres per year).

Most of the herring caught in BC is Roe Herring. The remainder of the fish is processed for meal and oil. The oil content of herring can vary from less than 10% to up to 20% by weight depending on the season and climatic conditions. If we assume 10% oil content represents a conservative level then about 2,500 tonnes of fish oil can be extracted from herring in BC each year.

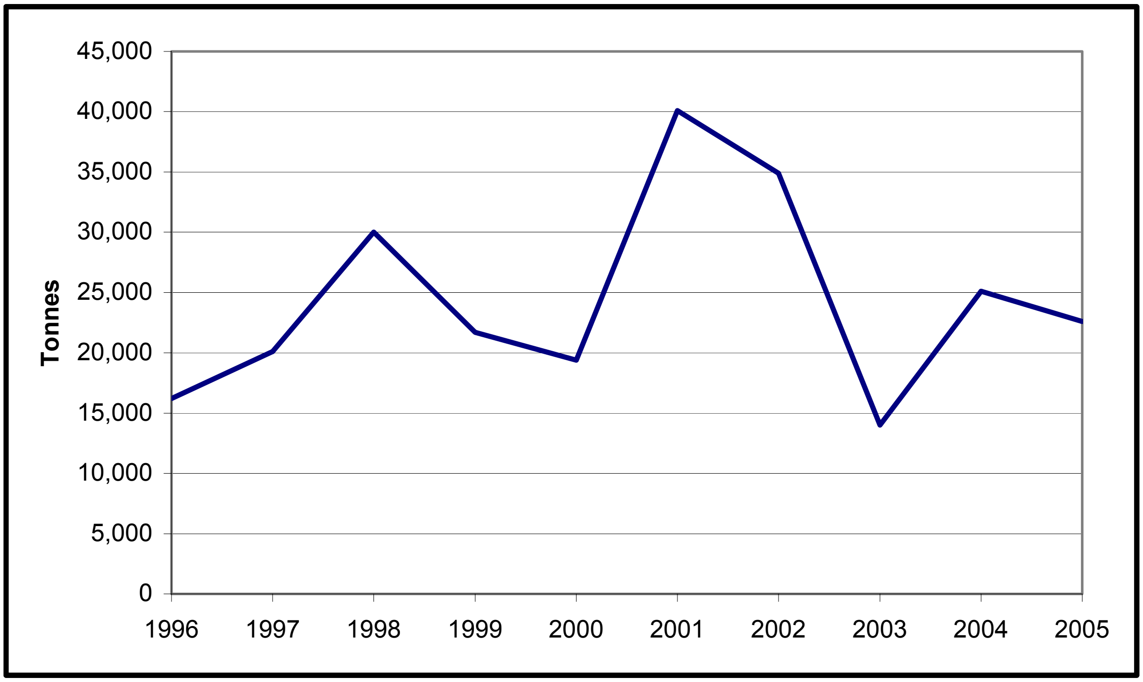
Of the fish caught for food world wide, about 10% is waste material that is rendered. The oil content of this material can vary from year to year but as noted above averages between 3 and 5%. If the hake and herring fisheries are removed from the total harvest, and the ten percent assumption for quantity rendered is used then an additional 600 to 950 tonnes of fish oil can be produced in BC.

The total quantity of fish oil that is produced in BC is therefore on the order of 4,000 to 5,000 tonnes per year. This is far less than the WISE estimates but is consistent with world estimates. The WISE data was checked against their original source of information. The original units were not in litres as reported by WISE and the source reported that for 2002, the year that WISE reported 53,336,830 litres, in fact the actual production was 5,864,337 litres (5,160 tonnes). This later value is in line with the estimates derived here (Carmen Mathews).

5.1.2 Imports

BC imports fish oil and the value of the imports is reported by Industry Canada. If it is assumed that the price of fish oil is 90% of that of canola oil (a typical value as reported in The Jacobsen newsletters) then the quantity imported can be estimated. This estimate is shown in the following figure. Typically 20,000 to 25,000 tonnes per year are imported.

Figure 5-1 Estimated Fish Oil Imports - British Columbia



5.2 Disposition

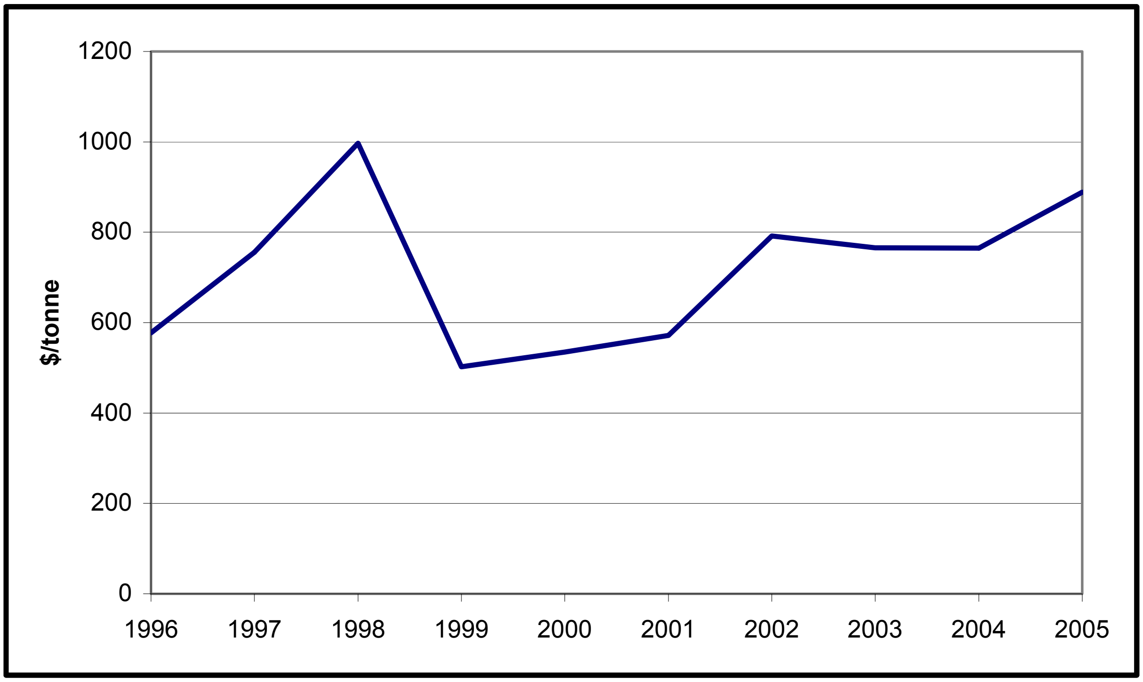
Fish oil in BC is used primarily for aquaculture feed. Vegetable oils exhibit inferior performance in aquaculture applications compared to fish oils. Thus almost all BC fish oil production and all imports are used for this application. A very small portion of the production is exported.

5.3 Availability for Biodiesel

Given the level of imports of fish oil relative to domestic production, the low levels of domestic production, and the special use application of fish oil it is unrealistic to assume that any fish oil would be available for biodiesel production in BC.

The price of fish oil exports from the United States is shown in the following figure. The values have been converted to Canadian $/tonne. Depending on market conditions imported fish oil can be a relatively low cost feedstock or a high cost feedstock. It is also important to note that world fishmeal and fish oil production has been relatively stable for many years and it is generally accepted that the natural harvest is close to the sustainable limit. Future increases in fish oil availability are therefore unlikely.

Figure 5-2 Fish Oil Price



5.4 TECHNICAL ISSUES WITH FEEDSTOCK

There is limited experience with the production of biodiesel from marine oils. Of all of the feedstocks marine oils tend to have the longest chains of fatty acids. The implication of this characteristic has not been clearly demonstrated.

The one plant in Canada that does process marine oils produces ethyl esters and not methyl esters and does some fractionation to extract the longer chain ethyl esters for nutraceutical applications. The plant does not however produce a product that meets the ASTM requirements for biodiesel. The degree to which this is due to the feedstock rather than the process is uncertain.

Little has been published on the cetane and cold weather properties of biodiesel produced from marine oils.

6. TALL OILS

Tall oil is produced from the soap skimmings of a sulphate pulp mill. The soap skimmings are processed into crude tall oil. The crude tall oil may be used as a fuel in the pulp mill or it may be distilled into its fractions of pitch, fatty acids, and rosins. The quantity and quality of tall oil produced is dependent on the wood species being pulped. In Canada the pulp mills that produce tall oil typically process large amounts of pine.

6.1 SUPPLY

The total production of crude tall oil in Canada was estimated to be 180,000 tonnes (Prakash, 1998). This would appear to a maximum theoretical value with the actual production somewhat less. Crude tall oil contains 40 to 50% fatty acids but practical fatty acid recovery is only about 80% of theoretical. The overall yield of fatty acid is therefore 32 to 40% at those mill that collect the tall oil soap or about 60,000 to 80,000 tonnes per year.

In order to produce the biodiesel the crude tall oil must be distilled to produce tall oil fatty acid. There is only one facility in Canada that does this commercially, the Hercules Inc. facility in Burlington Ontario. This plant has the capacity to process 18,000 tonnes of crude tall oil and thus could produce about 8,000 tonnes of tall oil fatty acid.

Tall oil fatty acids are mostly C:18 compounds similar to most vegetable oils.

6.1.1 Local Production

A list of tall oil producers and potential producers was compiled in the late 1980's by Paprican (Uloth) and that is shown in the following table. Many of the company names have changed since this list was prepared but this is the most current list produced by Paprican. The current names are shown.

Table 6-1 Tall Oil Producers and Potential Producers

Mill	Location	Production (tonnes)
Producers		
Canfor (PG Pulp)	Prince George, BC	4,000
Canfor (Intercontinental)	Prince George, BC	4,500
Canfor (Northwood)	Prince George, BC	8,000
Pope and Talbot	MacKenzie, BC	3,500
West Fraser	Quesnel, BC	2,500
Total		22,500

Tall oil production in mills that are producing pine beetle killed wood drops significantly. The West Fraser mill at Quesnel is producing less than 500 tonnes per year of tall oil at the present time due to the high proportion of beetle kill wood being pulped. This tall oil is burned in their lime kiln.

The three Canfor mills ship their soap skimmings to the BC Chemtrade facility in Prince George where it is upgraded to crude tall oil. The crude tall oil is then sent back to the Canfor mills to use as lime kiln fuel. The Canfor volumes have been higher than those shown in the above table but have started to drop as the amount of beetle-killed wood that is processed has increased. They estimate that the current volume is about 16,000 tonnes per year. This would produce about 6,000 tonnes per year of fatty acids.

The Pope and Talbot mill ships their soap to the BC Chemtrade facility in Prince George for processing. The tall oil that is produced goes to Canfor. Pope and Talbot are processing pine that has been attacked but not yet been killed by the pine beetle. These trees produce more soap. Once the tree has been dead for 1-2 years then the soap and thus tall oil production drops rapidly.

6.1.2 Imports

Canada is both an exporter and importer of tall oil fatty acid. In 2004, Canada exported 2,140 tonnes of tall oil fatty acid to the United States and imported 2,190 tonnes. The value of the exports was about $3,000/tonne and the import value was $737/tonne (US International Trade Administration).

There are no tall oil imports into BC or exports from BC according to the Industry Canada on line trade database.

6.2 DISPOSITION

All of the crude tall oil in BC is burned at the pulp mill and used to displace the purchase of natural gas or fuel oil. On a dry weight basis the energy content of crude tall oil is likely to be about 33,000 kJ/kg. When natural gas is valued at $8/GJ, this would suggest that the energy content of the crude tall oil is about 27 cents per kg. The mills that burn the tall oil use it in part to balance the purchase of purchased energy. It's use increases when energy prices are high or supplies are curtailed and thus it may be worth even more to the mills than the value calculated above. The crude tall oil would have to be processed to provide just the fatty acid for biodiesel production and this would further increase the cost of the feedstock.

6.3 AVAILABILITY FOR BIODIESEL

The cost of this feedstock is somewhat difficult to determine. The small amount of material that is being produced for industrial applications has a value of $0.70 to $0.80/kg. This would make the material less attractive as a feedstock that animal fats but more attractive than vegetable oils most of the time. If a market developed for the feedstock for biodiesel applications and pulpmills produced the tall oil fatty acids then the price would likely come down from the current industrial prices. The selling price would have to be higher than the energy content and the processing costs but even if the price were double the energy value then the feedstock would be one of the more attractive biodiesel feedstocks.

There is very little experience with the production of biodiesel fuel from tall oil fatty acids. The process is practiced commercially by companies such as Arizona Chemicals, but they are not serving fuel markets.

Given that

- only a small amount of tall oil fatty acids are currently produced (at a high price),
- substantial processing of crude tall oil would have to be undertaken to produce a biodiesel feedstock (at an unknown cost),
- relatively small volumes available at specific locations,
- the pine beetle killed wood is reducing the tall oil quantities, and
- relatively little published knowledge concerning tall oil methyl ester as a biodiesel feedstock is available,

it is not likely a part of the biodiesel feedstock potential at this time. Once a market for biodiesel develops then the situation could change, as one of the risks in investing in tall oil fractionation facilities would be eliminated. However the production levels may continue to drop as the area effected by the pine beetle continues to move north.

6.4 Technical Issues with Feedstock

Crude tall oil must be fractionated to separate the fatty acids from the rosin and other components before it can be processed into biodiesel. This fractionation is commercially practiced in the United States but it will increase the cost of the feedstock. The tall oil fatty acids must also be processed in a plant designed to process free fatty acids and not triglycerides. It may be possible to blend the tall oil with canola oil to lower the level of free fatty acids and then process the blend in a multi-feedstock plant.

The feedstock profile appears to be very similar to vegetable oils and thus the tall oil biodiesel could be expected to have cold weather properties and cetane values similar to that of canola biodiesel.

7. OTHER FEEDSTOCKS

There are other potential sources of biodiesel feedstocks that some proponents promote. These include materials often called brown grease or trap grease and black grease (grease that has collected in pipes and sewage systems over a long period of time). These materials have a lower quality and most are not suitable for traditional chemical of food applications. The quality is lower due to the higher level of free fatty acids (>20% for brown grease and >40% for black grease) and the presence of other contaminants.

There has been some work done on quantification of trap grease volumes and quality but the published results are quite diverse. There has been little work done on quantifying the black grease.

7.1 SUPPLY

Many municipalities have a requirement that facilities that produce oil and grease install grease traps to collect the waste and remove it from the sewage collection and treatment system. This requirement is more common in the larger municipalities. The production of these lower quality feedstocks is therefore related to population and probably population density.

7.1.1 Local Production

One of the first attempts to identify the quantity of trap grease was made by Wiltsee in 1998. He studied some 30 cities in the United States and concluded that 49 litres of trap grease were generated per person. The estimates were based not on measurements but on estimates of oil content provided by trap grease collectors. Also included were the estimates of the oil content found in municipal sewage, including oils and fats in the waste water of individual residences. The low concentration of fats and oils in raw sewage would be difficult to extract for biodiesel production. The Wiltsee estimates are now generally accepted to be an overstatement of the quantity that might be available for biodiesel production.

WISE in their report calculated the quantities of trap grease produced in BC based on estimated trap size and cleanout frequency. They estimated that the generation rate was 0.9 litres/person/year and that for all of BC the total would be 3.6 million litres. It is then estimated that restaurants make up 40% of the grease generated in the region. On this basis the average per person generation rate rise to 2.25 litres and the total BC production of brown grease would be 9.3 million litres/year. Even this higher estimate is far below the Wiltsee estimate.

In 2005 the Greater Vancouver Regional District undertook a technical and economic feasibility study of using Trucked Liquid Waste for biodiesel production. About half of this waste is generated by food service establishments with other significant generators being poultry plants, reduction facilities, dairies, fish processors, and meat packers. Within the GVRD only one sewage treatment plant accepts these trucked wastes, which allowed the total volume and the oil and grease content to be tracked accurately. The study estimated that about 450,000 litres per year of oil and grease would be available for biodiesel production.

This is not a large volume and it may not be feasible to extrapolate that to the whole province since smaller municipalities may not have the same restrictions on trap grease. It may also not be economically feasible to transport small volumes over long distances to aggregate the volume needed for biodiesel production.

7.1.2 Imports

Since brown grease is a waste product with no economic value there, are no imports of this material into BC.

7.2 Disposition

All brown grease produced in the province of BC is presently processed in sewage treatment plants.

7.3 Availability for Biodiesel

In the larger centres, brown grease could make up a small proportion of the feedstock used in commercial biodiesel plants. Disposal of this negative cost material requires trucking companies to pay a disposal fee. Since brown grease has a high fatty acid content, it would be advantageous to increase its quality by blending it with better quality feedstocks at a multi-feedstock biodiesel facility.

7.4 Technical Issues with Feedstock

This feedstock has very high free fatty acid levels and thus must be processed in a multi-feedstock plant. The quantities available would suggest that blending of this material with other feedstocks to lower the free fatty acid concentrations might be a preferable approach to a small purpose built facility.

The cetane and cold weather properties of the fuel will be a function of the source of the source of the original oils. These properties are likely to fall somewhere between those of vegetable oils and animal fats.

8. SUMMARY AND CONCLUSIONS

The feedstock volumes available for biodiesel production in BC are summarized here and then analyzed with respect to the economic viability for biodiesel production in BC focussing particularly on the trade of with respect to cost and volume in the overall production economics.

8.1 FEEDSTOCK VOLUMES AVAILABLE

Six classes of biodiesel feedstocks have been considered in this report. In five of the six cases the product is currently being sold for some application. Only in the case of trucked liquid wastes (brown grease) is the feedstock being disposed oil. These non-marketed volumes are very limited. In many cases there are also imports and exports of the feedstocks. The findings are summarized in the following table. The volumes of some of the materials can fluctuate significantly from year to year. Mean values are presented below.

Table 8-1 British Columbia Feedstock Summary

Feedstock	BC Production	Imports	Exports
	tonnes	tonnes	tonnes
Vegetable Oils	0	60,000	200,000
Animal Fats	5,000	2,000	120,000
Used Cooking Oil	13,000	Included above	0
Marine Oils	4,000	25,000	1,000
Tall Oils	7,500	0	0
Brown Grease	500	0	0
Total	30,000	87,000	320,000

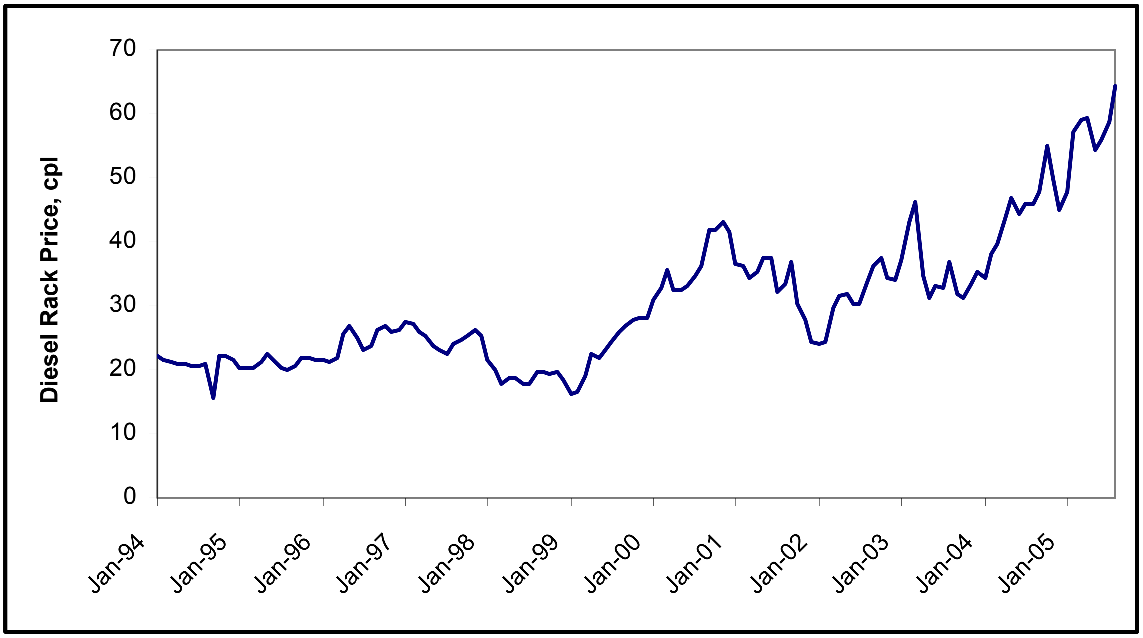
The Port of Vancouver reported that exports of oils and fats ranges from 300,000 to 700,000 tonnes per year. This is higher than is calculated here but some fats from rendering operations in Alberta and Saskatchewan are also exported and while some of this material is obviously counted as being exported from BC in the Industry Canada database some may be exported from the port but included in the export volumes of Alberta and Saskatchewan origin in the database. This would account for the difference.

The volume of BC produced feedstocks are quite small compared to the potential market demand in the province and compared to the quantity of potential feedstock that moves through the province before being exported. It should also be noted that about 60% of the BC production is probably controlled by West Coast Reduction. Only the tall oil, brown grease, and a small amount of the used cooking oils, animal fats, and marine oils are being produced by other companies.

8.2 FEEDSTOCK REQUIRED FOR ECONOMIC VIABILITY

The economics of biodiesel production are strongly influenced by the feedstock cost but plant size is also important. BC has one of the best fiscal environments for biodiesel use in Canada due to the provincial tax exemption (15 to 21 cpl) that blends between B5 and B50 receive. The biodiesel selling price should therefore be close to the diesel fuel rack price plus the BC and Federal excise tax exemptions. The Vancouver diesel rack price is shown in the following figure.

Figure 8-1 Vancouver Diesel Fuel Rack Price



The current rack price of diesel fuel is 65 cpl. This would suggest that the biodiesel selling price should be 85 to 90 cpl in the lower mainland, and 6 cpl less in the interior of the province.

In the following sections the financial model that was developed for NRCan is used to determine the unleveraged Internal Rate of Return (IRR) for each feedstock as the size of the plant is adjusted. The IRR is often used in capital budgeting, it is the interest or discount rate that makes the net present value of all cash flow equal zero. The model has been set to the province of BC and the other key inputs are shown in the following table.

Table 8-2 Financial Model Inputs

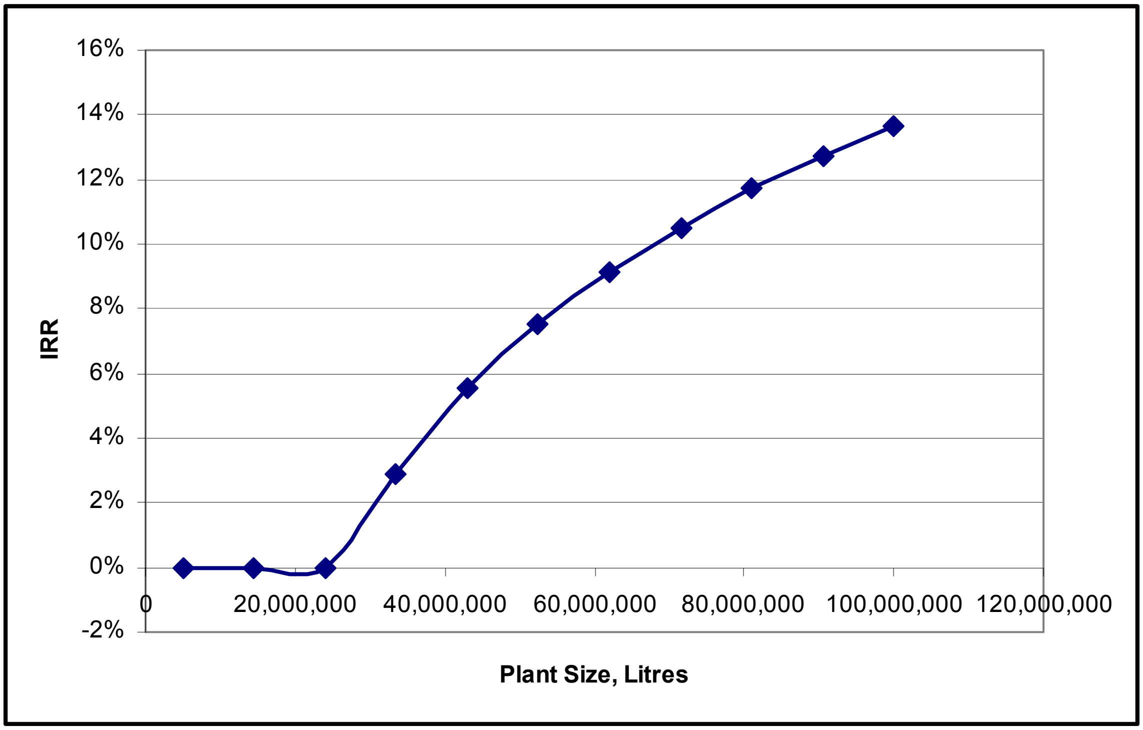
Input	Value
Glycerine selling price	$0.15/kg
Methanol	$0.30/litre
Natural gas	$9.50 /GJ
Electricity	$0.05/kWh
Labour	$45,000/year
Financing	100% equity

The model is run for each feedstock with an assumed feedstock price and the impact of plant size on the IRR is determined. The point at which the IRR drops below 15% is the point at which the smallest possible plant size could be considered for that feedstock. If the resource availability is less that than then the feedstock is not a viable resource for a dedicated plant. This exercise is not meant to be a feasibility study but merely and indication of approximate plant size required to provide a modest return for a particular feedstock.

8.2.1 Vegetable Oils

The assumed price for vegetable oils is $750/tonne. This is the long term average price in BC for canola oil. The plant size has been adjusted between 5 and 100 million litres per year. In the case of BC all of this material would be imported into the province since there is no local production.

Figure 8-2 Vegetable Oil IRR Results



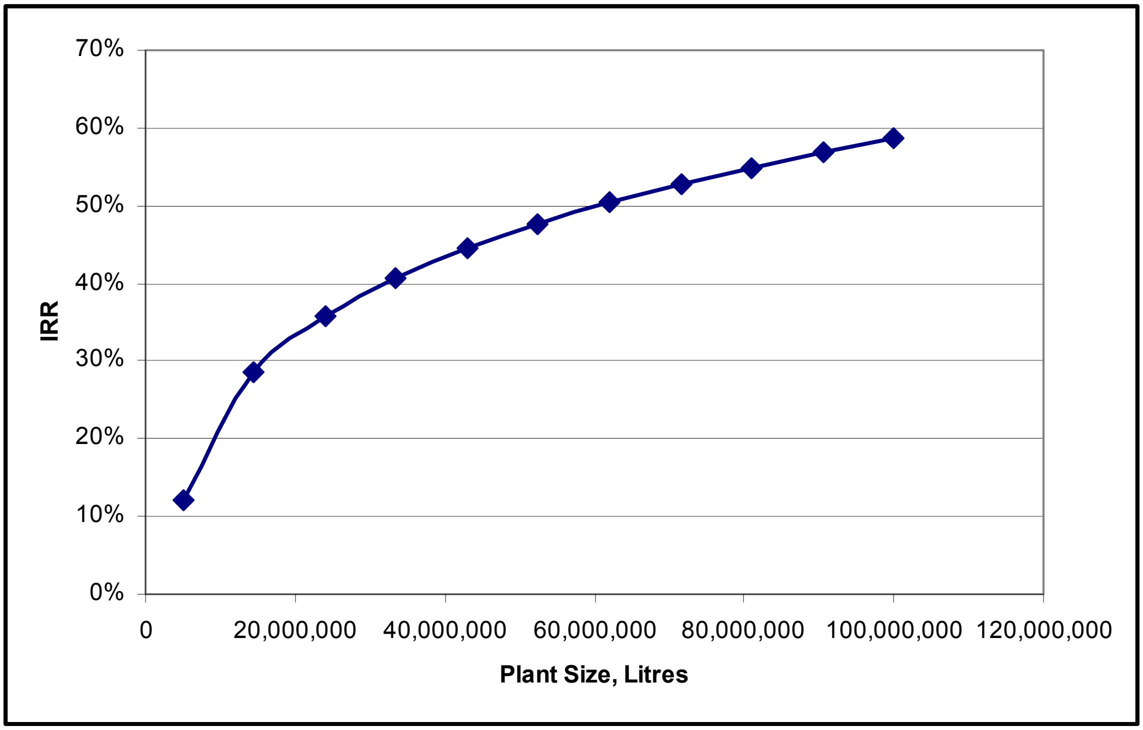
In this case the biodiesel plant does not meet the IRR hurdle even at the 100 million litre per year plant size. This plant size requires about 50% of the volume of vegetable oils exported from BC in a typical year.

8.2.2 Animal Fats

Plants processing animal fats have generally higher capital costs and have higher operating costs than vegetable oil plants. These factors are built into the financial model. The capital costs are assumed to be 20% higher. The feedstock cost has been assumed to be $480/tonne (the long term average).

The IRR versus plant size is shown in the following figure. The 15% threshold is met with a plant size of about 7 million litre per year. This is slightly higher than the amount of BC feedstock potentially available. Much larger plants could be built by diverting a portion of the exported material that is sourced from the Prairie Provinces.

Figure 8-3 Animal Fat IRR Results

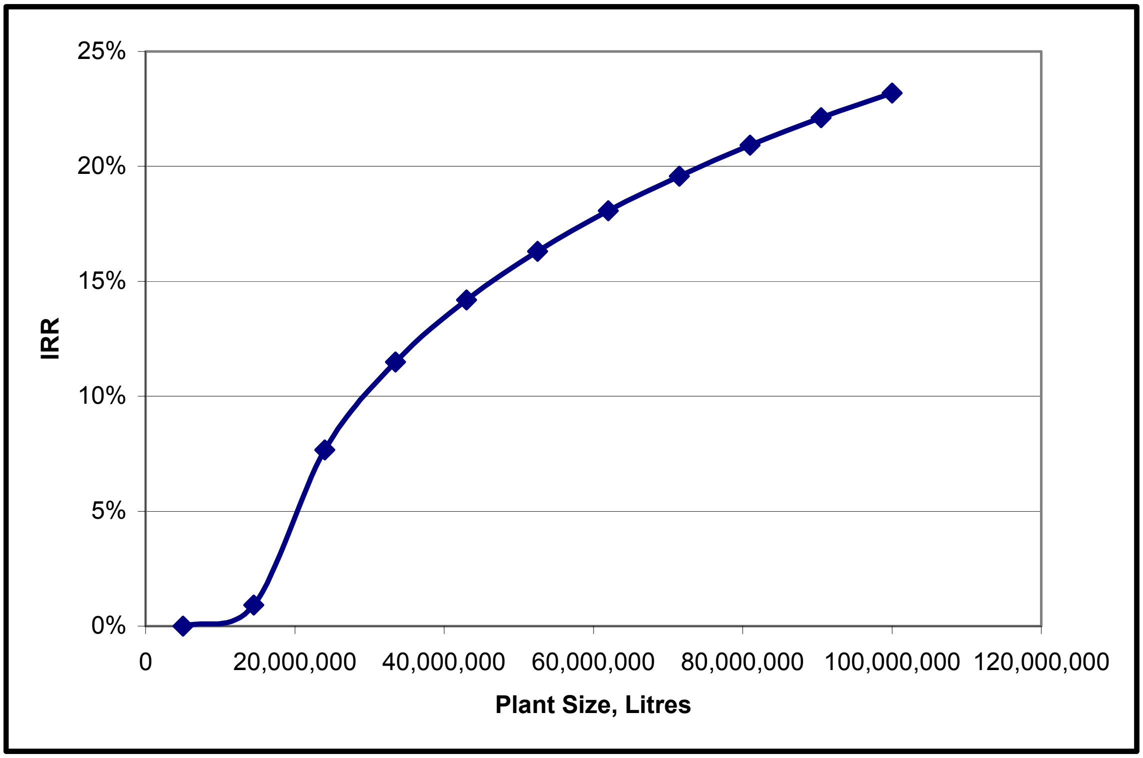


8.2.3 Marine Oils

The price of marine oils can vary widely. The 10 year average price for US fish oil exports would appear to be about $715/tonne.

The IRR versus plant size is shown in the following figure. The 15% threshold is met with a plant size of about 50 million litre per year. This threshold is far higher than the level of BC production and could only be achieved with imported feedstock.

Figure 8-4 Marine Oil IRR Results



8.2.4 Used Cooking Oils

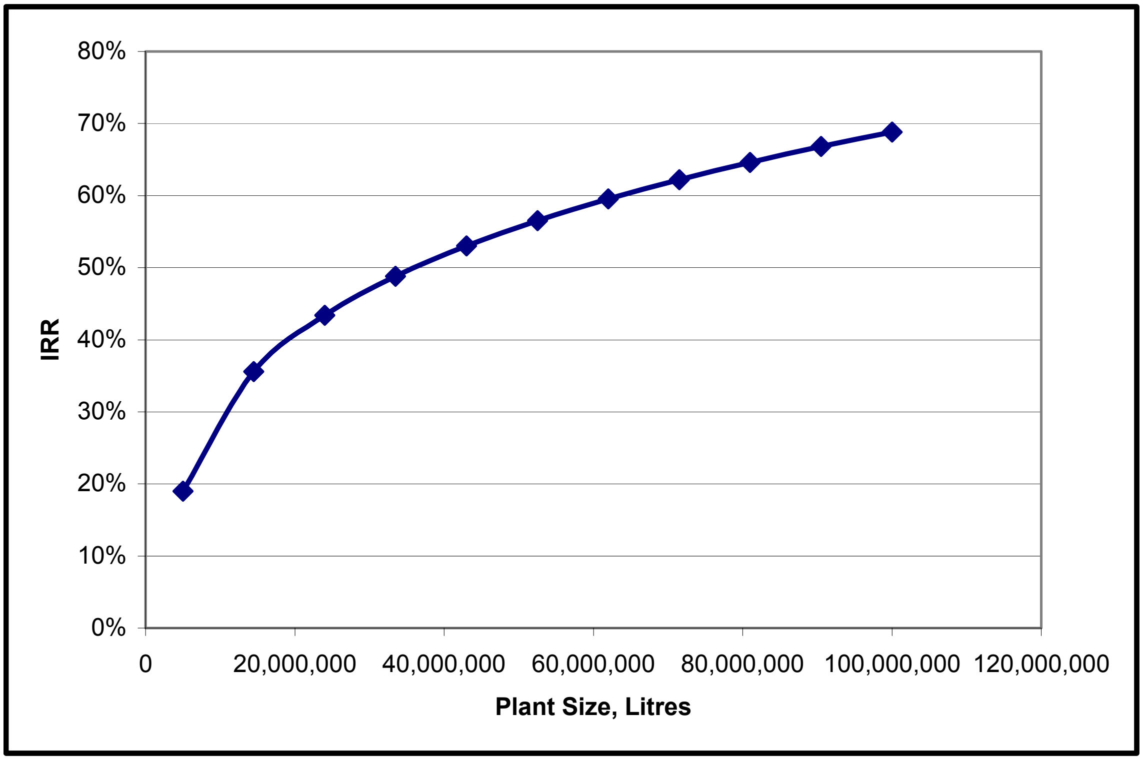
Used cooking oil or yellow grease generally sells for about the same price as animal fats. The 15% IRR threshold will therefore be reached with a plant size of about 7 million litres per year. This level of feedstock supply could be met with BC supply but most of the used cooking oil is currently supplying the animal feed market.

8.2.5 Tall Oil

The crude tall oil value is about $270/tonne at current natural gas prices. This material would have to be upgraded to separate the fatty acids from the rosin. If this step were to add $100/tonne to the feedstock cost then the feedstock would have a cost of $370/tonne. The capital cost of the plant has been increased by 30% to account for the slower reaction rates of acid catalyzed systems for processing free fatty acids.

The 15% IRR threshold will therefore be reached with a plant size less than 5 million litres per year as shown in the following figure. This is achievable in the province. The plant would have to be built in Prince George, which is the location of the feedstock.

Figure 8-5 Tall Oil IRR Results



8.2.6 Brown Grease

Due to the very high level of free fatty acids and potentially other contaminants the brown grease can only be considered as a supplement to other feedstocks and not as the feedstock for a standalone plant.

8.3 OTHER ISSUES

There are several other issues that have been considered during this investigation. They are discussed below.

8.3.1 Specified Risk Materials

Specified risk materials are the parts of slaughtered cattle associated with Bovine Spongiform Encephalopathy (BSE) infectivity. There is the possibility that this material will have to be treated differently and separately in the future. Should this happen the value of tallow derived from SRM is likely to be much lower than tallow from the rest of the animal. Some consideration has been given to the possible production of biodiesel from this material.

There is only a very small cattle slaughter in BC as shown earlier in the report. The total amount of fat produced from these cattle is about 3,000 tonnes per year and almost all of it is shipped to Alberta for rendering. The portion of tallow that could be produced from the SRM portions of the carcass is about 3.5 kg/head (Alberta Agricultural Research Institute). The total quantity of SRM tallow that might be produced in BC is therefore only about 300 tonnes per year. This very small amount is likely to follow the existing practice of being shipped to

Alberta for processing, where much larger quantities of SRM tallow are generated and can therefore be handled in a much more cost effective manner.

SRM tallow is therefore unlikely to be a significant feedstock for biodiesel production in BC.

8.3.2 Additional Research Requirements

There are some uncertainties about some of the feedstocks that have been identified in the report.

With respect to marine oils the characteristics of biodiesel produced from marine oils is unknown. These oils tend to have longer carbon chains than the other feedstocks identified. The impact of these longer chains on properties such as T90, cloud and pour points and cetane number are not known. While some fish oil is esterified in Canada today only a fraction of the esterified oil is used as a fuel.

The value of addressing these unknowns is probably not high due to the limited supply of domestic marine oils being produced and the high demand for this production in the aquaculture feed industry. World wide there is an increasing demand for fish oil for this application and the supply of marine oils is not increasing. The supply and demand dynamics make it unlikely that marine oils will become a significant biodiesel feedstock.

The other interesting BC feedstock is the fatty acids present in tall oil. These materials are currently being burned in pulp mill lime kilns so the value that the mills are deriving from the material is quite low in relation to the value of the other feedstocks. Only a small amount of information is available on esters that are produced from these fatty acids. It would appear that the tall oil methyl esters have properties that are similar to those of vegetable oils.

While tall oil fractionation is practiced in many parts of the world the costs for applying the technology to Canadian mills has not been investigated or determined.

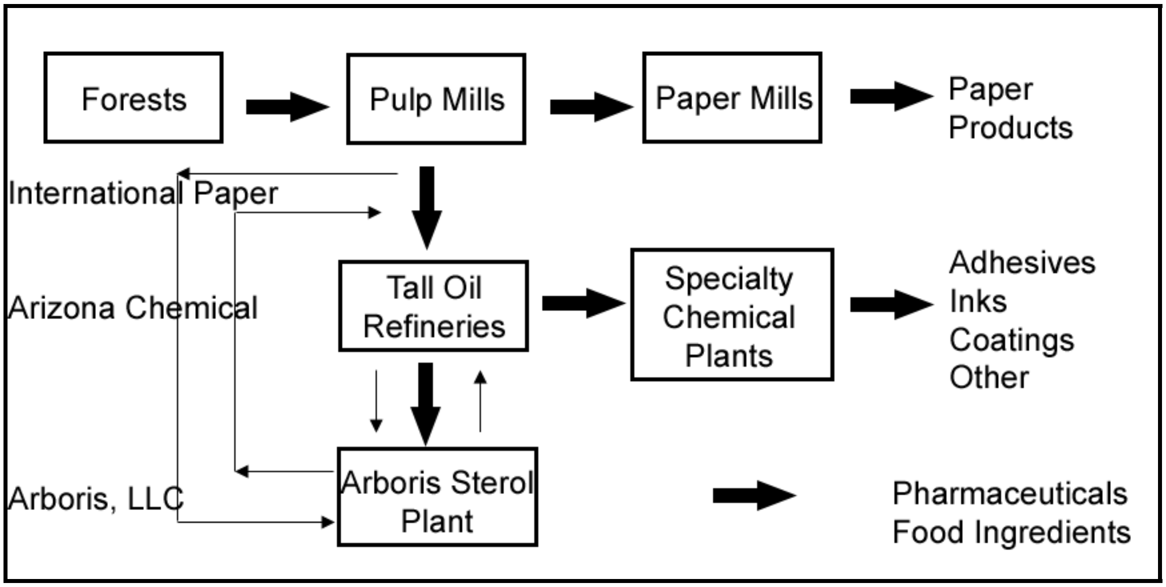
One of the downsides to this feedstock is that the long term availability of the tall oil is uncertain. The area of BC that produces tall oil is badly infested with mountain pine beetle, which is killing the pine trees. When a tree is first infected a natural mechanism is for the tree to produce more resin to protect itself however, once the tree dies the amount of resin that is recovered in the pulping process drops rapidly. Once the tree has been dead for more than two years tall oil production might drop to about 25% of the levels that a freshly harvested living tree would produce. In BC the pine trees are dying faster than they can be harvested so there is a growing backlog of dead trees that will be harvested in coming years. The one mill that is processing mostly dead trees has already experienced this and the other mills are staring to see the effect. In five years, tall oil fatty acid production could be less than 2,000 tonnes per year.

8.3.3 Co-product Opportunities

The high cost of biodiesel could be offset if there were other high value co-products that were produced at the same time or as part of the process. Since many groups are looking for ways to improve the biodiesel economics it is more likely that these high value co-products would be found in some of the more unique feedstocks.

Tall oil has some interesting co-product opportunities. The leading company in the world in this area is Arizona Chemicals. They produce over 40 products in their tall oil group. These are used for manufacturing plastics, paints, lubricants and other products. Another company, Arboris LLC (partially owned by Arizona Chemicals) manufactures Pine Tree Sterols, also known as phytosterols or sterols. Sterols have, for many years, been used as starting materials for manufacturing of pharmaceuticals and, in more recent years, as cholesterol-reducing agents in nutraceuticals. Some work in this area was done in BC several years ago by one of the pulp companies but no work has been done recently on manufacturing these products in BC. The following figure shows the supply chain for processing tall oil into nutraceuticals and other chemicals. One of the specialty chemical plants could be a biodiesel plant.

Figure 8-6 Tall Oil Supply Chain



The biofuel that is produced in Nova Scotia from marine oils is a co-product of a process to manufacture omega three fatty acids for nutraceutical applications. The fuel portion of the process does not meet the ASTM or CGSB specifications for biodiesel. Assuming that the inability to meet specification is a function of the manufacturing process and not the feedstock, the question must be asked are there similar co-production opportunities for nutraceutical production and biodiesel production with the marine oil resource in BC. This question could be addressed in future work.

9. References

(S&T)² Consultants Inc. 2004. Economic, Financial, Social Analysis and Public Policies for Biodiesel, Phase 1. http://www.ghgenius.ca/reports/nrcanbiodieselphase1.pdf

Agricultural Census. 2001. Farms with Gross Receipts of over $2500.

Alberta Agricultural Research Institute. 2005. Strategic R&D Priorities TSE Inactivation and Management of Bovine Specified Risk Material. http://www.aari.ab.ca/sec/new_res/docs/Specified_Risk_Materials_Feb15.pdf

Alfa Laval. 2000. High Tech Fish Plant. http://here.alfalaval.com/?pageID=3&articleID=14&regionID=6

Barlow, S. M. 2002. The World Market Overview of Fish Meal and Fish Oil. Presented to 2nd Seafood By-products Conference. Alaska, November 2002.

BC Biofleet. Biodiesel Suppliers in British Columbia. http://bcbiofleet.ca/biodieselsuppliersbc.htm

BC Ministry of Agriculture and Land. 2005.The 2004 British Columbia Seafood Industry Year in Review. http://www.agf.gov.bc.ca/fish_stats/pdf/Seafood_Industry_YIR_2004.pdf

BC Ministry of Agriculture and Land. Canola. http://www.agf.gov.bc.ca/aboutind/products/plant/canola.htm

Canola Council of Canada. 2006. Canadian Canola Industry, Market Statistics. http://www.canola-council.org/acreageyields.html

De La Torre Ugarte, D.G., White, R.L., Slinsky, S.P., Turhollow, A., Ray, D.E., Tiller, K.H., and Bagwell, D.B. 1999. Assessment of Potential Biodiesel Production in the Southeast: Final Report. Prepared for the Southeast Regional Biomass Energy Program. May 1999.

Dieterichs, B. 2006. Animal Fat Markets. National Biodiesel Board Meeting, San Diego, Feb 2006.

Duffield, J., Shapouri, H., Grabowski, M., McCormick, R., Wilson, R. 1998. US Biodiesel Development: New Markets for Conventional and Genetically Modified Agricultural Products. September 1998. Agricultural Economic Report No. 770.

F.O. Lichts. World Ethanol & Biofuels report. Feb 7, 2006.

Fishmeal Information Network. Fishmeal Facts and Figures. April 2004. http://www.gafta.com/fin/FINFactsFigs.pdf

Glasier, H. 2006. Personal communication. Industry Specialist, Grains and Oilseeds, Ministry Agriculture and Lands. Province of BC.

Implementation & Advisory Group Ltd. 2002 Supply and Demand Factors Relevant to Biodiesel Production in Alberta. April, 2002.

Investment Agriculture Foundation of British Columbia. 2005. Strategic Plan. http://www.iafbc.ca/livestock/downloads/LWTI_strategic_plan.pdf

Mathews, C. 2006. Personal Communication. Senior Statistics Officer. Ministry of Environment, Province of BC.

Port of Vancouver. Port Plan. http://www.portvancouver.com/the_port/docs/Port%20Plan_for%20web.pdf

Port of Vancouver. Statistical Overview 2004. http://www.portvancouver.com/statistics/docs/2004_Statistical_Report.pdf

Prakash, C. 1998. A Critical Review of Biodiesel as a Fuel in Canada. Prepared for Environment Canada.

Statistics Canada. 2005. Poultry and Egg Statistics. Catalogue no. 23-015-XIE. http://www.statcan.ca/english/freepub/23-015-XIE/23-015-XIE2005004.pdf

Statistics Canada. 2006. The Supply and Disposition of Refined Petroleum products in Canada - October 2005. Statistics Canada – Catalogue no. 45-004.

Statistics Canada. 2006b. Hog Statistics. Catalogue no. 23-010-XIE. http://www.statcan.ca/english/freepub/23-010-XIE/23-010-XIE2006001.pdf

Statistics Canada. 2006c. Sheep Statistics. Catalogue no. 23-011-XIE. http://www.statcan.ca/english/freepub/23-011-XIE/23-011-XIE2005002.pdf

Statistics Canada. 2006d. Cattle Statistics. Catalogue no. 23-012-XIE. http://www.statcan.ca/english/freepub/23-012-XIE/23-012-XIE2005002.pdf

Uloth, V. Paprican, Prince George. Personal communication. May 18, 2004.

United States International Trade Administration. 2006. http://dataweb.usitc.gov

US Department of Commerce. 2003. Fats and Oils Production, Consumption and Stocks: 2002. July 2003. M311K(02)-13.

Wiltsee, G. 1998. Urban Waste Grease Resource Assessment. NREL/SR-570-26141. November 1998.

Wise. 2004. Biodiesel in British Columbia, Feasibility Study Report. Wise Energy Co-op. http://www.deo-wd.org/rpts/research/biodiesel/full_e.pdf