Biodiesel in British Columbia

Feasibility Study Report

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generating positive energy

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II. DOCUMENT FORMAT

This report is laid out in a sequence reflecting the activities necessary to perform a biodiesel plant feasibility study. This report is intended to be used as a guide by B.C. groups interested in assessing the potential of manufacturing biodiesel in their own community. It can be used by those with no prior knowledge of the biodiesel industry through to those just wishing to understand the biodiesel resources that may be available in their region.

The document format closely tracks the sub-phases of the study, including a review of the primary potential feed stocks (source material biodiesel can be manufactured from) in B.C., the available manufacturing technology options and vendors, a distribution overview, and a financial assessment sample. In addition, a project process checklist is included in the appendices to complement the report.

Although each project will ultimately have its own unique logistics and decision points this format was selected to ensure those wishing to conduct a biodiesel assessment project could readily follow a proven process and ensure all parameters are considered.

III. EXECUTIVE SUMMARY

This report has been produced so as to provide relevant information to anyone who is exploring the potential to develop a commercially viable biodiesel business in British Columbia.

Biodiesel is a safe, non-toxic, biodegradable and renewable fuel that can be easily used in unmodified diesel engines, and a variety of other applications. Vegetable oil as a fuel source is not a new concept, in fact when Dr Rudolf Diesel designed his prototype diesel engine nearly a century ago, he ran it on peanut oil. He envisioned that diesel engines would operate on a variety of vegetable oils.

Since its first production on a commercial scale in Germany, in 1991, global biodiesel production has increased rapidly. Biodiesel is now the fastest growing alternative fuel in Europe. In 2003, Germany, France, Austria and Italy produced over two billion litres of biodiesel, and in Germany and Austria, around 1700 service stations now sell biodiesel. Many European car manufacturers, including VW and Mercedes Benz, have approved biodiesel use for their engines. In Germany, over 19,000 jobs have been generated growing the feedstock, processing the raw materials, and marketing the resulting biodiesel. Two German bus companies run their entire fleets on biodiesel, and most major bus networks in France run on biodiesel blends.

In the U.S., a blend of 20% biodiesel with 80% petro-diesel (referred to as B20) is quite widely used, and 15 states have passed legislation favourable to biodiesel. In North Dakota and Minnesota, all diesel fuel is required to include 2% biodiesel. In Washington State, the Intercity Transit Authority uses a B20 biodiesel mix in its entire fleet, and is moving to B40 in 2004. In 2003, there were 123 gas service stations offering biodiesel. Almost all of the biodiesel that is used in Europe and the US comes from agricultural crops grown specifically for this purpose.

In Canada, biodiesel remains in the early stages of market development. Several bus companies are doing trials with imported biodiesel, and following trials, all 137 transit buses in Brampton, Ontario, are now using a B20 biodiesel blend. Canada's first and only biodiesel service station was opened by Topia Energy Inc. in Toronto on March 2nd, 2004. Because of its practicality and its many environmental benefits, the federal government has established a target production rate of 500 million litres a year by 2010, under Canada's Climate Change Action Plan.

Biodiesel can be used either as a substitute for conventional diesel, or as an additive. In both its pure and blended forms, biodiesel reduces the emissions of air toxins, CO_2, particulate matter, carbon monoxide, hydrocarbons and black smoke from vehicles.

In its regular form, diesel exhaust contains more than 40 constituents which are listed by the U.S. Environmental Protection Agency as hazardous air pollutants or toxic air contaminants, and at least 21 that are listed by the State of California as known carcinogens or reproductive toxicants. 80% of the total cancer risk for all hazardous air pollutants is associated with the inhalation of diesel exhaust.

Compared to regular diesel, pure biodiesel (B100) produces a 73% reduction in lifecycle CO_2 emissions, a 67% reduction in unburned hydrocarbons, a 48% reduction in carbon monoxide, a 47% reduction in particulate matter, a 100% reduction in sulphur oxide emissions, and an 80% reduction in polycyclic aromatic hydrocarbons, which can cause cancer and emphysema. Biodiesel's only downside is up to a 10% increase in nitrogen oxide emissions.

Biodiesel is produced by chemically reacting vegetable based oils, animal fats, or waste cooking oils with an alcohol (usually methanol), using either sodium or potassium hydroxide or sodium methoxide as a catalyst. The conversion results in pure/neat biodiesel (referred to as B100) with crude glycerine as a co-product.

This report mainly focuses on the potential to produce biodiesel from recycled bio-oils, rather than from virgin oils derived from agricultural seed crops, since B.C. has little available agricultural land. This approach provides a means of producing biodiesel in smaller urban communities across the province with more practical economics, and enhanced environmental benefits.

The biodiesel feedstocks that are examined in this report include recycled yellow and brown greases from restaurants and other foodservice establishments, fish oils from B.C.'s seafood processing industries, and rendered animal fats from the livestock industry.

Yellow grease, from recycled restaurant and food processing fryer oils, is typically the most consistent and economically viable raw feedstock that is available in most communities. It is currently being used by rendering companies for the manufacture of animal feeds. In this application, extensive processing is required to eliminate the risk of contamination in the final feed product. When yellow grease is used as a feedstock for biodiesel production, however, all that is required is filtering and de-watering.

An analysis of B.C.'s biodiesel feedstock volumes and transportation uses suggests the following market potentials:

- When all potential feedstock sources are considered (including agricultural seed crops), they yield a total theoretical capacity for 125 million litres a year of biodiesel (B100), representing 4.5% of B.C.'s total diesel usage and 11.4% of the total on road diesel market.
- If this entire total of biodiesel was used as a substitute for petroleum diesel, it would reduce B.C.'s greenhouse gas emissions by over 2,451,000 tonnes of CO_2 equivalent per year.
- This is enough biodiesel to fuel 3,716 BC Transit buses using B100, or 18,580 buses using a B20 blend. It could also be used to fuel privately owned diesel vehicles, such as the Volkswagen Jetta or the new Mercedes Smart CDI.
- If a 5% biodiesel mixture (B5) was used, blended with around 2.5 billion litres of low-sulfur petro-diesel, this would enable locally produced biodiesel to be incorporated into B.C.'s entire annual diesel supply.
- The potential supply of waste yellow grease from B.C.'s restaurants and food service establishments is estimated at 21.4 million litres a year. This is enough to provide a B100 biodiesel fuel for 636 BC Transit buses, or a B20 blended fuel for 3,180 buses, yielding an annual reduction of 411,500 tonnes in greenhouse gas emissions.

While these estimates do not take account of the logistical and economic challenges involved in diverting available feedstocks towards biodiesel production and diesel fuel substitution, they do indicate the market potential, and the economic and environmental benefits that could be realized within the province.

In addition to analyzing biodiesel's potential feedstock characteristics, output volumes and environmental impacts, this report examines:

- The existing diesel fuel industry, and its environmental impact
- Current biodiesel activity in North America and around the world
- Biodiesel standards and regulatory issues
- An environmental comparison between biodiesel and regular diesel
- Biodiesel production technologies and processing options
- Potential markets and distribution channels
- Critical success factors for the development of a biodiesel business plan

- Recommendations to project developers and governments that will accelerate the development of the biodiesel market in B.C..

The report identifies four critical strategic factors that will drive the success or failure of a commercial biodiesel project. These are:

- The ability to balance feedstock supplies, processing technology, and market penetration in an integrated system that that is both reliable and efficient;
- The ability to form stable strategic alliances with feedstock suppliers, distributors, end users, and other stakeholders;
- The ability to anticipate and deal effectively with competitive pressures; and
- The ability to generate a business plan that will allow a project to attract financing, and maintain its financial health.

The report concludes that community-based biodiesel production at a plant scale of 2 million litres a year could be economically viable if regional sources of low-cost feedstocks are combined with high-value fuel markets, chiefly in the transportation sector.

Given the many environmental benefits, and the contribution that biodiesel can make to greenhouse gas reduction, government funding may also be considered, to close the gap in meeting financing challenges.

Project proponents are encouraged to:

- Update any time sensitive information, using sources referenced in the report combined with local market data, to complete a detailed feasibility study of the proposed project;
- Identify low priced local feedstocks that could support a local plant;
- Determine the capital and operating costs required to run a plant;
- Identify local fleet managers who may have the desire and the capability to run their fleets on a biodiesel blend.
- If a project appears viable, proponents are encouraged to prepare a full business plan, secure the required financing, and solidify contractual arrangements with suppliers and customers.

Recommendations to governments:

- In view of the many benefits to the economy and environment, the BC Provincial government should level the playing field for alternative fuels by removing the Transportation Fuel Tax for biodiesel, as it has already done for propane and natural gas. This is an essential move that will encourage the development of viable biodiesel projects in B.C..
- Both federal and provincial governments should provide additional incentives for alternative fuel substitution in all major fuel use categories, and financial support for the development of community-based alternative fuel programs.
- Provide leadership by mandating a minimum 1% biodiesel blend in diesel fuel.
- Provide leadership by running biodiesel in government fleets.

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1 INTRODUCTION

1.1 Purpose of this Section

This section of the document introduces the purpose of the study, the background reasoning for conducting this study, and a framework for the scope and constraints of the project itself. It provides an overview on biodiesel and its many benefits, details the diesel fuel industry in B.C., and describes how biodiesel compares, first with diesel fuel, and then with other alternative fuels. The Introduction ends with a description of the project sub-phases and methodology with a high-level review of the mandatory requirements and critical success factors.

1.2 Project Background

Due to its many benefits, biodiesel manufacturing is escalating rapidly on a global basis, while commercial production in Canada is still virtually negligible. An association of renewable energy project developers intends that this best practise '**Biodiesel in British Columbia - Feasibility Study Report**' (report) will be the catalyst to stimulate this industry in B.C.

The vision of this guide is to provide the background and activities necessary to assist those interested in accessing the commercial biodiesel potential within their community. The intent is to show that biodiesel plants of this size can provide a viable business opportunity, while offering many environmental benefits. The goal is to provide communities with a practical means to significantly reduce greenhouse gas emissions in their community.

The production of biodiesel in many countries is, for the most part, based on virgin agricultural crops. Due to the high price of these crops, tens of millions of litres of biodiesel must be produced annually, for a plant to remain economical. This means the concept of community-level biodiesel plants is still very new to the industry.

This feasibility study report is based on manufacturing biodiesel from recycled bio-oils, which is both more economically viable than virgin crops, and results in greater environmental benefits. This approach, combined with developing local collection and distribution networks, provides a viable means to produce biodiesel in smaller urban communities.

Client definition is starting with fleets and fuel distributors having their own storage and blending facilities. The goal here was to minimize initial infrastructure costs. Once a plant is fully operational it should be possible to revisit the additional infrastructure requirements necessary to sell to independent consumers.

Although the main focus of this document is to provide a means to assess biodiesel potential at a B.C. community level, the framework necessary to access this potential needed first to be defined. For each major analysis area, e.g. bio-oil statistics, research was conducted at a top-down approach starting at the international level.

The findings from this research formed the benchmark on which B.C. community potential could be analysed and measured. These findings were summarized and presented in the body of this document to provide focused, supportable assumptions for users of this guide.

1.2.1 Feasibility Study Report Proponents

Eco-Literacy Canada

Eco-Literacy Canada (formerly Nous Autres Canada), is a registered non profit charitable foundation. ELC's mandate is to empower people, through the values, knowledge and skills learned from ecoliteracy research and education, to create sustainable communities.

The road to a sustainable human enterprise, both locally and globally, requires making wise decisions about a wide range of environmental issues. Intelligent, informed decisions about land-use, growth, energy-use, open space, pollution, and many other issues require citizens who are ecologically literate.

Eco-Literacy Canada's diverse thirty year history embraces many beneficial works and activities including two videos. *A Cut Above: My Grandfather Was a Logger* received an award for excellence from the Association for Media and Technology in Education, and *Thinking like a Forest: A Case for Selective, Sustainable Forestry* previewed on CBC and the Knowledge Network.

Current projects include: *City Green*, a community-based Victoria group endorsing healthier, natural living by promoting alternative lifestyle changes in the home and workplace; the *Wise Energy Bio-Diesel Feasibility Project* exploring the potential for commercial bio-diesel production in BC; the *Values Based Business Network* providing opportunity for local business to foster sustainability values, networking and learning opportunities and the annual *Your Business and the Environment Conference* engaging local businesses in exploring the financial and social benefits of adopting innovative environmental practices.

Future projects include; a television program combining new media and experiential learning to connect people more deeply with the planet and to assist them in learning how to live more sustainably, and an environmental innovations award recognizing not only environmental excellence but enhanced local economy.

WISE Energy Co-op

WISE Energy Co-op (WISE) is a technical and management consulting firm providing services for the emerging Canadian biodiesel industry, with a focus on community based, GHG reduction initiatives in BC. Our areas of expertise within the biodiesel industry include market research, project development, keeping up-to-date with latest industry technology developments, and providing feasibility studies for potential biodiesel production opportunities in small-mid scale communities.

Currently, WISE is developing the potential for biodiesel production on Vancouver Island. Additionally, WISE is beginning research into a variety of new and exciting feedstocks for biodiesel production. WISE will utilize its knowledge to determine the opportunities and roadblocks for communities to access potential sources of biodiesel feedstock.

WISE is also participating in the start up of the BC Sustainable Energy Association (www.bcsea.org). BCSEA is a non-profit organization working to promote renewable energy, energy efficiency, conservation and sustainability.

1.3 Project Scope

The scope of this project is to provide an overview of the biodiesel potential in the province of British Columbia. The product is a set of guidelines for others to initiate a detailed evaluation of the biodiesel potential in their community. At a minimum the guidelines should provide:

- A discussion of the benefits biodiesel offers, including the reduction of greenhouse gas emissions by its use, the health and social benefits.
- Background on biodiesel industry status in other jurisdictions in the world.
- A detailed description of the technical and feed stock components and processes needed to manufacture biodiesel.
- Initial analysis of potential biodiesel feed stocks in B.C..
- Guidelines on sizing plants.
- Suggestions for feed stock collection and product distribution.
- Capital and operational costs associated with a biodiesel plant startup.

A project checklist: **Biodiesel Production Checklist – General Considerations** is included in the appendices to assist evaluation.

1.4 Project Approach

This project was conducted over a number of mini-phases based on a predefined reporting framework and a list of critical success factors. As closely as possible the reporting framework follows the following biodiesel life cycle model (see Figure 1).

Figure 1: Biodiesel Production Cycle Model

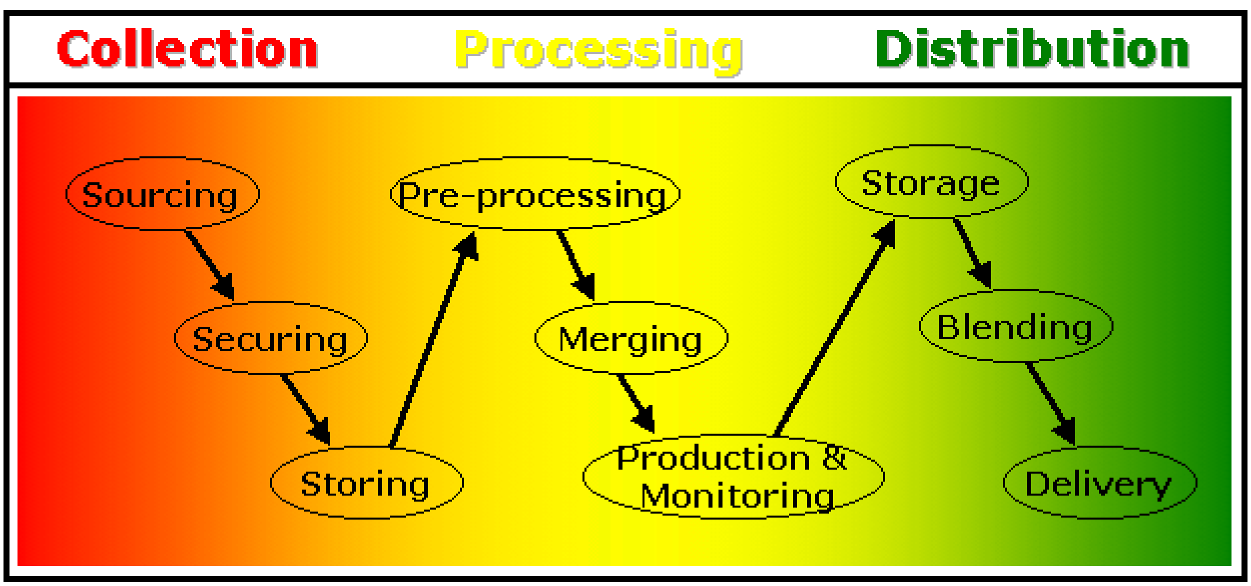


Table 1: Project Phase Descriptions

Phase	Description
1 Biodiesel Industry Analysis	This included the review of the global, Canadian and B.C. biodiesel markets and its competitor markets. Biodiesel benefits were also reviewed.
2 Analysis & Projections of B.C. Feedstock Potential by Type	A number of potential B.C. feedstocks were reviewed including yellow and brown grease (FOGs), agri-culture and aqua-culture wastes. Industrial mustard seed crops and algae were reviewed at a high level. Research included initial web review for statistics, followed by detailed data gathering through questionnaires, meetings and conference calls.
3 Investigation & Categorization of BioDiesel Processing Technology Options	Based on the feedstock results a list of potential biodiesel plant manufacturers was researched. This was conducted through a combination of the web, and fact checking telephone calls and emails.
4 Assessment of Feedstock Sourcing/Collection/ Processing Options, Costs & Logistics	Information was gathered on the current practices involved with each of the feedstocks analyzed. Theoretical options were examined for the collection or supply of some of the feedstocks.
5 Preliminary Assessment of Market Potential & Development Options	Storage and blending requirements and options were reviewed. Distribution options and by-product markets were reviewed. Profiles of potential fleets that are most likely to be the early adopters of biodiesel were examined.
6 Assessment of Potential Environmental & Social Benefits	Attempts were made to determine how best to apply triple bottom line accounting: economic, environmental and social benefits, to biodiesel projects. As this is a new method of evaluating projects there are no standards and few guidelines.
7 Financial Assessment	Based on findings from the earlier phases, high-level financial start up and production costs tables were prepared using a small scale plant configuration. Financial assumptions are provided for background. Project Financing information is presented to assist with the transition to the next phase of business planning.
8 Project Management & Administration	This included preparing project files, a Personal Information management policy, and conducting a project kickoff meeting, Steering Committee and team planning meetings. Monthly status and budget reports were prepared for the Eco-Literacy Canada Board and for the purpose of project reporting to other participants.

A draft report was then prepared recording all findings in the predefined reporting framework. Next, draft report review cycles were conducted with the Project Steering Committee and the Eco-Literacy Canada Board members. The draft report was updated based on the collective feedback and expectations of these reviewers.

This document “**Biodiesel in British Columbia - Feasibility Study Report**” was then completed and delivered. A brief Project Guide Checklist was prepared and included with the deliverable to assist other groups interested in conducting a biodiesel feasibility project in their jurisdiction.

1.5 The Impact of Climate Change in British Columbia

The United Nations Intergovernmental Panel on Climate Change's 'Third Assessment Report' (2001) states:

"There is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities. In the light of new evidence and taking into account the remaining uncertainties, most of the observed warming over the last 50 years is likely to have been due to the increase in greenhouse gas concentrations."[1]

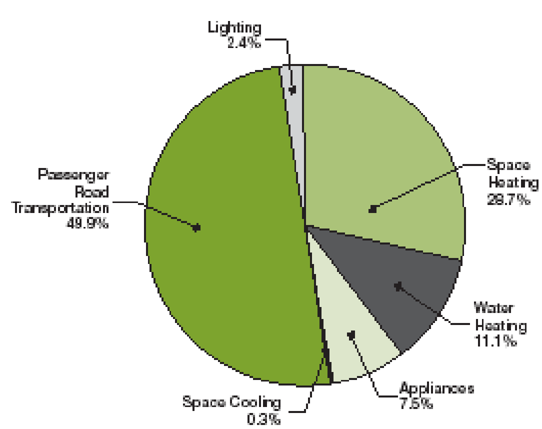
Climate change affects us all both environmentally and economically. In our every day lives British Columbians use coal, oil and natural gas to fuel our cars and provide electricity. A few of the impacts that these non-sustainable habits have on our province are listed below.[2]

- ❖ During the past 100 years, coastal temperatures have increased by 0.6° and the interior has increased by more than 1.0°, twice the global average.
- ❖ Warmer, drier summers and milder winters are taking their toll on BC's forests. The infestation of the mountain pine beetle and the frequency and intensity of forest fires are on the rise each year.
- ❖ Climate change will also change water levels, temperature and peak flow timing for rivers and streams leading to further pressures on already stressed fish species. This in turn affects all species dependant on the spawning fish species such as bears and eagles.
- ❖ Oceanic temperature changes is pushing the pacific salmon range farther north, making the return migration to spawning runs on B.C.'s coast much longer and more stressful.

1.6 Impact of Transportation

Transportation is the single largest source of greenhouse gas emissions in urban centers producing a number of emissions with varying degrees of environmental impact. These include global pollutants (such as carbon dioxide which contributes to global warming), national or regional pollutants (sulphur and nitrogen oxides which produce acidification or acid rain) and local pollutants (such as particulate matter which contributes to respiratory health problems).[3]

Sources of Personal GHG Emissions in Canada



The 2003 Climate Change Plan for Canada, states:

"The transportation sector accounts for about one quarter of Canada's greenhouse gas emissions and is a major contributor to smog in our urban areas. Approximately 70% of GHG emissions from transportation are a result of people driving cars and goods being moved by truck, and two-thirds of these emissions are generated within urban areas."

When we realize the extent of the impact transportation has on the environment, and strive to make a change, biodiesel stands out as a sustainable fuel that needs further development in British Columbia and Canada.

1.7 Biodiesel Overview

Biodiesel is not a new fuel technologically. In fact, when Dr. Rudolf Diesel developed the diesel engine in 1912, he designed it to run on peanut oil. It is a safe, non-toxic, biodegradable, and renewable fuel that can be easily used in unmodified diesel engines.

Fuel markets that can benefit from biodiesel include bus and truck fleets, heavy equipment, diesel cars and boats, and electric generators. Engines that use biodiesel last longer due to its inherent lubrication quality.

Biodiesel is produced by chemically re-acting an alcohol (usually methanol, occasionally ethanol) with vegetable based oils, animal fats, or waste cooking oils, using either sodium methoxide, sodium hydroxide, or potassium hydroxide as a catalyst. The most common process for producing biodiesel from virgin seed oils is the transesterification of fatty acid glycerol esters into methyl esters with one of the aforementioned base catalysts. From an overall ideal material balance standpoint, about 0.1 kilogram of methyl alcohol reacts with 1 kilogram of oil to form approximately 1 kilogram of biodiesel and about 0.1 kilogram of crude glycerin. (see image on right)

B100 (pure/neat 100% biodiesel) is a very clean burning, non-toxic fuel, offering significant benefits over fossil fuels. Biodiesel can also be splash blended with any percentage of petro-diesel to meet a variety of purposes. A B20 (20% B100 + 80% petro-diesel) blend is the most common to date in North America, as it provides a large number of benefits while easily maintaining current biodiesel standards. B2, on the other hand, is popular as a lubricant due to a high lubricity rating.

Biodiesel assists both the global and the local environment by minimizing air toxins, greenhouse gases, particulate matter, carbon monoxide, hydrocarbons and black smoke. It also contains no sulphur dioxide (acid rain) or aromatics. Vehicle performance, storage, and maintenance requirements are all comparable to diesel.

Biodiesel is used extensively in Europe (over 1 billion litres annually) with ~1700 service pumps in Germany and Austria alone. A B5 minimum is mandated in many parts of Europe. Biodiesel is the fastest growing alternative fuel in many EU countries and in the U.S.

1.8 The Global Biodiesel Market

Biodiesel is used for many purposes throughout the world. This section of the Report reviews the status of biodiesel in other jurisdictions in greater detail, with a focus on use by fleets.

Many industries are recognizing the environmental and health benefits realized by the use of biodiesel in place of petroleum. This move to biodiesel is most evident in government fleets, schools bus fleets, agriculture, and private companies offering green services. Adoption by private fleets is also starting to grow where biodiesel is fairly price competitive.

1.8.1 International

Biodiesel was first produced, on a commercial scale, in Germany in 1991. Since the late 1990s capacity has increased rapidly.

In 2000, an estimated 900,000 tons was produced globally (850,000 tons in Europe and 50,000 tons in the U.S. Major European producers at this time were Germany (400,000 tonnes), France (330,000 tons) and Italy (75,000 tons) according to an oleo chemicals market report by Montmorency, France-based HBI International S.A.[4]

In 2002, an estimated one billion litres of biodiesel was consumed globally.[5] Of this volume the vast majority was produced in Europe (see Table 2).

Table 2: VOME Production in Europe, by country (2002)

Country	Germany	France	Italy	Austria	Denmark	United Kingdom	Sweden	Total
Kt/Year*	450	365	210	25	10	3	1	1,064

* Kt/Year – Kilotonnes per year
Source: European Biodiesel Board, http://information.ifp.fr/IFP/en/files/cinfo/IFP-Panorama04_12-BiocarburantVA.pdf

In 2003, these seven countries almost doubled their production to 2,048kt.[6], and in 2004, Germany's production alone is predicted to surpass 1.1B litres (1,100+ kt).[7] Similar rates of growth are occurring in many other countries, with significant numbers of new, under development, or in planning biodiesel plants.

The countries producing biodiesel are for the most part consuming all that they produce. This means that biodiesel has not yet become a significant international trading commodity, though some European countries, and the U.S., do export to some extent. Rapid growth in international export activity is anticipated shortly.

1.8.2 Europe

In Europe, 50 percent of all transportation fuel consumed is diesel.[8] The size of the potential market, in conjunction with very high fuel prices, has provided European countries with a strong impetus to select alternative fuel technologies. The EU is now by far the world's largest producer and user of biodiesel.

Stringent biodiesel standards have been in place in individual EU countries for many years. Two new standards concerning biodiesel were enacted by the EU European Committee for Standardization in 2003. They are EN 14213 for heating fuel, and EN 14214 automotive fuel for diesel engines.[9]

The EU biodiesel market is helped by a 2003 EU Directive aimed at the transportation industry that requires 2% (by energy) of the fuel supply to be biofuels by 2005 and 5.75% by 2010.[10] It is further aided by very high road fuel taxes on petroleum-based fuels, versus significantly lower taxes on biodiesel. Examples of this are[11]:

- Germany's tax incentive (EU$470.00/$m^3$) includes a carbon tax exemption but only applies to B100 VOME (Vegetable Oil Methyl Ester or biodiesel). Having no production limit, Germany has recently invested substantially in new units and finds itself with excess capacity. It is anticipated that biodiesel blends will be authorized in the very near future.
- France allows a tax break (EU$350.00/$m^3$) for motor fuel blends containing VOME (up to 5% at service stations, up to 30% in captive fleets). The production quota (317,500 tons/year) will be raised by 70,000 tons in 2004, while the tax incentive is expected to drop to EU$330/$m^3$.
- Italy allows a tax break (EU$403.00/$m^3$) for motor fuel blends containing VOME (up to 5% at service stations, up to 30% for captive fleets). For transport applications, there is a quota of 300,000 tons/year. Pure VOME is totally exempt from tax when used for heating oil.
- In Austria, the tax incentive (EU$290.00/$m^3$) applies to pure VOME used in motor fuel blends (up to 2%).
- Spain does not tax VOME, which represents savings at the pump of EU$294.00/$m^3$.
- Sweden extends a tax exemption (EU$344.00/$m^3$) for VOME.
- The United Kingdom introduced a tax break for VOME of 20 p/l (EU$138.00/$m^3$) on January 1, 2003.

The EU biodiesel industry has expanded far beyond a niche market to become a significant industrial player:

- There are now over 1700 biodiesel filling stations in Germany and Austria.[12]
- Many European car manufactures, including VW and Mercedes Benz, have approved biodiesel use for their engines.
- Most French refineries add VOME to motor fuels for sale in proportions ranging from 2% to 5%. Up to 30%, it is used in captive fleets without any particular technical constraints. For Renault V.I. and PSA, the upper limit is 30%; neither will deliver a manufacturer's warranty if this threshold is exceeded.[13]
- Over 19,000 jobs have been generated in Germany to grow the feedstock, process the raw materials, and market the biodiesel.[14]

As examples of EU fleets using biodiesel:

- Upwards of 500 million km are run with biodiesel annually in the EU.
- The Kreiswerke Heinsberg GmbH and the Stadtwerke Neuwied GmbH bus companies in Germany run their entire fleets on biodiesel.
- Most major bus networks in France run on biodiesel blends.
- All bus fleets and a taxi fleet in Graz, Austria and Lille, France run on biodiesel.

- A German truck was entered into the Guinness Book of Records for traveling more than 1.25 million km on biodiesel on its original engine.

1.8.3 United States

United States interest in biodiesel was stimulated by the Clean Air Act of 1990, combined with regulations requiring reduced sulphur content in diesel fuel and reduced diesel exhaust emissions. The follow-up Energy Policy Act (EPACT) of 1992, amended in 1998, authorized federal, state and public utilities to use biodiesel to meet the alternative fuel vehicle requirements of EPACT.[15] Bills supporting fuel excise tax exemptions were introduced to the U.S. Congress in 2003.

In 2001, 15 states passed legislation favorable to biodiesel, including Missouri, Arizona, Hawaii, Iowa, Montana, Nevada, North Dakota, South Dakota and Oregon. North Dakota and Minnesota have taken this a step farther by enacting legislation requiring state diesel fuel be comprised of 2% biodiesel.

These activities have resulted in a rapid growth in biodiesel use and plants in the US. By 2001, biodiesel had been used for more than 40 million successful road miles.[16] As of 2003, 123 U.S. service stations were registered with the U.S. Department of Energy Alternative Fuels Data Center as biodiesel suppliers.[17]

The US D6751-03a Standard Specification for Biodiesel Fuel (B100) is ANSI (American Nation Standards Institute) approved.

As examples of U.S. fleets using biodiesel:

- The National Park Service is using biodiesel in their vehicles to protect the environment. Yellowstone National Park is using 100% biodiesel.
- Transit systems across the country are adopting biodiesel blends to reduce emissions18.
- Hennepin County, Minnesota, has switched from diesel fuel to a biodiesel blend in its fleet of 175 diesel-engine vehicles, including snow plows, road pavers, ambulances and the county's mobile forensic crime lab.
- The U.S. Postal Service, the U.S. Departments of Defense, Energy and Agriculture, and countless school districts, transit authorities, national parks, public utility companies, and garbage and recycling companies are using biodiesel.19
- The Henry A. Wallace Beltsville (MD.) Agricultural Research Center uses 100,000+ gallons of B20 biodiesel in its fleet of more than 150 diesel vehicles, in standby generators, in boilers to provide steam for heating buildings, and for research equipment that need to be sterilized.
- On September 1, 2000, the University of Michigan in Ann Arbor began using B20 biodiesel in their vehicles, (approximately 7500 gallons per week).
- Green service companies such as TerraClean (in Portland and Phoenix), are using biodiesel in their fleets.
- Washington's Intercity Transit Authority, which provides public transportation services to Lacey, Olympia, Tumwater and Yelm, WA, uses B20 biodiesel throughout its fleet of buses, with plans to convert to B40 in 2004.
- The Clark County School District (Las Vegas) was the largest U.S. school bus fleet using biodiesel in its schools buses in 2002.
- A New Hampshire Ski Resort announced plans in 2004 to power its snow grooming machines with biodiesel.
- Berkeley, CA, recently celebrated one year of running nearly all its 200 diesel vehicle fleet on 100 percent biodiesel. Berkeley had previously been running its refuse trucks, street sweepers, fire

trucks, paramedic ambulances, large mowers, and other diesel vehicles on a blend of B20 for 18 months. The environmentally conscious city switched to 100 percent biodiesel in January 2003, and city officials estimated use of approximately 220,000 gallons/year.

- Darien, Illinois, has 47 trucks, three school districts and two area fire departments running on B20.
- In California, biodiesel fuel is being increasingly used in organic farm vehicles.
- Biodiesel powers a number of marine fleets in Hawaii.

1.8.4 Asia

The market for biodiesel is also growing in Asia. In 2002, the Malaysian government opened Asia's first biodiesel plant, using palm olein as the major feedstock, and with a capacity of 500,000 tonnes/annum.

In the Philippines, the President issued a Memorandum Circular on February 9, 2004, mandating that all government vehicles should run on a diesel blend with 1% volume Coconut Methyl Ester (CME) starting March 1, 2004.[20]

Starting January 1, 2004, the sulfur limit in diesel was reduced from 2,000 ppm to 500 ppm according to the Clean Air Act (CAA). A revised Philippine National Standard (PNS/DOE QS 004:2003) has recently been adopted and enforced to reflect this change in the diesel fuel quality requirement.[21]

In Indonesia, a memorandum of understanding has been signed between the Agency for the Assessment and Application of Technology and the Jakarta Environmental Management Agency to develop biodiesel for use in Jakarta.[22]

As examples of Asian fleets using biodiesel:

- To reduce air pollution emissions, Jakarta City government plans to require public buses and trucks to run on biodiesel blends. Between 5 & 30% biodiesel blends are being considered.
- Japan is the largest soybean importer from the US. A considerable volume of the biodiesel produced from the soybean is used for heating oil. In 2002 the Matto-Ishikawa Central Hospital in Matto City installed what is believed to be the world's first cogeneration turbine fueled by biodiesel. The micro turbine, originally made by Capstone in the U.S., was modified by the company Meidensha to burn biodiesel.
- With the support of the US National Biodiesel Board, Taiwan completed registration of soy-based biodiesel to the clean fuel list. Road tests were conducted in September, 2000 using a local bus fleet.

1.8.5 Australia

The Australian Fuel Standard Determination 2003 was signed by the Minister for the Environment and Heritage on September 18, 2003. The determination sets out the physical and chemical parameters of the biodiesel standard. It also sets out the associated test methods that the Government will use to determine compliance. The draft standard is at: www.ea.gov.au/atmosphere/transport/biodiesel/pubs/proposed-standard.pdf.

The Australian Taxation Office is implementing a biodiesel excise licensing and the cleaner fuels grants scheme. Bills on this plan were introduced to Parliament on September 11, 2003. Manufacturers will have to send the excise tax of $.038143/litre sold to the ATO. The Cleaner Grants Fuel Scheme will provide an offsetting grant of $.038143/litre which can then be applied for by the manufacturer.[23]

Although a little cumbersome in its approach the Biodiesel Association of Australia anticipates this legislature will help biodiesel use grow at a far faster rate in Australia.

Newcastle City Council, NSW, runs all 228 council diesel powered vehicles on biodiesel.

1.8.6 Brazil

In Brazil ethanol is the major bio-fuel at this time however they are considering implementing a national program that would require a biodiesel blend minimum. Soybeans are the only widely available oil-producing crop in Brazil, however, the amount grown would have to be expanded 20 percent to produce the two billion litres of biodiesel that the country would need if a fuel mixture of just five percent (B-5) was to be mandated.[24] This is currently being considered.

As examples of Brazilian fleets using biodiesel:

- The company América Latina Logística (ALL), with 15,000 km of railroad in strategic areas like Argentina and southern Brazil has decided to replace a quarter of the petroleum-based fuel it consumes with B20 biodiesel. If all goes as planned, ALL will use 35 million litres of biodiesel a year in its 580 trains.
- A B20 biodiesel is used in buses in the southern Brazilian city of Curitiba, the capital of Paraná.

1.8.7 Canada

Canada's First Retail Biodiesel Pump was opened by Topia Energy Inc. in Greater Toronto on March 2nd, 2004. Vehicle owners, and bus and trucking fleets in the Greater Toronto Area (GTA), for the first time in Canada, now have convenient access to biodiesel.[25]

Canadian biodiesel production is starting to expand even though Canada has not yet defined a national standard (the Canadian biodiesel industry uses the American standard as a guide). Biodiesel is currently being produced commercially in Saskatchewan, Nova Scotia, Quebec and Ontario. The Manitoba government is currently exploring that provinces potential, while companies across Canada are researching commercial biodiesel production, at some level, in the near future.

Ocean Nutrition in Nova Scotia produces 5+ million litres/year for home heating fuel purposes. Also, Rothsay in Ontario has a 4 million litre/year plant in Montreal with a recent announcement for plans to build a 30 million litre/year plant, also in Quebec.

The Canadian Renewable Fuels Association states Canada Clean Fuels, Topia Energy Inc., and UPI, Inc., all of Ontario, have received verification for having met the US ASTM biodiesel standard.

A number of Canadian companies, including Canadian Biofuels Technology Corp. of Vancouver, import biodiesel from the US. Examples of Canadian fleets using biodiesel include:

- In early 2004 five BC Lower Mainland municipalities (Burnaby, Delta, the City of North Vancouver, Richmond and Vancouver) plus the Resort Municipality of Whistler combined forces in a pilot program to test biodiesel in twelve heavy-duty vehicles such as dump trucks, street cleaners and garbage trucks.[26] The program, which was initiated by Whistler, ran until the end of March 2004.[27] Each municipality contributed two vehicles to the pilot program that measured tailpipe emissions. The B100 biodiesel fuel for the Municipal Fleet pilot program was provided by Western Biofuels of Vancouver. For this pilot program Western Biofuels imported the B100 from United States since it does not yet have a production plant in BC.[28]

- Brampton, Ontario recently announced it has expanded its use of biodiesel fuel to include all transit buses, as part of the city's ongoing commitment to reduce vehicular emissions. Brampton initially tested the fuel during a two-month pilot project, which revealed that exhaust emissions were reduced by about 27 per cent. Mid-2002, the City of Brampton committed to the use of biodiesel in all 200 of its fleet vehicles, becoming the first Canadian municipality to do so. In October, 2003, all 137 Brampton Transit buses began using B20 biodiesel.
- In September 2001, Toronto Hydro-Electric began a large-scale pilot project using biodiesel in about 100 fleet vehicles. The pilot project tested the fuel under all climatic conditions in a variety of diesel-powered fleet vehicles. While Toronto Hydro-Electric initially intended to run the pilot program for a full year, it soon became obvious that they would encounter no difficulties with biodiesel. They moved to full scale use of biodiesel in all their diesel-powered vehicles July 2002, a first for Ontario, possibly Canada.
- In Saskatoon a test was run in 2003, where two transit service buses used a B5 blend while two other control buses ran with conventional fuel. Halfway through the project, the buses were switched. Throughout the test period, each bus was monitored, measured and evaluated for characteristics including emissions, fuel economy and engine wear. Findings are being evaluated.
- Between March, 2002 and March 2003, 155 Montreal Transit Corp. buses on 19 routes ran B20 biodiesel. The trial was considered a success by participants, but funding could not be sustained for a second year.
- In the 1990s a consortium comprising Arbokem Inc., BC Transit, Canada Post, Canfor Corp., Environment Canada, Ottawa-Carleton Transpo, Natural Resources Canada and Petro-Canada ran a pilot test using a B40 Canadian super-cetane technology blend on a fleet of Canada Post delivery vans. The capability and emission reduction findings were very positive however a steady source of feedstock to produce this fuel could not be guaranteed.

1.9 Potential Alternative Methyl Ester (Biodiesel) Markets

This bulk of this study has focused on methyl esters (a.k.a. biodiesel) as a diesel fuel alternative. In addition to being an alternative fuel for **freight and transportation fleets**, the **marine**, **farming**, **rail**, and **aviation** industries, there are many other markets for this product. Such uses include:

- Biosolvents – for use as industrial solvents or shoreline reclamation.
- Home Heating and Refinery Boiler Fuel.
- Lubricating Oils – diesel lubricity additives, concrete form release, concrete curing agents, sealers and stains, pump lubricants, wire rope lubricants.
- Electrical Generation.
- Landscaping.
- Herbicide Adjuvant.
- Consumer Products.

We review these alternative methyl ester markets in greater detail in **Appendix I – Potential Alternative Methyl Ester (Biodiesel) Markets**.

1.10 Background on the Fuel Industry

The following sections describe the current fuel market in B.C., and how biodiesel compares. Diesel fuel is focused on here, since it is the main fuel that biodiesel will complement or compete with. Other alternative fuels have also been included since they have the potential of being competitor fuels in the future. To support these fuel comparisons, information has been gathered on the status of biodiesel markets in other countries for purposes of comparison.

1.10.1 Diesel vs. Gasoline

Although diesel engines are much more efficient, and are the primary engine type used in the non-personal transportation industry, they are less commonly understood than the internal combustion engine found in most personal automobiles. The historical reasons for this are explained in more detail below. This trend is changing rapidly as consumers, especially Europeans, are adopting diesel vehicles.

The internal combustion cycle typically occurs in four steps:

1. Intake Stroke – takes in air and gas
2. Compression Stroke – compacts air and fuel mixture
3. Combustion Stroke – spark from sparkplug releases energy of mixture resulting in vehicle motion
4. Exhaust Stroke – releases spent combustion gases

The Octane rating of gasoline is important since it indicates the degree to which the fuel can be safely compressed, where the higher the compression rating the greater the energy returned. The engine's compression ratio dictates the octane rating of the fuel that can be used.

The diesel engine's major cycle differences are:

1. Intake Stroke – takes in air
2. Compression Stroke – compacts the air and direct injects fuel by spray
3. Combustion Stroke – heat of compressed air lights the fuel spontaneously, releasing the energy and resulting in vehicle motion
4. Exhaust Stroke – releases spent combustion gases

Diesel compression can be two to three times that of gasoline engines, since it is only air that is being compressed. This much higher compression ratio translates into more power being generated per unit of fuel, therefore a higher energy density.

The Cetane rating is a measure of the ignition quality, or ignition delay, of a diesel fuel (the time period between the start of injection and start of combustion (ignition) of the fuel). Typically, higher cetane fuels will have shorter ignition delay periods than lower cetane fuels.

1.10.2 Diesel Fuel Overview

In 2000 Canada produced about 20.2 billion litres of low sulphur (less than 500 ppm) diesel fuel. In 2002 thirteen Canadian petroleum refining, product distribution, and marketing companies operated twenty refineries, and distributed through a network of about 13,000 retail outlets. On an annual basis Canada imports about 3% (~600 million litres) of the total demand for diesel fuel, and exports about 10% (~2 billion litres), almost all to the United States.

See **Appendix G – The Diesel Industry in Canada** for an in depth look at the Canadian diesel industry.

Refined diesel fuel oil usage (DFO) sales in B.C. averaged 2.75 million cubic meters/year between 2001-2003 (Statistics Canada – Catalogue no. 57-601-X1E and B.C. Revenue) (see Table 3).

Table 3: British Columbia Wholesale and Retail Diesel Fuel Sales

Diesel Fuel Volumes in BC Aug 2001 – July 2003		
	Aug'01 - July '02 (Litres Sold)	Aug '02 - July '03 (Litres Sold)
Clear On Road Diesel Fuel		
GVTA* – DIESEL	265,825,194	277,638,280
BCTA* – DIESEL	33,246,715	34,034,553
Balance of BC	1,023,195,997	1,112,662,177
BC on land DIESEL	1,322,267,906	1,424,335,010
Marked and Marine Diesel Fuel		
Total Marked and Marine Diesel	1,324,748,356	1,391,261,371
Total Diesel Fuel Used in BC	**2,647,016,262**	**2,815,596,381**

Source: BC Revenue, personal communication Mr. Hugh Hughson, Manager Fuel Tax
Notes: * Not actual sales to consumers (i.e., not fuel consumed) the majority is fuel sales/movement to wholesalers.
* GVTA = Greater Vancouver Transit Area (essentially Greater Vancouver)
* BCTA = BC Transit Area (essentially Greater Victoria)
* Marked diesel can also be used for marine purposes

In 2003 diesel fuel prices in Victoria fluctuated significantly from a low of 30.8 cents/litre to a high of 52.1 cents/litre (see Table 4).

Table 4: 2003 Diesel Oil Rack Rate Averages (Reported by MJ Ervin)

LOCATION/COMMODITY	YTD	YTD 2003	
	AVG	HIGH	LOW
VANCOUVER/DIESEL	35.5	51.6	29.9
NANAIMO/DIESEL	36.2	52.1	30.6
VICTORIA/DIESEL	36.3	52.1	30.8

1.10.3 Low Sulphur Diesel Fuel

There are pending changes in Canadian diesel fuel regulations that are important to potential biodiesel manufacturers.

In May 2000 the federal ministries of Environment and Health jointly announced that respirable primary particulate matter less than or equal to 10 microns (PM_{10}) was being declared "toxic" as defined by section 64 of CEPA 1999. Additionally, in July 2000 those same ministries announced their intention to also declare the principal substances that form secondary PM "toxic" under CEPA 1999.

Secondary PM is formed when sulphur dioxide, nitrogen oxides, ammonia and volatile organic compounds combine in the atmosphere. According to Environment Canada, emissions from diesel-fuelled vehicles are a significant source of both PM and several of its precursors.

To reduce primary/secondary PM emissions, pursuant to subsection 332(1) of the Canadian Environmental Protection Act 1999 (CEPA 1999), the Minister of the Environment published notification (December, 2001) of pending regulations for sulphur content in diesel fuel. On July 17, 2002 Environment Canada enacted the Sulphur in Diesel Fuel Regulations (SOR/2002-254) (Regulations) for all on-road diesel vehicles. This regulation goes into affect June 1, 2006.

According to the new Regulations, diesel fuel is now defined as "…petroleum fuel that can be evaporated at atmospheric pressure that boils within the range of 130 degrees C to 400 degrees C and that is for use in diesel engines, or any fuel that is sold or represented as diesel fuel"[29]. The new Regulations lowers the maximum limit for sulphur to 5 milligrams per kilogram of the fuel, (equivalent to 15 parts per million (ppm) (Current Diesel Fuel Regulations specify a maximum limit of 500 ppm).

According to the Regulatory Impact Analysis Statement, published with the new regulations, this reduction will comply with new heavy-duty diesel vehicle emissions standards that are anticipated on 2007 models.[30] 2004 model light-duty diesel vehicles already use these new technologies to meet emission standards.

With the exception of a northern supply area, the Canadian Sulphur in Diesel Fuel Regulation specifies that diesel fuel produced or imported for use in on-road vehicles shall not exceed 500 mg/kg up to May 31, 2006 and 15 mg/kg after this date. A three-month transition period is allowed so that diesel fuel sold for use in on-road vehicles shall not exceed 500 mg/kg up to August 31, 2006 and 15 mg/kg following this date.

In the northern supply areas of the Yukon, the Northwest Territories, Nunavut, northern portions of Ontario and Quebec, and Labrador the concentration of sulphur in diesel fuel for use in on-road vehicles shall not exceed 500 mg/kg up to August 31, 2007and 15 mg/kg after this date.

Other jurisdictions that have moved to restrict the sulphur content of diesel fuel include:

- in 1998 the EU passed a directive setting the maximum limit for sulphur in on-road diesel at 50 ppm by 2005. In May 2001 however, the EU went further and proposed to introduce "zero" sulphur (<10 ppm) gasoline and on-road diesel fuel in every member state beginning January 1, 2005 (subject to review);
- the U.S. has also set standards of 15 ppm to come into effect on June 1, 2006;
- Mexico and several Asian countries already require less than 500 ppm; and
- Japan will be requiring 50 ppm starting in 2007.

Projections are the capital and operational costs of meeting the Regulatory Impact Analysis Statement will raise the price of diesel fuel by between 1.7 and 3.1 cents per litre. This equates to approximately $240 to $470 annually in fuel costs for heavy-duty diesel vehicles, and to about $22 to $40 per year for light-duty diesel vehicles.

At present, the Canadian Government Standards Board only specifies a voluntary limit for sulphur in diesel fuel for off-road vehicles and engines (of 5000 ppm). Environment Canada, however, has stated plans to recommend a regulatory limit for off-road diesel fuel be established in the same time frame as the EPA plans.[31]

In June 2003 the U.S. EPA proposed a rule that would impose a 500 mg/kg limit for sulphur in off-road diesel fuel by:

- June 1, 2007 at refineries and points of import,
- August 1, 2007 at diesel bulk storage terminals, and
- October 1, 2007 at bulk plants, wholesale purchaser-consumers and retail stations.

A 15-mg/kg limit would come into effect by:

- June 1, 2010 at refineries and point of import,
- July 15, 2010 at diesel bulk storage terminals, and
- September 1, 2010 at bulk plants, wholesale purchaser-consumers and retail stations.

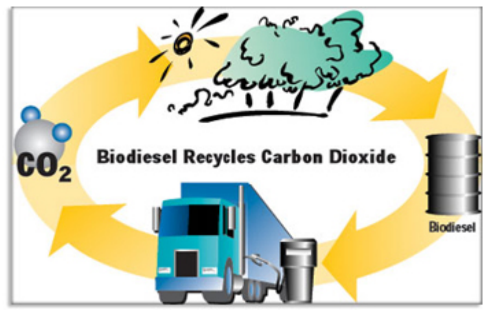
Under the EPA's proposed rule, the 15 mg/kg limit would not yet apply to marine and rail diesel fuel.

1.11 Biodiesel/Diesel Comparison

In this section biodiesel fuel is compared with diesel fuel on a number of categories including emissions, energy balance, hazardous material rating, health and social impacts, and engine performance rating.

1.11.1 Carbon Lifecycle

B100 biodiesel contains ~11% oxygen. This provides enhanced combustion properties over diesel, and therefore results in lower tailpipe emissions. Transportation greenhouse gas emissions are usually measured at the tailpipe. To gain a full understanding of emissions, however, those occurring upstream in the production process must also be accounted for. This full cycle, or life cycle, analysis includes all production through the combustion steps, including the effects of land use changes and incremental fertilizer use.



In a life cycle study published in October, 2002, entitled *A Comprehensive Analysis of Biodiesel Impacts on Exhaust Emissions, 2002* the U.S. Environmental Protection Agency (EPA) analyzed biodiesel produced from virgin soy oil, rapeseed (canola) and animal fats.[32] The study concluded that the emission impact of biodiesel produced slightly increased NOx emissions while significantly reducing other major emissions (see Table 5).

Table 5: Biodiesel Source Effects

Percent Change in Emissions

	Soy Oil		Rapeseed Oil		Animal Fats	
	20 %	100 %	20 %	100 %	20 %	100 %
NO_x	+3.1	+15.4	+2.4	+12.0	+0.6	+3.3
PM	-6.8	-34.0	Not reported	Not reported	-10.3	-48.7
CO	-3.7	-17.2	-5.5	-25.1	-8.7	-40.3

To bring the life cycle biodiesel emissions work into a Canadian context, Natural Resources Canada (NRCan) sponsored a study to expand its GHGenius model of vehicle fuels and emissions. In September 2002 the study, entitled *Assessment of Biodiesel and Ethanol Diesel Blends, Greenhouse Gas Emissions, Exhaust Emissions, and Policy Issues* was published by Levelton Engineering and $(S\&T)^2$ Consultants.[33] The methodology used in the study is consistent with that recommended by the Intergovernmental Panel on Climate Change (IPCC).

Similar to the EPA study referenced above, NRCan examined the life cycle emissions associated with biodiesel produced from soy, canola oils, and animal fats. NRCan studied the impact of B2, B20 and B100 blends, although for simplicity only the B20 and B100 results are summarized in this report. The detailed report divided the emissions by chemical characteristics according to three stages (vehicle operation, upstream and vehicle material & assembly), however for ease of presentation only the summary result by feedstock type are presented in this report.

The results reported in the study for a B100 blend are shown in Table 6.

Table 6: Lifecycle GHG and non-GHG Emissions for B100 Blends (grams/mile)

	Diesel Fuel	Biodiesel		
		Canola	Soy	Animal Fat
GHG Gases				
CO_2	2180.2	718.0	714.9	588.3
CH_4	4.906	2.970	2.959	2.408
N_2O	0.094	0.187	0.246	-1.443
Total CO_2 Equiv.	2312.4	838.4	853.3	191.4
Non-GHG Gases				
CFC's + HFC's	0.003	0.003	0.003	0.003
CO	20.448	6.195	6.405	5.232
NO_x	25.292	38.712	38.532	25.976
VOC ozone weighted	2.206	1.255	1.272	1.595
SO_x	1.305	1.044	1.027	0.746
PM	1.278	1.127	1.126	0.777

Similarly, the results reported in the study for a B20 blend (see Table 7).

Table 7: Lifecycle GHG and non-GHG Emissions for B20 Blends (grams/mile)

	Diesel Fuel	Biodiesel		
		Canola	Soy	Animal Fat
GHG Gases				
CO_2	2180.2	1895.4	1894.8	1870.4
CH_4	4.906	4.526	4.524	4.418
N_2O	0.094	0.112	0.123	-0.202
Total CO_2 Equiv.	2312.4	2025.2	2028.0	1900.5
Non-GHG Gases				
CFC's + HFC's	0.003	0.003	0.003	0.003
CO	20.448	17.698	17.738	17.512
NO_x	25.292	27.868	27.833	25.413
VOC ozone weighted	2.206	2.020	2.023	2.086
SO_x	1.305	1.243	1.240	1.185
PM	1.278	1.232	1.232	1.165

There is a broad consistency between these studies:

- ❖ With the exception of NO_x, biodiesel clearly has significantly lower life cycle emissions profile when compared with petroleum diesel; and
- ❖ Biodiesel made from animal fats has a lower emission profile than all vegetable oils.

Recycled oils should further improve the full life cycle emissions profile, when compared with virgin vegetable oils, since they have already been used for another purpose.

1.11.2 Energy Ratio Balance

The primary method for evaluating a potential transportation fuel is to examine its overall energy balance or EROI (Energy Return of Investment). The energy balance measures the units of energy yielded for each unit of energy required to produce the fuel. A low energy balance means that almost as much energy was used to produce the fuel as was returned as fuel energy.

Most fossil fuels have a negative energy balance meaning it takes more units of energy to recover, transport and process the fuel than it returns in units of fuel energy. As an example, petroleum diesel yields only 0.83 units of fuel product energy per unit of fossil energy consumed.[34]

Biodiesel's energy ratio balance cannot be matched!

For every unit of energy needed to produce biodiesel, at least 3.2 units (for virgin soybean crops) of energy are returned. **This ratio is the highest energy balance ratio of any alternative fuel. If recycled oils are used the energy balance ratio is even higher.**

Also, biodiesel plants can be run on biodiesel which would result in an even greater return on energy produced versus energy used.

1.11.3 Smog-Forming Pollutants (Ozone precursors)

In comparison with diesel, biodiesel's effects on engine tailpipe exhaust are laid out in Tables 9 and 10. B100 refers to neat (pure) biodiesel, B20 refers to 20% biodiesel blended with #2 diesel.

Table 8: Smog-Forming Pollutants (Ozone precursors)

Smog – Forming Pollutant	B100	B20
Unburned Hydrocarbons: (HC)	67% reduction	14% reduction
Carbon Monoxide (CO)	48% reduction	10% reduction
Particulate Matter (PM)	47% reduction	10% reduction
Sulphur (SOx)	100% reduction	20% reduction
Nitrogen Oxides (NOx)*	10% increase**	2% increase

Source: National Biodiesel Board: http://www.biodiesel.org/pdf_files/emissions.PDF

* Testing of biodiesel in in-use diesel engines showed NOx reductions of 10-18% compared to diesel baselines. This is believed to be due to biodiesel use in older diesel engines helping to restore fuel injectors to their original spray pattern, resulting in improved fuel economy and reduced NOx. However, testing of used heavy-duty engines in laboratory testing has not shown similar reduction levels.

Laboratory testing on new engines (also called golden engines) indicates an NOx increase of up to 10% for B100.

1.11.4 Toxic Emissions

In relation to diesel fuel, biodiesel produces much fewer toxic emissions (carcinogens that can cause diseases including cancer and emphysema).

Table 9: Toxic Emissions

Smog – Forming Pollutant	B100	B20
Polycyclic Aromatic Hydrocarbons (PAH)	80% reduction w/ B100	13% reduction w/ B20
NPAH (nitrated PAH)	90% reduction w/ B100	50% reduction w/ B20

Source: National Biodiesel Board: http://www.biodiesel.org/pdf_files/emissions.PDF

1.11.5 Hazardous Material Rating

Transport Canada endorses biodiesel as a non-hazardous and non-flammable material for transportation and storage purposes, the only alternative fuel that has received this designation (see Table 10 for a comparison with diesel).

Table 10: Biodiesel/Diesel Hazard Comparison

Property	Biodiesel	Petroleum Diesel (CARB low-sulfur)
Biodegradability[1]	Readily biodegrades 3+ times faster than diesel	Poor biodegradability
Flashpoint	150^{o} C	51.7^{o} C
Toxicity[2]	Essentially non-toxic	Highly toxic
Spill Hazard	Benign. Biodiesel is safe to handle with no dangerous fumes. No training required for handling.	Dangerous and toxic. Hazmat training required.

1. A University of Idaho study showed biodiesel samples degraded more rapidly than dextrose control and were 95% degraded at 28 days. Biodiesel blends were actually found to accelerate the biodegradability of petroleum diesel, e.g. a 20% blend degraded twice as fast as #2 Diesel. For these reasons biodiesel has been used for the clean up of ground and marine contamination.
2. Biodiesel is the only alternative fuel in the U.S. to complete EPA Tier I Health Effects Testing under Section 211 (b) of the Clean Air Act, which provide the most thorough inventory of environmental and human effects attributes that current technology will allow. Aquatic toxicity LC50 > 1,000 mg/l (based on 96-hr, concentrations above 1,000 are deemed insignificant by NIOSH).

The Transport Canada designation "non-hazardous" means that biodiesel transport and storage can use the existing petro-diesel infrastructure, or can use single-walled containers. This greatly reduces the expense of twin walled containers typically required for petroleum fuels. A growth in biodiesel will also result in a reduction in the transfer of large volumes of the more hazardous petro-diesel.

1.11.6 Improved Environmental Health

All climate scientists accept that greenhouse gases are contributing to the rapid increase in global mean temperatures. Many recent widespread weather phenomena are being attributed to these rising temperatures. A local biodiesel plant will:

- Reduce GHGs.
- Reduce effluent impacts on terrestrial and marine ecosystems. This objective is based on finding an effective means to incorporate interceptor grease as a biodiesel feedstock thereby reducing the volume of waste cooking oils reaching municipal sewage systems, and resulting overflows into ecosystems.

- This would also educe the volume of grease waste that currently makes its way into landfills where it biodegrades into hazardous, environmentally impacting, methane gas.
- Fine particulate matter plays a major role in creating the brown smog that shrouds many urban areas.

1.11.7 Human Health Impact

The downstream human health impacts and related costs are often overlooked when calculating the economics of energy.

Diesel engines account for 79% of all particulate matter emitted by vehicles.[35] Their emissions consist of a wide range of organic and inorganic compounds produced during the gaseous and exhaust phases. These particles have hundreds of chemicals absorbed onto their surfaces, including many known, and suspected, mutagens and carcinogens. 92% of these particulates are less than 1.0 microns by mass, making them fully respirable.[36]

The critical constituents of diesel exhaust include PM, NOx, SO2, CO and an extensive list of toxic chemicals that are contributors to cancer risk, chronic and acute respiratory injury, asthma attacks, ground-level ozone formation, acid deposition, particulate haze, and visibility impairment.[37]

More than 40 constituents of diesel exhaust are listed by the U.S. Environmental Protection Agency as hazardous air pollutants or toxic air contaminants. At least 21 of these substances are listed by the State of California as known carcinogens or reproductive toxicants,[38] and “80 percent of the total cancer risk from all hazardous air pollutants is associated with the inhalation of diesel exhaust”. [39]

It is estimated that as many as 13,800 Canadians/year will develop critical cancer over their lifetimes as a result of direct exposure to this diesel fine particulate matter over a period of time. Others will develop acute and chronic health problems.[40] New studies and reanalysis of pre-existing work show that chronic exposure to fine particle pollution may lower life expectancy by months to years.[41]

Also in Canada, 11.2% of children now have asthma, up significantly from the1979 figure of 2.5 %, and steadily rising.[42]

Biodiesel is the only alternative fuel to have completed the rigorous Health Effects Testing requirements of the U.S. Clean Air Act.[43] A significant reduction of harmful air-borne particulate matters in the atmosphere can reduce cancers and respiratory illnesses.

It is difficult to put a monetary value on emissions reductions, or indirect benefits such as improved health due to the reduced emissions. The David Suzuki Foundation has attempted to provide this value by equating some of the costs of healthcare to greenhouse gas emissions. They commissioned a study entitled ‘Clearing The Air: A Preliminary Analysis of Air Quality Co-Benefits from Reduced Greenhouse Gas Emissions in Canada’ (March 2000).[44] This research estimated the following values for avoided public health damages in major urban areas:

- PM_{10} - C$20,000/tonne — SO_2 – C$1,300/tonne
- NO_x - C$1,300/tonne — CO - C$5.60/tonne

1.11.8 Social Benefits

In addition to the environmental and health benefits of using biodiesel, there are also potential local social benefits realized.

Diesel fuel production is driven mainly by cost/recovery economics. The market price fluctuates significantly beyond straight recovery, processing, transportation and tax costs, however, is due to many factors, including world stability.

While a biodiesel plant must be economically viable, it should also provide a very real means for communities to reduce both their greenhouse gas emissions and dependence on imported energy. In tandem, the project should add to building local expertise, economic development and jobs in this emerging, high-potential sector in Canada while increasing renewable energy awareness in the public.

In the U.S. biodiesel plants are being developed as large conglomerate entities. The feedstock is mainly oils from virgin crops, but is transported to the plant from across many states. The produced fuel is then transported back to widely dispersed distribution depots.

By developing plants at the community level, using local, recycled materials, and by distributing the biodiesel back into the same community should result in a more sustainable and price stable fuel. This community enabling focus will help build knowledge about, and participation in, renewable energies.

1.11.9 Engine Performance

Over forty million kilometers of field-testing with biodiesel in a variety of vehicles showed performance similar to or significantly improved, over, petro-diesel (see Table 11).

Table 11: Engine Performance

Property	Biodiesel	Petroleum Diesel (CARB low-sulfur)
Engine Efficiency	A 10-15 point higher cetane rating provides improved combustion, a smoother running engine, and quieter operation.	Runs slightly rougher and louder with increased “knocking”.
Energy Density	Approximately 10% less at 950 Btu/cu.ft	Approximately 10% more at 1,058 Btu/cu.ft.
Horsepower and Torque	Comparable	Comparable. Acceleration is slightly better due to a lower viscosity.
Fuel Consumption	In in-use engines, fuel economy substantially improves and is maintained due to continuous cleaning effects of biodiesel. Clean fuel lines, injectors, and other engine components will improve combustion.	Comparable in new engines.
Lubricity	Biodiesel’s much higher lubricity rating provides for increased engine life. A B2 blend will increase diesel lubricity by up to 65%. This will be critical for engines as pending regulations require diesel fuel sulphur levels be reduced.	Diesel’s lubricity is the result of its sulphur content. Once the sulphur is removed, expensive chemical additives are needed to increase the lubricity.

Source: National Biodiesel Board

1.11.10 Comparative Costs of Biodiesel versus Diesel

Table 12 is based on the information from the table in **Appendix F: North American Biodiesel Pricing**.

Table 12 US and Canada Biodiesel / Diesel Price Comparison Summary

	B100	Spread to # 2 Diesel	# 2 Diesel
US			
Low	$1.96	$0.92	$0.96
Average	$2.11	$1.08	$1.03
High	$2.37	$1.39	$1.11
Canada			
Low	$1.29	$0.21	$1.08
Average	$1.80	$0.59	$1.21
High	$2.11	$0.91	$1.29

Source: Energy Management Institute, Alternative Fuels Index, Feb. 19, 2004, Volume 2 Issue 7
Prices do not include taxes and may be net of certain subsidies. Prices are in US dollars and US Gallons

It can be seen in table 12 and the table in Appendix F that the biodiesel pricing in Canada is significantly lower than that of the U.S. and even more importantly when compared to the significantly higher priced diesel in Canada. This demonstrates the needed effort in developing the Canadian Market and demand for biodiesel. The U.S. Energy Policy Act also creates a ready market for biodiesel with a large federal fleet spread throughout the country that has been mandated to use alternative fuels. As can be seen in the table in Appendix F, that the lower level blends such as B20 or B2, can reduce the impact of the higher priced B100. This is often the only reason the fuel is blended and not run neat.

1.12 Biodiesel Regulatory and Legislative Issues and Incentives

In an effort to encourage the biodiesel industry and its indirect beneficiaries, such as the agricultural industry, many governments are providing various forms of incentives, regulations and/or legislated renewable fuel standards.

1.12.1 British Columbia

In their February 17, 2004 budget, the Province of British Columbia amended the Alternative Motor Fuel Tax Act, which will open the door for a biodiesel exemption. It is expected that the regulations will be implemented by June 1, 2004. Based on the recommendations given to the Ministry of Provincial Revenue by an independent consulting firm, biodiesel is likely to receive a full exemption from all provincial on-road fuel taxes (see Tables 13 and 14).

Table 13: Provincial Clear Diesel Fuel Tax Rates

Fuel Tax Allocation	Effective Date	Greater Vancouver Transportation Service Region	Victoria Regional Transit Service Area	Remainder of the Province
BCTFA	March 1, 2003	6.75¢ / litre	6.75¢ / litre	6.75¢ / litre
TransLink	April 1, 2003 April 1, 2005	11.5¢ / litre 12.0¢ / litre	nil	Nil
BC Transit	Current	Nil	2.50¢ / litre	Nil
Province Diesel	April 1, 2003 April 1, 2005	2.75¢ / litre 2.25¢ / litre	8.25¢ / litre	8.25¢ / litre
Total Tax Diesel	March 1, 2003	21.00¢ / litre	17.50¢ / litre	15.00¢ / litre

Source: www.rev.gov.bc.ca/ctb/publications/bulletins/099.pdf

Table 14: Province-Wide Tax Rates on Diesel Related Fuels

Type of Fuel	Tax Rates
Jet fuel	2.0¢ / litre
Aviation Fuel (non-jet)	2.0¢ / litre
Locomotive Fuel	3.0¢ / litre
Marked (coloured) fuels, marine diesel (including any fuel sold as diesel fuel for use as fuel for a ship) and butane, but not including propane	3.0¢ / litre
Marked (coloured) fuels purchased for use by a *bona fide* farmer	Exempt
Marine Bunker fuel (heavy fuels for marine use)	Exempt

Source: www.rev.gov.bc.ca/ctb/publications/bulletins/099.pdf

1.12.2 Canada

In their March 2003 budget, the Government of Canada provided a full exemption of the 4¢ per litre federal excise tax on diesel, for biodiesel. In November 2002, under the Climate Change Plan for Canada, the Government of Canada established a new target for biodiesel: the production of 500 million litres of biodiesel/year by 2010.

Future incentives to manufacture biodiesel could include legislation for a Renewable Fuel Standard, where all diesel would be required to have a minimum biodiesel component (2-5%). This low level blend also addresses the lubricity problem that will occur when the ultra low sulphur regulation is enacted in 2006. A mandated renewable fuel standard would be an effective way to spark the biodiesel market and allow the industry to build the foundation it needs to establish itself.

1.12.3 Europe

As noted above, the European biodiesel industry is leaps and bounds ahead of the rest of the world. There are two major reasons for this:

1. In 1992, European agricultural surpluses sparked reform of the Common Agricultural Policy by idling some land used for food production through a set-aside policy. This stimulated the use of set-aside land for non-food purposes, while providing a substantial subsidy to non-food crop

production. In many cases the set-aside subsidy is increased if the land is planted with raw material for biodiesel production.[45]

2. High fuel taxes in European countries generally constitute 50 percent or more of the retail price of diesel fuel. In February 1994, the European Parliament adopted a 90 percent tax exemption for biodiesel. [46]

The combination of legislation supporting the use of alternative fuels, differential tax incentives and oilseed production subsidies has resulted in biodiesel being priced competitively with diesel fuel in a number of European countries.[47] (see image on right)

1.13 Biodiesel/Other Alternative Fuel Comparison

The comparison of the strengths and weaknesses of alternative fuels is often a subjective process that depends on a number of parameters, including the past experience of the reviewer. To a significant extent the weighting assigned to the importance of one or more comparative factors may also depend on non-technical issues. Furthermore, since the weighting assigned to individual factors will vary in importance both geographically and temporally, this section of the report will adopt a qualitative approach that assigns only relative comparisons, rather than specific numerical values.

As discussed elsewhere in this report, the impact of taxes and subsidies on the final delivered price of any fuel can be substantial, and differs markedly from one jurisdiction to another. These factors can materially influence the preference for one fuel over another, particularly if minimizing cost is assigned the highest priority, as is often the case.

For the purposes of this research, alternative fuels are considered in relationship to diesel engine performance, particularly with respect to tailpipe emissions. Since this study focuses on large vehicle fleets propane is not considered a viable option for comparison purposes.

In addition, new fuels such as hydrogen and new technologies such as fuel cells are being developed rapidly. However, they are not yet commercially or logistically viable, and therefore will not be compared with the other alternative fuels.

Although numerous studies have compared aspects of one alternative fuel with another, one particularly useful study from the United States compared biodiesel to five other fuels, using an evaluation matrix comprised of twelve criteria.[48] In this tabulation (see Table 15) the following meanings are intended:

Table 15: Diesel / Alternative Fuel Comparison

10 – Most Desirable, 0 – Least Desirable

Class*	Factor	Diesel	Biodiesel	CNG	LNG	Methanol	Ethanol
Cost	Vehicle cost	10	10	5	5	5	5
	Infrastructure	10	10	2	5	5	5
	Operating	10	7	5	7	5	5
	Training	10	10	5	5	5	5
	Fuel	6	6	8	8	6	6
Performance	Operating Range	10	10	5	10	10	10
	Reliability	10	10	7	5	3	3
Public Acceptance		5	8	8	8	8	9
Safety	Hazard	7	8	4	3	1	3
Funding	Availability	1	2	10	2	0	2
Fuel	Availability	10	6	10	5	5	5
	Quality	9	9	5	10	8	8
Totals		**98**	**96**	**74**	**73**	**61**	**66**
Environmental Impact**	Emissions	2	9	7	7	3	4
	Spills	1	5	9	9	5	5
Summary		**101**	**110**	**90**	**89**	**69**	**75**

Source: Biodiesel vs. Other Alternative Fuels, L. Howard, Bi-State Development Agency, March 1994

****We have incorporated the Environmental aspects of the fuels.**

*Definition of the factors used in Table 15;

- Vehicle cost includes direct capital cost, preparation of specifications, delivery and inspection costs,
- Infrastructure cost includes the capital cost to add or modify equipment for on-site fueling, assuming daily operation,
- Operating cost refers to non-capital expenses to fuel and operate the vehicle, including maintenance, labour and permits,
- Training costs includes training time for vehicle mechanics and facility maintenance, fuelers and vehicle operators,
- Fuel cost refers to all-in delivered cost at the dispensing nozzle, including procurement policies and market factors affecting price stability,
- Operating range is distance covered on a comparable volume of fuel,
- Reliability refers to the maturity of the technology including frequency of unscheduled maintenance,
- Public acceptance refers to an assessment of the operator's views on appearance, comfort and noise,

- Safety includes toxicity, spill risk, miscibility, flash point, proximity of fuel system to road hazards, and permissible exposure levels,
- Funding refers to the availability of funding from non-financial sources for procurement, infrastructure and facility modifications,
- Fuel availability refers to maturity of the supply network including delivery lead time, production capabilities, availability of alternate suppliers and total supply capability,
- Fuel quality refers to the consistency over time of the delivered fuel and its comparison to manufacturers' specifications,
- Emissions refers to the sum total of tailpipe emissions of Greenhouse Gases and Criteria Air Contaminants,
- Spill impact refers to the cumulative impact on the air, water, land and biota of accidental releases of the fuel to the environment.

In summary, according to this qualitative analysis, biodiesel is approximately equivalent to petroleum diesel for almost all factors, and has clear advantages in some areas. Furthermore, it has distinct advantages over gaseous fuels such as CNG and LNG, and alcohol fuels such as methanol and ethanol.

Since this study was performed with a US perspective and is quite dated -1994, it should be noted there are a few categories that will be impacted if the same comparisons are made in Canada, specifically Funding and Fuel Availability.

1.13.1 Conclusions

This section has shown that Biodiesel:

- Is a proven, alternative fuel that could complement petro-diesel in various B.C. regions.
- Is, if not the fastest, one of the fastest growing alternative fuels in the world. It is well established in Europe and the U.S., and has gained considerable attention in these, and in many other, countries where standards are defined.
- Is sold in other markets such as heating oil or lubricants, however, due to its emission reduction potential, it is as a transportation fuel that the most benefits are realized.
- Challenges and even surpasses petro-diesel and other alternative fuels, in cost, performance, safety, and environmental categories.
- Offers extensive, documented, environmental and human health benefits.
- Is not yet a significant industry in Canada. Its potential, however, is considerable once a broader foundation is established and by the fact that the federal government has made a commitment that Canada will produce 500 million litres annually by 2010. Its potential market as an additive is further enhanced by the 2006 low-sulphur diesel mandate.

2 FEEDSTOCKS AND RELATED LOGISTICS IN B.C.

2.1 Purpose of this Section

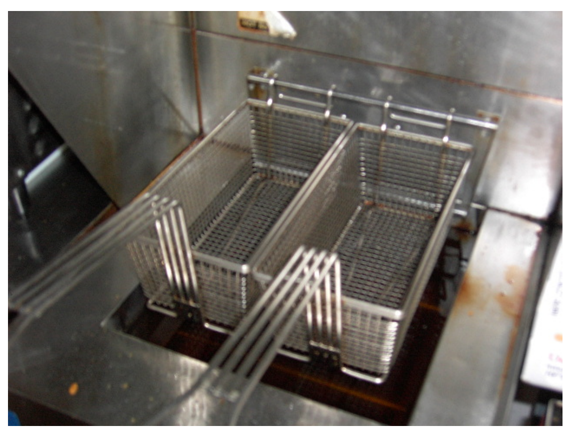
The Feedstock and Related Logistics section takes a close look at some of the lower cost feedstocks that are available in the B.C. market and an overview of the feed stock collection options. Also included are a breakdown of the other components and reagents required to produce biodiesel, including anticipated volumes, estimated quantities, and the cost of these components.

2.2 Feedstocks Overview

The feedstocks that are being reviewed in this study are recycled yellow and brown greases from foodservice establishments, fish oils from the fish farming and processing industries, and rendered animal fats from the agriculture industry. We will briefly comment on some of the other potential and future feedstock sources, however, they are not within the scope of this study, and will be researched in greater detail in separate studies.

Smaller scale, decentralized biodiesel plants that utilize waste oils as feedstocks will be focused on here since they have a distinct advantage over virgin oil biodiesel plants. Virgin vegetable oil is an expensive feedstock that can be adversely affected by the volatility of the vegetable oil markets. Crop growing variables such as drought, early frost, poor harvest and biological pests all have an impact on the virgin vegetable oil market price. Recycled waste oils are much less expensive and are not directly affected by the growing season.

2.3 Restaurant Fats, Oils and Greases (FOG)



The rendering industry breaks down used cooking oils into two categories: Yellow grease and Brown grease. The factors that differentiate the two are the free fatty acid (FFA) content and suitability as animal feed.

The biodiesel industry classifies feedstocks by their FFA content:

- ❖ Refined oils, such as canola or soybean oil (FFA <1.5%);
- ❖ Low free fatty acid yellow greases and animal fats (FFA <5%); and
- ❖ High free fatty acid greases and animal fats (FFA ≥20%).

A fat molecule is called a triglyceride from which FFAs detach through hydrolysis. Steam from cooking foods, salts, chemicals and heat work together to break triglyceride chains.

Additional pre-processing is needed to convert oils and greases that have a FFA content higher than 1.5%. If the oils are not pre-processed, the alkaline catalyst used in the conversion process causes the FFAs to form soaps, which can block the separation from the glycerine and dramatically reduce yields. This will be discussed in detail in section 3.2 Biodiesel Processing Options.

2.3.1 Yellow Grease / Used Cooking Oils

Yellow grease comes from restaurant and food processing deep fryers. #2 Yellow grease cannot exceed 10% FFA content, and # 3 yellow grease can reach up to 20%. Traditionally, yellow grease is used by rendering companies in the manufacturing of animal feed (most of western Canada's is exported to the Asian market). The difference between yellow grease and raw used cooking oils is the amount of processing involved.

To use waste cooking oils for biodiesel production, all that is required is filtering and dewatering. The price and pre-processing of this feedstock for biodiesel purposes will depend on whether it is supplied directly from the restaurants or purchased as a processed commodity from a rendering plant.

2.3.2 Brown Grease

Brown grease typically comes from restaurant grease traps (interceptors) or waste water treatment plants, and is not suitable for animal feed due to its highly contaminated state. Brown grease generally has an FFA of over 20% and can reach levels as high as 50 - 100%[49]. Most brown grease is disposed of in landfills. Depending on the degree of contamination, it could also be composted.

2.3.3 FOG Collection Options and Analysis

There are two major sub-phases that comprise the Collection Phase. They are: Sourcing and Securing.

Sourcing the Feedstock

2.3.3.1 Yellow Grease

There are between 9,700 and 11,500 restaurants in British Columbia at any point in time (determined from a combination of BC Statistics, BC Health Authority and Yellowpages.ca statistics).

In most jurisdictions, yellow grease is not a regulated waste product, so restaurants are free to dispose of it in whatever manner they please. Most choose the services of a collection company, since this is the cleanest, simplest and most convenient method. The small fee charged ($10-30/pickup), if charged at all, is generally not a deterrent to restaurateurs.

The grease collectors generally use one of two methods to collect used cooking oil from the restaurants.

The first is the use of 45-55 gallon barrels, which are picked up and exchanged for the appropriate number of "clean" barrels. These barrels are generally used by:

- smaller operations with low volumes of fat;
- restaurants with limited storage space, or without direct vehicle access; or
- restaurants that use highly saturated fats that solidify at ambient temperatures.

The second is the use of ~200 gallon plastic tanks. These tanks are left in place, but must be easily accessible for a large truck to deliver, and then to pump out the grease. The tanks are used by restaurants that generate large volumes of deep fryer waste, and to make collection more efficient. These tanks are also more aesthetically pleasing where they are visible to the general public. For the tanks to be considered an option for restaurants, the grease must remain in a semi-liquid state to facilitate pumping.

While most restaurants choose to use the services of a grease collector, a few dispose of their waste grease with their garbage. This is done for the following reasons:

- They are remotely located and there is no grease collection service available;
- They have no outside storage space to store collection barrels; or
- They are not legislated and do not wish to pay for the service.

A review of some of the major centers in BC indicates that yellow grease is being collected from restaurants in larger cities pretty well province-wide. In the northeast, Northern Alberta Processing Co., a subsidiary of West Coast Reduction Ltd. in Vancouver, is providing the service. McLeod's By-Products (head-quartered in Armstrong B.C.) is providing the service to most of the major centers outside the northeast and southwest corners of the province (see Table 16). Island Processing, also a subsidiary of West Coast Reduction Ltd., is collecting Vancouver Island restaurants. Canadian Waste Services, Inc. collects from the majority of Greater Vancouver Regional District locations.

Table 16: Provincial Yellow Grease Collection

Town/City	Approximate # of Area Restaurants	FOG Disposal Company
Prince Rupert/Kitimat/Terrace	133	McLeod's By-Products (McLeod's)
Prince George/Smithers	168	McLeod's
Quesnel/Williams Lake/100 Mile House	119	McLeod's
Kamloops	170	McLeod's
Kelowna/Westbank	287	McLeod's
Salmon Arm/Revelstoke/Golden	111	McLeod's
Creston/Cranbrook/Nelson/Fernie/Trail	221	McLeod's
Dawson Creek/Fort St. John area	137	Northern Alberta Processing
Vancouver and District	4900	Canadian Waste Services, Inc.
Powell River	54	Sunshine Coast Recycling
Vancouver Island	900	Island Processing

Note: This table was prepared from telephone surveys.

Well-developed infrastructures for the collection of yellow grease leaves prices open to competitive market forces. As mentioned, the principal use for yellow grease in British Columbia is as a supplement to animal feed in the Canadian, US or Asian markets. The current onset of bovine spongiform encephalopathy (BSE or Mad Cow Disease) in Canada, and more recently in the US, has led to a greatly reduced demand for this type of animal feed.

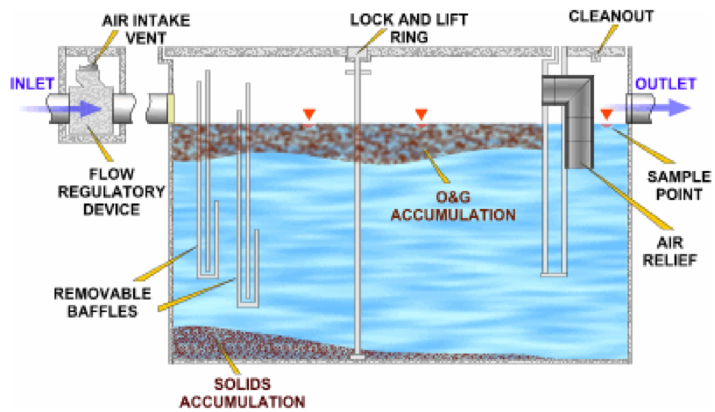
This is resulting in an increase in demand for cheaper vegetable based feeds, which has driven the price for yellow grease beyond what it would normally be when influenced by canola and soybean market trading only. The yellow grease (max 10% FFA, tanks) March 1, 2004 spot pricing from Chemical Market Reporter was US $0.13 lb.

2.3.3.2 Brown Grease

The day to day operations of the restaurant industry result in FOG being sent down various sink drains. The FOG slowly builds up in sewer drainage pipes, both large and small, and can cause sewage back-ups. This can result in costly and dangerous sewage overflows into marine ecosystems, and even into the restaurants themselves.

In addition, the continuous cleaning and occasional replacement of sewer pipes can be costly for the local governing body with authority over the sewage system.

The use of grease traps is only slowly growing in many jurisdictions. One of the exceptions to this has been the Capital Regional District (CRD) where a regulation was adopted in late 1999 in the Sewer Use Bylaw No. 5 (Bylaw 2922) requiring grease traps in food services operations. The CRD Environmental Services estimates 90% compliance with the installation requirements as of the end of 2003[50].



Grease traps separate the grease based on differences in specific gravity. This difference forces the heavier water to flow under a baffle to reach the exit where it flows into the sewage system. The lighter grease floats above the water level and remains trapped in the tank until it is pumped out. (see image above)

Restaurants must maintain their grease traps when the floating layer of grease reaches a maximum level of six inches. The restaurant will either hand skim the grease or hire a pumping company for a fee of $60 to $80 for the service. Once pumped, the wastes are typically disposed of at a waste treatment plant (WTP) or landfill, where tipping fees usually apply. Although the WTP is forced to accept the FOG, this grease is typically unwanted as it “gums up the works”[51].

The potential use of brown grease as a feedstock to produce biodiesel provides many benefits. It will reduce the impact of FOG on municipal sewage systems, both reducing effluent overflows into local marine ecosystems, while saving taxpayer dollars spent trying to prevent, and recover from, these overflows. Using trap grease to produce biodiesel also reduces the volume of fats, oil and grease entering the landfill where, as it decomposes, it creates methane emissions which must be controlled.

Brown grease may prove to be a cheap, or potentially negative cost biodiesel feedstock. However, to process brown grease into biodiesel presents many challenges. Brown grease remains trapped in the grease trap’s tank, possibly for many weeks, until it is pumped out. As a result, the fat molecules degrade from continuous contact with water, solids and cleaning agents.

This results in a high FFA content grease that needs to be mechanically separated from the solids and water through the use of heat, filtration, and possibly a centrifuge. After the brown grease has been separated from the solids and water there may be several additional steps required including; deodorizing; bleaching, and vacuum distilling.[52]

Depending on the region, the number of restaurants having grease traps installed will affect the collection patterns of these pumping companies. In urban / metropolitan areas where many grease traps are installed, pumping companies will often have dedicated trucks for grease trap pumping. In areas where there are few grease traps installed, most septic pumping companies will use the same truck for pumping grease traps and sewers. In this case the grease trap portion is contaminated and cannot be used to produce biodiesel.

Securing the Feedstock

2.3.3.3 Yellow Grease

The simplest method for securing a constant supply of yellow grease is to arrange a long-term supply contract with a rendering company, such as West Coast Reduction or McLeod's By-products. Well-established animal feed markets and market price volatility may deter these companies from supplying a biodiesel plant with a long term supply agreement. Purchasing the yellow grease on the open commodities market will likely be cost prohibitive for a small plant. It also creates a significant risk, due to the inconsistency of the market.

There may be other collection agencies eager to compete with the rendering companies, if a new market is available to sell to (this may require some prompting). Discussions with several groups (cannot disclose names) indicate that if they were able to charge the restaurants the current rate (average $10 / 55 gallon drum and 35$ for 200 gallon tank), they would be looking for $0.00-0.05 per litre for the oil to be delivered to a biodiesel plant. This amount will vary depending on the price charged to the restaurant and the distance of the restaurant from the plant site.

It would likely be more beneficial to pay a restaurant a bit more for the oil, and reduce the cost of managing the grease for the restaurant, in return for quick market penetration and increased market share and feedstock volumes.

2.3.3.4 Brown Grease

Two potential options exist for securing a reliable supply of brown grease:

1. Pumping companies with dedicated grease trap trucks deliver the trap wastes to the biodiesel plant. This will involve significant pre-processing infrastructure and waste disposal costs (solids and water), however, a tipping fee comparable to the waste treatment plant could be charged. Typical tipping fees at waste treatment plants are in the range of $0.04 - $0.07 cents per litre. This income would quickly offset the additional costs and capital required to perform the pre-processing in-house. This option will also require additional zoning considerations due to the inherent odours of grease trap wastes.
2. Arrange collection of FOG from waste treatment plants subsequent to the removal of water and solids. If the WTP does not perform a separation, this would also need to be done at the biodiesel plant. A fee would be charged to the WTP for taking this "waste", comparable to the landfill-tipping fee they would otherwise be charged.

2.3.4 Restaurant FOG Potential Feedstock Volume Analysis

In this section we estimate available yellow and brown grease volumes, provincially and regionally, using available statistical information, verified it with information gathered directly.

The following section correlates existing feedstock data from a number of studies to determine B.C. restaurant FOG volumes.

2.3.4.1 Population and Restaurant Based Yellow Grease and Trap Grease Production Estimates by NREL[53]

A 1998 detailed study of urban waste grease resources for 30 metropolitan cities in the United States, sponsored by the US Department of Energy's National Renewable Energy Laboratory (NREL), indicates a consistent 1.41 restaurants / 1000 population.

There is not much variability from one urban area to another in the number of restaurants per 1,000 people. The number is between 1 and 2 restaurants/thousand people for each of the 30 cities, and is usually in the middle of this range, with a weighted average of 1.41 restaurants/1,000 people.

The method that was used in the NREL study to determine the number of restaurants per region was generally the yellow pages of the local phone book. This does not take into account other producers of yellow grease such as institutions (i.e. hospitals and care homes) or food processing facilities.

The average amount of grease generated by a restaurant is greatly dependent on the amount of grease used in cooking. The amount of yellow grease feedstock collected from restaurants ranged from 3 to 21 pounds/year/person, or 2,000 to 13,000 pounds/year/restaurant for the 30 metropolitan areas sampled. The combined resource of collected grease trap waste and uncollected grease entering sewage treatment plants ranged from about 800 to 17,000 pounds/year/restaurant.

Based on the NREL study findings, we expect that the number of restaurants and the number of people in a metropolitan area allow us to predict the quantities of waste grease resources in any given area.

Table 17: NREL Estimated Yellow/Trap Grease

vs. Population	**Yellow Grease**	**Trap Grease**
Weighted average, pounds/year/person	8.87	13.37
vs. Number of Restaurants		
Weighted average, pounds/year/restaurant	6,268	9,453

2.3.4.2 Population Based Yellow Grease Production Estimates by Various Sources.

According to a 1993 study by Applewhite[54], the amount of yellow grease produced in the U.S. was approximately 1.5 billion pounds. This conclusion was made by adding the amount of frying fat purchased to the amount of fat rendered from meat cooked, then subtracting the amount of fat absorbed from the foods that are fried[55]. Based on the 1993 U.S. population of 260 million this equals 5.78 pounds of yellow grease per capita. This figure multiplied by the 2001 BC population of 4.14 million equals ~24 million pounds or ~12.3 million litres annually of yellow grease.

According to a 1990 study conducted by the U.S. rendering industry, 2.5 billion pounds of waste restaurant fats were collected, and after processing yielded 1.6 billion pounds of finished yellow grease. The report stated that the reduced yield was due to the high level of water and impurities in the grease. Since this deep fryer oil is used at temperatures around 350° F, it is difficult to comprehend how it could contain as much as 35% water. This result, however, is quite similar to the 1.5 billion pound estimate that Applewhite used in his 1993 study to validate his findings[56].

The April 2002 issue of the rendering industry trade publication, Render Magazine[57], uses information from the U.S. Census Bureau indicated that in 2001, the U.S. production of grease was 3.17 billion pounds. Based on the 2000 U.S. Census population of 280 million, the national per-capita production of grease was

11.3 pounds. This figure, multiplied by BC's 2001 population of 4.14 million, indicates annual provincial grease production of 47 million pounds (24 million litres).

Finally, the United States Department of Agriculture (USDA) average yellow grease production for 1995-2000 was indicated as 2.633 billion pounds[58]. Based on the 2000 U.S. Census population of 280 million, this equals 9.4 pounds per capita. Applying BC's 2001 population of 4.14 million again, this would indicate an annual yellow grease production for the province of 39 million pounds or ~20 million litres. This estimate is possibly conservative as the USDA estimate is an average of six years production, and because the yellow grease production trend in the U.S. is on an increase.

As seen in these studies, there are varied estimates for yellow grease production, however the three most recent studies (NREL, USDA and US Census Bureau) all come to similar estimates, with the most detailed research coming from the NREL study. The US Census Bureau estimate of 11.3 pounds/person may be less accurate as it states "grease" but does not specify yellow grease.

In conclusion we are using the NREL results as a comparison for B.C. estimating purposes.

2.3.4.3 Estimated British Columbia Restaurant FOG Volumes (based on stats)

2.3.4.3.1 Analysis By Population

Using the NREL study estimates, and based on BC's 2001 population, provincial production of yellow grease would equal ~19 million litres per year and for grease trap fats, provincial production would equal ~27 million litres per year (see Table 18).

Table 18: Estimated Maximum BC Restaurant FOG Volume Estimates per Region Based on Population Statistics (2001 Census)

Regional District	Population	Yellow Grease	Trap Grease*	Total Grease
Alberni-Clayaquot	31,753	147,181	212,595	359,777
Bulkley-Nechako	43,513	201,691	291,332	493,023
Capital	341,563	1,583,211	2,286,861	3,870,072
Cariboo	69,558	322,415	465,710	788,125
Central Coast	4,013	18,601	26,868	5,469
Central Kootenay	9,245	274,612	396,662	671,274
Central Okanagan	56,033	723,244	1,044,685	1,767,929
Columbia-Shuswap	50,826	235,588	340,294	575,883
Comox-Strathcona	101,038	468,331	676,478	1,144,809
Cowichan Valley	75,525	350,073	505,661	855,734
East Kootenay	60,234	279,196	403,284	682,480
Fraser Valley	253,844	1,176,617	1,699,557	2,876,174
Fraser-Fort George	100,366	465,216	671,979	1,137,195
Greater Vancouver	2,114,314	9,800,260	14,155,931	23,956,190
Kitimat-Stikine	42,914	198,915	287,321	486,236
Kootenay Boundary	33,013	153,022	221,031	374,053
Mount Waddington	13,656	63,298	91,431	154,729
Nanaimo	133,988	621,061	897,088	1,518,148

Regional District	Population	Yellow Grease	Trap Grease*	Total Grease
North Okanagan	77,268	358,152	517,331	875,483
Northern Rockies	6,131	28,418	41,049	69,467
Okanagan-Similikameen	79,472	368,368	532,088	900,456
Peace River	58,997	273,463	395,002	668,464
Powell River	20,781	96,324	139,135	235,459
Skeena-Queen Charlotte	22,912	106,202	153,402	259,604
Squamish-Lillooet	35,565	164,851	238,118	402,968
Sunshine Coast	27,110	125,660	181,509	307,169
Thompson-Nicola	126,173	584,837	844,764	1,429,601
British Columbia	**4,139,805**	**19,188,807**	**27,717,166**	**46,905,973**

Source: Socio-Economic Profiles at www.bcstats.gov.bc.ca/data/sep/rd/rd_main.htm

* Based solely on NREL study. Includes uncollected grease entering sewage treatment plants

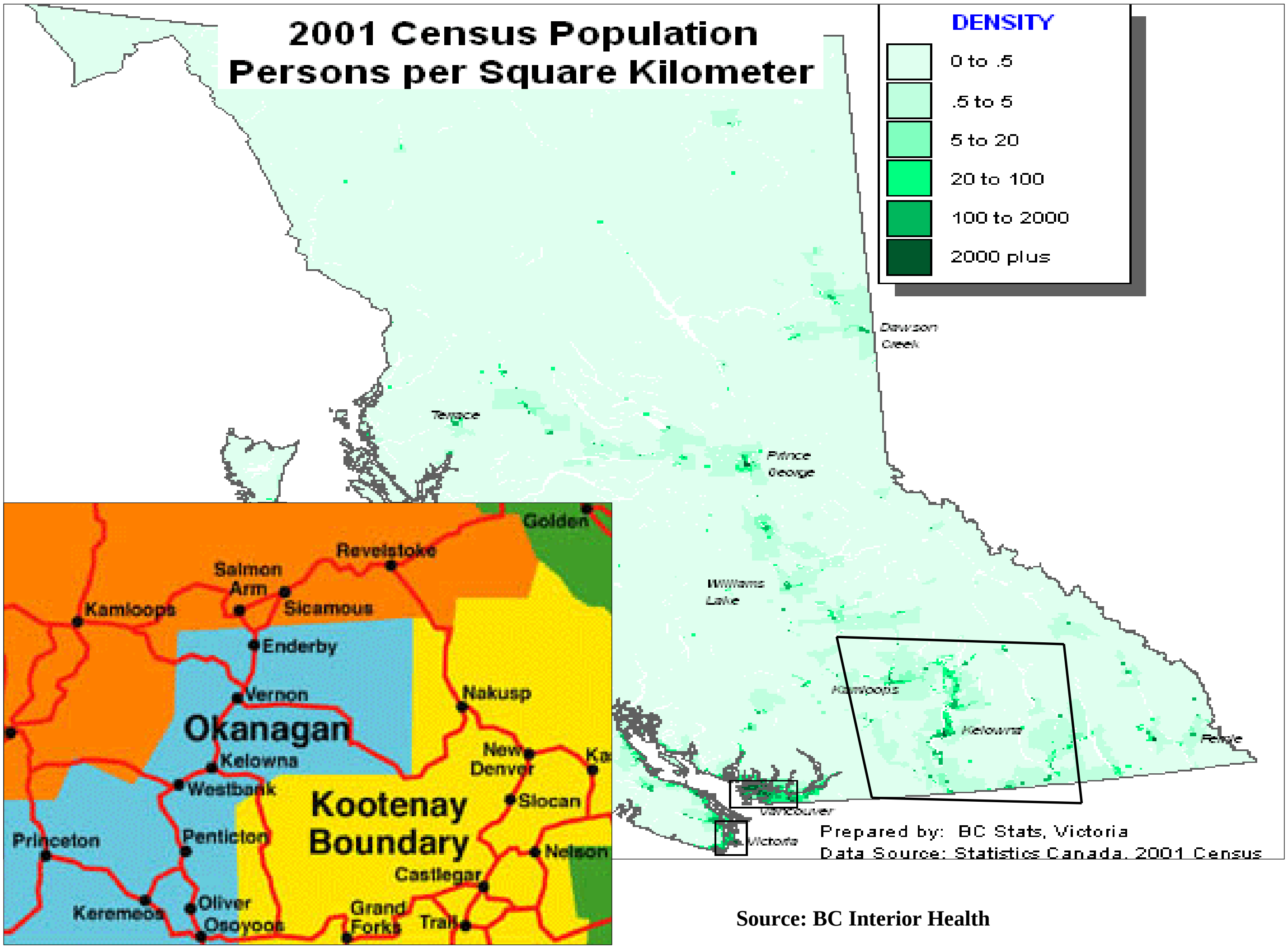
2.3.4.3.2 Potential Plant Locations in B.C.

The heavily populated areas of Vancouver, Fraser Valley and Vancouver Island, could support one or more community-based biodiesel plants based on yellow grease as the primary feedstock. Municipal population statistics from BC Stats[59], and highway routes, indicate the Okanagan and Kootenay regions have the next highest potential based on the same feedstock (see Figure 2 and Table 19).

If other feedstocks are to be used as the primary raw material from which to produce biodiesel, other regions in B.C. may become more attractive, e.g. Prince Rupert for fish oils.

Simple small scale batch plants (See section 3.3.1) with a capacity around 500,000 to 1,000,000 litres/year have been successfully operated in many jurisdictions around the world, such as Maui, Hawaii; Nagano, Japan; and many parts of Europe. The key to these plants is keeping the operating costs as low as possible. Many regions in BC could implement a plant of this scale using one or more feedstocks. The University of British Columbia / Environmental Youth Alliance's 'The Biodiesel Project" has been working on developing an efficient, low operating cost, biodiesel production system within these smaller capacities. Their progress should be followed. www.eya.ca/biodiesel

Figure 2: Map of Potential Central Interior BC Yellow Grease Collection Area



Source: BC Interior Health

Table 19: Potential Central Interior BC Yellow Grease Collection

Municipality	Population	Yellow Grease Potential
Kelowna	103,500	479,743 litres
Kamloops	80,500	373,133
Vernon	35,000	162,232
Penticton	32,500	150,644
Salmon Arm	16,000	74,163
Armstrong	4,642	21,517
Enderby	2,800	12,979
Total	274,942	1,274,410 litres

Source: www.bcstats.gov.bc.ca/data/pop/pop/mun/Mun9603e.htm

Table 19 above highlights a condensed population area within a relatively small geographic region. These numbers do not include other small towns within the collection route. The estimated volumes could potentially be increased by including adjacent small towns.

McLeod's By-Products currently performs yellow grease collection in this region.

2.3.4.3.3 Analysis By Restaurants

Using the NREL study's[60] estimate of 1.41 restaurants per 1000 people average, and the 2002 BC population of 4.14 million, this would indicate that there are 5,837 restaurants in the province. If each restaurant produced the average 6300 pounds (~3250 litres) of yellow grease per year indicated by the NREL study, this would equal almost 37 million pounds or ~19 million litres per year.

2.3.4.4 Verification of Statistical Analysis by Regional / Provincial Analysis

In order to verify these statistical restaurant volume #s, a telephone survey of 165 restaurants was conducted in one metropolitan region in the province of B.C. In order to determine the volume of waste oils coming from each restaurant, the participants of the survey were asked two key questions:

1. the total volume of oil held in all deep fryers within their kitchen, and
2. the annual average frequency that the fryer oil is discarded.

The average for Question 1 was 52 litres capacity, with a range from 12 litres to 150 litres. The average for Question 2 was every 5.6 days, with the range from every 1.5 days to every 18 days.

The total annual average volume of oil for all restaurants was added together. A standard practice within the restaurant industry is to not top up the deep fryer oil on the last day of its use; therefore, it was conservatively estimated that the deep fryers are usually only 85% full at the time of disposal. The total volume was multiplied by this percentage, resulting in an average 3906 litres per restaurant.

The list of restaurants surveyed was developed with the assistance of the BC Restaurant and Foodservice Association. Many of the restaurants surveyed were known to be larger users of deep fryers (such as fast food establishments, fish and chip shops and pubs); however many smaller operations were intentionally included while many high volume restaurants were intentionally not included.

Due to this approach, a conservative 77% estimate was used against the 3906 litres to ensure estimates were realistic. This resulted in a finding of ~3000 litres, per year, per restaurant. This is close to the NREL study estimate of ~3250 litres per year, per restaurant.

The Provincial Health Authorities are the only groups that seem to maintain reasonably accurate figures on the number of restaurants within their geographic area of the province. The environmental health department within each Service Delivery Area (SDA) of each provincial health authority, use public health officers to perform regular inspections of all Foodservice Establishments (FE). Since each of the five major health regions in the province have at least three SDA's, this helps ensure that all FE's are accounted for. They believe their BC FE database is at least 96% accurate on an ongoing basis.

Many of the more populous SDA's have online food inspection reports detailing all of the FE's within the region. Information was gathered by phone conversation with Environmental Health management, and in several cases with the public health officers themselves and through a freedom of information request.

This research was performed to obtain high level figures for the number of FE 1's and FE 2's within each region (see Table 20). In order to obtain more detailed information for many regions, the online food inspection report databank will be invaluable.

For a map of the Provincial Health Authorities as well as links and web addresses to the online FE listings see **Appendix C – Provincial Health Authorities**.

Table 20: Estimated Yellow Grease Volumes per Provincial Health Region

(Based on Restaurant Volumes and Health Authority Foodservice Establishment Figures)

Provincial Health Authority	Number of Foodservice Establishments (1)	Foodservice Establishments w/ Deep fryers Estimate (2)	Yellow Grease Volume Estimates (Litres) (3)
Vancouver Island Health Authority			
South Island Service Delivery Area (SDA)			
FE 1	1,680	672	2,016,000
FE 2	54	11	8,100
Central Island SDA			
FE 1	1,042	417	1,250,400
FE 2	44	9	6,600
North Island SDA			
FE 1	530	212	636,000
FE 2	17	3	2,550
Total VIHA	**3,367**	**1,324**	**3,919,650**
Vancouver Coastal Health Authority			
Vancouver			
FE 1	3,581	1,432	4,297,200
FE 2	73	15	10,950
Richmond			
FE 1	812	325	974,400
FE 2	8	2	1,200
North Shore			
FE 1	631	252	757,200
FE 2	10	2	1,500
Coast/Garibaldi			
FE 1	550	220	660,000
FE 2	6	1	900
Total VCHA	**5,671**	**2,249**	**6,703,350**
Fraser Health Authority			
FE 1	4,187	1,675	5,024,400
FE 2	322	64	48,300
Total FHA	**4,509**	**1,739**	**5,072,700**
Interior Health Authority			
East Kootenay SDA			
FE 1	600	240	720,000
FE 2	24	5	3,600
Kootenay/Boundary SDA			
FE 1	520	208	624,000

Provincial Health Authority	Number of Foodservice Establishments (1)	Foodservice Establishments w/ Deep fryers Estimate (2)	Yellow Grease Volume Estimates (Litres) (3)
FE 2	16	3	2,400
Okanagan SDA			
FE 1	1000	400	1,200,000
FE 2	70	14	10,500
Thompson / Cariboo / Shuswap SDA			
FE 1	800	320	960,000
FE 2	50	10	7,500
Total IHA	**3,080**	**1,200**	**3,528,000**
Northern Health Authority			
Northern Interior SDA			
FE 1	750	300	900,000
FE 2	16	3	2,400
Northwest SDA			
FE 1	632	253	758,400
FE 2	21	4	3,150
Northeast SDA			
FE 1	500	200	600,000
FE 2	16	3	2,400
Total NHA	**1,935**	**763**	**2,266,350**
Total	**18,562**	**7,275**	**21,490,050**

FE 1 – Low Risk i.e. Restaurants, cafes, delis, bakeries
FE 2 – High Risk i.e. Hospitals, care facilities

1. Information provided by Environmental Health Services Officer from each SDA of each Health Region.
2. Estimated FE 1 w/deep fryer - 40%, Estimated FE2 w/deep fryer - 10%
3. Phone Survey of 165 restaurants (FE 1) determined average annual volume of deep fryer oil to be ~3000 litres per year.

It is clear by the findings in Table 20 above that the results verify the statistical estimates from the NREL study. The only discrepancy was in the wording of the NREL study which stated; 1.41 restaurants per 1000 population. Using this figure, B.C. should have 5837 restaurants, compared with the 9,700 - 11,500 restaurants that are actually licensed, 7,275 of which we estimate have deep fryers. In order for the results to be compatible, we would have to assume the NREL study was referring to 1.41 restaurants with deep fryers per 1000 population. Using NREL's population based estimate we arrive at a comparable number of 19 million litres per year of yellow grease in BC.

Table 21: Comparison of NREL-statistics to BC-actual Yellow Grease Estimates

	# of Rests in BC w/deep fryers	Volume per Rest	Total YG in BC
NREL Study[61](based on)	5,837	~3250 litres	19,000,000
Actual BC findings	7,275	~3000 litres	21,490,050

2.3.4.4.1 Yellow Grease Seasonality

In many areas of the province, the restaurant industry has seasonal variability's due to regional tourism industries. The above estimates for yellow grease volumes did not take these variability's into account as they are very regionally specific. These variability's will be felt more if the biodiesel plant is being supplied directly from the restaurants. If yellow grease is purchased from a rendering company, they should be able to absorb most of the seasonal differences.

Most of the variability for the province will occur during the summer months when restaurants are busier due to an increase in tourists. A few localized locations may be busier during the winter months from the winter sports industry. An analysis will need to be performed to determine the most appropriate capacity for the plant being built, allowing for this variability.

2.3.4.4.2 Actual Grease Trap FOG Volume Findings

The use of grease traps in British Columbia seems to be mostly limited to the Capital Regional District (CRD) (due to the Dec 2001 by-law) and the more populous regions of the south western region of the province. As the CRD has recently implemented their new by-law, and has knowledgeable staff on the issue, it was chosen as the reference region to verify the grease trap volumes found by the NREL study[62]. Due to the extensive number of variables, however, the CRD was only able to provide rough approximations.

CRD Estimate of the Volume of FOG Generated in the Capital Region[63]

The volume of available FOG is difficult to estimate. Although the CRD collects data on the number of food services operations connected to the CRD sanitary sewer, data is not collected on the size or type of food service operation. As a result, some broad assumptions were made in developing FOG estimates.

A number of reference materials were reviewed to assist in this evaluation, the information was highly variable. Therefore, a very simple approach is presented that represents a maximum quantity of available FOG. Several other estimates are included for consideration.

<u>Number of Grease Interceptors in the CRD</u>

Sanitary	1450
On-site Treatment	125
Total CRD	1575

<u>Average Size of Grease Interceptor</u>

The majority of grease interceptors inspected by CRD staff fall between 25 and 75 US gpm. For the purposes of this study a 50 US gpm unit has been selected to represent the average case.

<u>Capacity</u>

A 50 US gpm grease interceptor has a capacity of around 200 L. Capacity varies with design. A 50 US gpm unit can hold 100 lbs (45 kg) of grease. The food services code allows grease to accumulate to 25% of the wetted height of the grease interceptor. It is likely that many food services operations exceed the level prior to cleaning the grease interceptor. The assumed level at pumping is 50% capacity or 22.5 kg. There is evidence that the interceptors are not being cleaned out as often as they should. A duration of six weeks to reach 50% full has been assumed.

An estimate of the total amount of FOG available is:

1575 (interceptors) x 22.5 (kg fat per interceptor per pumping) x 52/6 (pumpings per year) = 307,125 kg

CRD Comparison of Estimate With Field Data

Several references on FOG concentration in restaurant discharges were reviewed. These were all quite different. Based on CRD food services effluent sampling data, the average wastewater quality from food services operations is around 1,400 ppm FOG. This is higher than found in the references. Also, the reported flows are much higher in the reference material than our estimates derived from field work.

Using the following assumptions there is some agreement with the estimate above:

Number of units	1575
Wastewater flow	500 L/day
FOG content	1400 ppm
Effluent FOG quality	140 ppm
Retained FOG at 90%eff.	0.63 kg/day
GI FOG capacity	45 kg
Days to 50% capacity	35
Total grease	992 kg/day
Annual total (312 days per year)	309,600 kg/year

Using the first CRD estimate and with a population of 341,500 in the CRD, this equals an average of ~0.9 litres (~1.75 lbs) per person per year.

This is in comparison to the 13lbs/person estimated in the NREL study. The NREL study estimate for trap grease includes uncollected grease entering sewage treatment plants as well as the collected trap grease.

CRD Environmental Services also estimates that restaurants are responsible for ~40% of potential grease production in the region[64]. This would then mean the total collected and uncollected grease in the region would total ~768,000 litres/year or ~2.25 litres (~4.37 lbs) per person.

Using the 2001 BC population of 4.14 million, this would equal ~9.3 million litres of potential collected and uncollected brown grease in BC.

This only slightly closes the gap with the NREL estimate.

2.3.5 Conclusions – Provincial Restaurant FOG Volumes

A review of available statistical information on yellow grease volumes indicated comparable estimates when using the most recent and reliable sources. These sources point toward an estimate of between 19-21 million litres per year of yellow grease in BC.

In order to verify these findings, information was gathered from the five Provincial Health Authorities to determine the number of foodservice establishments (FE) in the province. Using estimates from public health officers and the BC Restaurant and Foodservice Association, we were able to estimate the percentage of FE's with deep fryers.

In order to verify the volume of yellow grease per restaurant that was available from a detailed study by NREL, we performed a survey of 165 restaurants in the province. We found that each restaurant produces an average of ~3000 litres of yellow grease per year.

Using these figures we were able to determine regional yellow grease volumes and verify the estimates for provincial volumes. Correlating population based statistical information with provincial population statistics resulted in ~19 million litres of yellow grease in BC. Detailed analysis of restaurant figures and phone surveys resulted in ~21.4 million litres of yellow grease in BC. The latter figure is thought to be the more accurate of the two estimates.

Brown grease is an attractive feedstock due to its low to negative cost and the fact that it is the only feedstock not currently being used for another purpose. Unfortunately, due to the lack of available and potential feedstock, the need for further research, the extensive pre-processing requirements, and the additional capital costs for the necessary infrastructure, a business case cannot likely be made based on brown grease alone. Once a plant has been successfully commissioned and operating smoothly on yellow grease, brown grease could become an attractive supplementary feedstock. Estimated potential collected and uncollected brown grease in BC equals ~9.3 million litres.

2.4 Summary of BC Fisheries & Seafood Processing / Biodiesel Feedstock Potential

2.4.1 Introduction

The fisheries and seafood processing industries in British Columbia are both diverse and volatile. The primary potential source of biodiesel feedstock from this sector is fish oil. Fish oil is currently being used as feedstock for biodiesel blends in Alaska and in Nova Scotia (see sections following). In BC, fish species are no longer harvested specifically for fish meal and fish oil production. Fish oil produced in the province is derived from processing fish wastes and by-products from several fisheries and value-added seafood operations. **Appendix D: BC Fisheries & Seafood Processing / Biodiesel Feedstock Potential**, provides details and analysis regarding: BC Fisheries and Aquaculture; BC Seafood Processing; Fish Oil Production Methods, Fish Oil Products; World Fish Oil Production and Markets; Other Uses of Fish Wastes; Current Biodiesel Projects Using Fish Oil; and the Fish Oil Resource in BC.

2.4.2 BC Fisheries and Seafood Summary[65]

The seafood industry is British Columbia's largest agri-food sector. The industry contributed $368 million in GDP and generated more than $1 billion in revenues to BC's economy in 2002. Exports of BC seafood products exceeded $1 billion with shipments to 47 countries. The total commercial harvest in 2002 reached 194,300 tonnes, up 7% from the previous year. Aquaculture is the fastest growing component of BC's seafood industry. Over 30 species of finfish, shellfish and plants are farmed in BC at some 700 sites.

One hundred and eighty-six companies were licensed to operate two hundred and thirteen fish processing facilities in BC during 2002. Of this total, seventy-four operations were licensed for local sales and services. 139 operations were geared towards producing seafood products for domestic use and for export to Japan, the US and other markets around the world. In addition to the fish landed from domestic commercial fisheries and aquaculture operations, processors source sockeye, pink salmon, Atlantic salmon, halibut, herring and trout from fisheries outside of the province.

In 2002 the total wholesale value of British Columbia seafood products approached $1.2 billion. Products from farmed salmon generated $359 million. Wild salmon generated $198.6 million. Groundfish provided $226.5 million. Shellfish added $209.5 million. Herring totaled $127.8 million and other fish generated $26.5 million.

2.4.3 Regional Concentration

Seafood production and the resulting generation of waste by-products that may be processed into fish oils is highly concentrated in British Columbia. Activity is centered on the lower mainland, Vancouver Island, and the North Coast.

Table 22 shows the distribution of fish processing facilities by region in 2001. The Lower Mainland, Southern Vancouver Island and the North Coast contained 83% of the licensed facilities.

Table 22: Distribution of Fish Processing Facilities by Region 2001

Region Number and Description[2]	Canning Only	Cold Storage	Canning and Cold Storage	Plant Only	Total Processing Facilities	Region %
Lower Mainland	3	57	2	43	105	53.0%
Southern Vancouver Is.	1	13	-	25	39	19.7%
West Coast Vancouver Is.	-	5	-	1	6	3.0%
Northern Vancouver Is.		3	-	5	8	4.0%
Sunshine Coast	-	1	-	8	9	4.5%
Central Coast	-	2	-	1	3	1.5%
North Coast/ Prince Rupert	1	8	1	10	20	10.1%
Queen Charlotte Is.	-	2	-	2	4	2.0%
Interior of B.C.	-	1	-	3	4	2.0%
Total	5	92	3	98	198	100.0%

Source: Special Statistical Report, BC Ministry of Agriculture Food & Fisheries

Table 23 shows the regional distribution of seafood production by wholesale value in 2001. The Lower Mainland and Vancouver Island alone accounted for 89% of the total provincial wholesale value.

Table 23: Regional Wholesale Value of Seafood Production 2001 ($'000)

Product Category	Lower Mainland	Vancouver Island	Sunshine Coast	Central Coast & North Coast & Interior & QCI	Total B.C.
Fresh	253,950	289,942	15,350	29,093	588,335
Frozen	124,050	30,106	9,277	7,272	170,705
Cured	140,217	8,919	2,745	9,121	161,002
Canned	35,961	1,165	-	32,930	70,056
Other	23,085	10,337	2,468	5,444	41,334
Grand Total	577,263	340,469	29,840	83,860	1,031,432
Region %	56.0%	33.0%	2.9%	8.1%	100.0%

Source: Special Statistical Report, BC Ministry of Agriculture Food & Fisheries

Table 24 shows regional employment in the fish-processing sector for 2002. The monthly average for the province in 2002 was 5,679 person days per month. The regional averages for the Lower Mainland and Vancouver Island contributed over 90% of this total.

Table 24: Regional Employment in the Fish Processing Sector - 2002

Month	Lower Mainland	Vancouver Island	Sunshine Coast	North Coast[2]	Total
January	2,506	1,574	36	190	4,306
February	2,527	1,637	43	186	4,393
March	2,939	1,733	42	328	5,042
April	3,202	1,776	46	376	5,400
May	3,480	1,915	100	439	5,934
June	3,461	2,400	90	515	6,466
July	3,600	2,447	86	1,130	7,263
August	4,244	2,393	48	1,232	7,917
September	3,325	2,091	44	699	6,159
October	3,440	1,990	37	328	5,795
November	3,210	1,672	8	225	5,115
December	2,609	1,568	8	178	4,363
Average	3,212	1,933	49	486	5,679
Regional %	56.6%	34.0%	0.9%	8.5%	100.0%

Source: Special Statistical Report, BC Ministry of Agriculture Food & Fisheries

2.4.4 Processing of Seafood Wastes[66]

Wastes generated by commercial fish processing can represent both a problem and an opportunity. A variety of technologies make it possible to process these waste streams into profitable, marketable products. The resulting products are as diverse as cosmetics and fertilizer, but are all derived from the efficient recovery of proteins and other biological constituents in fish wastes.

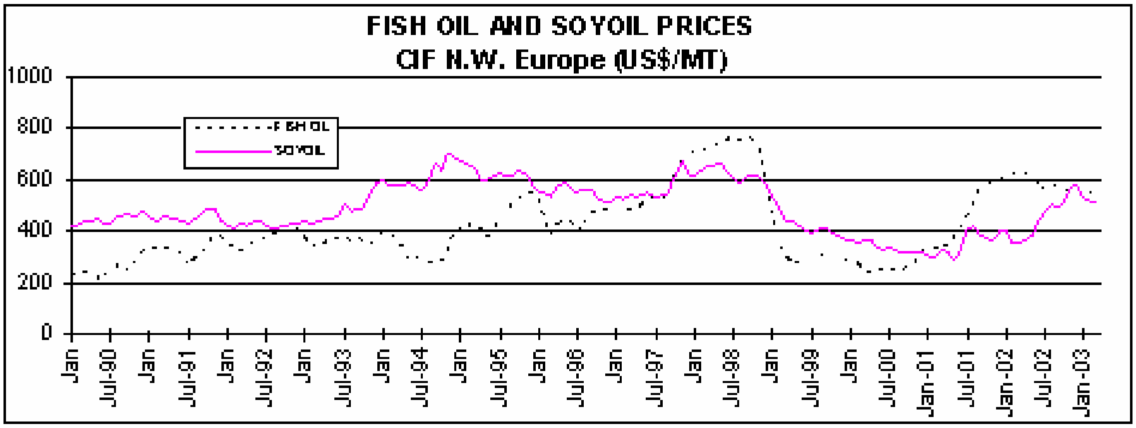
There are several processing technologies in use for converting fish waste into marketable products. Most of these processes encompass grinding and cooking the raw fish and offal with subsequent separation of the liquids from the solid material. Others involve the hydrolysis of fish protein through a form of enzymatic action. Products resulting from these processes fall into a variety of market categories including pharmaceuticals and nutraceuticals (nutritionally functional foods), industrial compounds, food products (oils, gelatins, flavors and extracts), feeds and fertilizers.

Rendering is the most common process used to extract usable oils from fish wastes. Rendering is essentially the extraction of fat or oil from animal tissues using heat. The rendering process can be wet or dry. Wet rendering, which is used most often in the recovery of fish oils, uses large amounts of water. Fat cell walls are hydrolyzed by steam under pressure until they are partially liquefied. Released fat floats onto the surface of the water. Separated fat was traditionally removed by skimming, but centrifugal methods are now commonly used.

2.4.5 Fish Oil Production & Markets[67]

Fish oil is a commodity that is produced and traded on a large scale worldwide. Both supply and demand are determined by a complex series of market and climatic factors. Worldwide uses for fish oil (2002) are as follows: Aquafeed 56%; Edible 30%; Industrial 12%; and Pharmaceutical 2%. Over the next several years, the use of fish oils for aquafeed is projected to increase, primarily at the expense of edible oil applications (see Figure 3).

Figure 3: Fish Oil and Soy Oil Prices



Total world fish oil production was approximately 1.1 million tonnes in 2002, a reduction of 18% compared to 2001. Lower oil yields in Peru and Chile (the world's leading fish oil producers) were only partly offset by higher production in the USA (the third main producer). World fish oil prices peaked in August 2002, and declined modestly during the early part of 2003. Peru's enormous fish oil production capacity tends to set international prices for fish oil. The following chart shows comparative commodity prices for fish oil and for soybean oil in Europe. Prices shown are US dollars per metric tonne. During 2003, crude fish oil prices in the US hovered around US $0.22 - $0.23 per pound (equivalent to $495/Tonne). The asking price on the National Marine Fisheries Service's "Fishery Market News" report as at Feb. 9th, 2004 was US $0.25/lb[68]

2.4.6 Current Projects Utilizing Fish Oil for Biodiesel

In North America, two significant projects that utilize fish oil as feedstock for the production of biodiesel have been successfully implemented.

2.4.6.1 Alaska Fish Oil Biodiesel Project[69]

Alaskan seafood processing operations produce approximately 8 million gallons (30.24 million litres) of fish oil annually. UniSea, Inc. owns and operates a large shore-based seafood processing facility located on Amaknak Island in Alaska's Aleutian chain. Bering Sea pollock, one of several species processed by UniSea, yields a number of commercial products such as frozen fillets and surimi (a commodity fish protein product used in the manufacture of a variety of food products). Typically, Alaskan shore-based processors recover 3% to 5% of the raw landed weight of pollock as fish oil. The market value of the raw oil ranges from US $0.75 to $1.50 per US gallon (at US $1.00 = CAD $1.33 equivalent to CAD $0.26 - $0.53 per litre).[70]

The seafood processors and their communities are heavily dependent on diesel-fueled reciprocating engines for electric energy generation. The UniSea Fish Oil Demonstration Project has been demonstrating the feasibility of using blends of fish oil and low-sulfur No. 2 diesel fuel in 2.3-megawatt, stationary medium-speed, two-cycle, engine-generator sets. The project entails assessments of the blended fuels' impacts on both engine exhaust emissions and engine operability and maintainability.

Engine exhaust emissions resulting from the use of fuel blends ranging from 0% to 100% fish oil were measured at multiple engine loads. Results indicated up to 60% reduction in particulate matter, 33% reduction in carbon monoxide, and 78% reduction in sulfur dioxide emissions. These benefits were partially offset by an increase of up to 8% in nitrogen oxide emissions. Over a 10-month test period, the engines operated normally in all respects utilizing a 50% fish oil fuel blend, and consuming over 526,000 gallons (2 million litres) of fish oil with no apparent adverse operational or maintenance impacts.

2.4.6.2 Ocean Nutrition / Wilson Fuels[71]

Ocean Nutrition, a division of Clearwater Fine Foods, has been making omega-3 concentrates from fish oil at its plant in Mulgrave, Nova Scotia since 1997. Ocean Nutrition uses some fish oils that are available from local processors, but the bulk of their fish oil feedstocks are sourced from large-scale processors of anchovy and sardine species in South America. The company sells its Omega-3 concentrates to dietary supplement and functional-food businesses in North America, Asia and Europe. As a byproduct, Ocean Nutrition had been producing about a million litres per year of waste fish oil containing the less desirable saturated fat from the fish.

Since 1999, the company has been making biodiesel from the residual oil, which it uses to fuel its generators and supplies to a nearby subcontractor to meet part of its energy needs. A 400% expansion of the Mulgrave facility was scheduled for completion in October 2003. As a result of this expansion, the amount of waste oil was projected to grow to five or six million litres per year, far more than could be used by the plant or its subcontractor. Ocean Nutrition's contracted with a local fuel distributor, Wilson Fuels, to take the biodiesel byproduct. As a result of this arrangement, Wilson will buy about five million litres annually for the next 10 years.

Wilson Fuels pays a modest premium for the biodiesel as compared to standard diesel fuel, but the company intends to sell the product at a premium price, initially as environmentally friendly furnace oil. Wilson mixes the biodiesel output with standard heating oil in blends from 5% to 20%. The odor from combustion of the product is reported to be sweet rather than fishy, and not as unpleasant as the odor from traditional furnace oil. The appearance is described as looking lighter than apple juice.

Wilson Fuels is also targeting the potential biodiesel market for transportation applications. The Halifax Regional Municipality Metro Transit bus system tested the fish oil-based biodiesel fuel from late November 2003 to March 15th 2004. The product reportedly performed well, but the premium price compared to conventional diesel fuel has been a disincentive for full-scale use. Nova Scotia does not currently exempt biodiesel from Provincial road tax. Such action would provide a significant incentive to expand biodiesel market penetration. Wilson Fuels Vice-President David Collins has indicated that the company might be interested in expanding biofuel production if there were stronger incentives for consumers to use it. Under these circumstances, the company would consider building a plant to process the oil byproduct that comes from rendering plants, such as the one operated by Rothsay Recycles, a division of Maple Leaf Foods, in Truro. Such a plan might also provide a market for local farmers looking to sell their older cattle, which currently have little market value.[72]

2.4.7 The Fish Oil Resource in BC

Three companies dominate the production of fish oil in BC: West Coast Reduction (Vancouver operation); Island Processing – Division of West Coast Reduction (Nanaimo), and JS McMillan Fisheries North Coast (Prince Rupert). The following summary was obtained from Ms. Carmen Matthews, Senior Seafood Statistics Officer for the Ministry of Ministry of Agriculture, Food and Fisheries. Ministry officials are prohibited from releasing statistics when fewer than three companies respond in a specific survey. As a result, data for the years 1998, 1999 and 2002 has not been made available for fish oil production.

The output of fish oil was reported at approximately 13.5 million litres in the province for 2000. The reported output rose dramatically in 2001 to almost 53.4 million litres. The hake fishery is a significant source of raw material used in the production of fish oil in BC. In 2000, the hake fishery brought in only 6,100 tonnes compared to 69,000 tonnes in 1999, 53,000 tonnes in 2001 and 57,000 tonnes in 2002.

Ministry officials confirm that the change in hake supply is the primary factor behind the decline in oil production during 2000 and the subsequent increase the next year[73]. Hake processors have suffered both from fluctuating fishery volumes and from an offshoot of the reaction to BSE. A significant portion of the hake catch is processed in the production of surimi, primarily for Asian markets. Beef plasma is used as an ingredient in the manufacturing surimi. When concerns surfaced about potential BSE contamination in Canadian beef products, Asian markets essentially closed to Canadian surimi products. The industry was then hit with the news in February 2004 that Canadian Seafood Processor Ltd's surimi plant in Ucluelet would be closing, resulting in the loss of 140 seasonal jobs.

Table 25: Fish Oil Production in BC

BC Reduction Facility Production (Preliminary Data) 1998 - 2002[74]						
Product	**Units**	**1998**	**1999**	**2000**	**2001**	**2002**
Animal Feed [1]	pounds	*	*	*	*	27,745,714
Offal Meal [2]	pounds	*	25,268,335	20,184,851	24,642,962	*
Hydrolosate	pounds	**	**	*	**	**
Solubles	pounds	**	**	*	*	*
Fish Oil [3]	**Litres**	*	*	**13,531,965**	**53,366,830**	*

* Denotes confidential data where less than three companies reported.
**Data Not Reported

(1) Includes animal feed derived from salmon and groundfish offal.
(2) Includes meal derived from salmon and groundfish offal and herring bodies and herring offal
(3) Includes oil derived from salmon and groundfish offal and herring bodies and herring offal..

2.4.8 Profile of Companies Producing Fish Oil in BC

The following companies produce and fish oil in the province of BC.

2.4.8.1 West Coast Reduction Ltd.[75]

West Coast Reduction is the largest rendering company in western Canada. The firm renders inedible animal by-products from the meat, poultry and fish processing industries to produce protein meals and fats and oils used in the feed, oleo-chemical and soap industries. West Coast receives and transports each type of raw material in custom-designed trucks that collect bones, fat, offal, feathers, fish, blood, and used restaurant grease. Each category of raw material is processed separately in fully enclosed computer controlled processing systems. Plants are serviced by rail and other major transportation networks. The company is headquartered in Vancouver and ships bulk products to Asia, Europe, South, North and Central America.

2.4.8.2 Island Processing Company (Wholly Owned Division of West Coast Reduction)[76]

Island Processing, located in Nanaimo BC, is a wholly owned division of West Coast Reduction. The company renders both fish and animal wastes from sources on Vancouver Island. Island Processing's new fish rendering plant opened in Nanaimo in May 1999. The operation produces fish meal and fish oil from June to October, when hake is fished on the West Coast. The plant is capable of handling 22.5 tonnes of raw material per hour. For every tonne of fish waste utilized, the operation produces about 160 kg of fish meal and 20 kg of oil. Although West Coast Reduction already had a plant with similar capacity on the mainland, the company reportedly invested in this second installation because it believed that the pacific hake industry on Vancouver Island would grow substantially. It may be anticipated that the closure of Canadian Seafood Processor Ltd's hake plant in Ucluelet in February of 2004 will have a negative impact upon capacity utilization at Island Processing's operation. Output from the plant was geared to supply the extensive nearby aquaculture industry. It was planned that most of the meal would be sold in Canada, with some being exported.

2.4.8.3 JS McMillan Fisheries (North Coast)[77]

The JS McMillan Fish Reduction Plant in Prince Rupert BC converts fish offal, by-catch, and other fishery wastes generated from the fish processing facilities in northern British Columbia into fish meal and other fish by-products. The operation primarily produces salmon oil as a byproduct. Estimated volume is approximately 40 tonnes per year (approx. 45,000 litres). Oil production is extremely seasonal, with virtually all output being generated in July and August. The oil is currently sold under contract to Purdue Chicken, which uses both the fish meal and oil as feed in its Abbotsford BC operation. The raw oil is sold FOB McMillan's plant in Prince Rupert for approximately $500 per tonne (equivalent to approximately CAD $0.45 per litre).

2.4.9 Conclusions

The opportunity to provide biodiesel feedstock from the fisheries and seafood-processing sector in BC is centered upon the potential use of fish oil as a feedstock for biodiesel processing. Fish oils in BC are derived from the rendering and recovery of waste by-products resulting from value-added seafood processing. The tasks of collecting the raw wastes and of extracting usable oils from them are capital-intensive and complex operations. It is unlikely that a potential biodiesel manufacturer in the province would find it strategically or economically viable to integrate backwards, i.e., to invest in purpose-build rendering/recovery facility for producing an in-house source of fish oil feedstock from raw waste.

With a proven output capacity exceeding 50 million litres per year, the province of BC generates a significant quantity of fish oil through its existing facilities. Some portion of this resource could theoretically be diverted for biodiesel production if the economic and logistical incentives were made available to the limited number of processors that produce these oils in the province. Prices for refined fish oil have averaged US $0.22 - $0.25 per pound[78] during 2003/2004. This would equate to a range of CAD $0.57 - $0.66 per litre.

Biodiesel production can utilize crude, unprocessed fish oil. Based upon pricing from sources in Alaska, crude fish oil could be supplied from this region at a price ranging from CAD $0.26 - $0.53 per litre[79]. In Prince Rupert, the price for crude fish oil was reported at CAD $0.45 per litre. In more remote areas, the cost of diesel fuel tends to be higher than in densely populated regions. These factors may combine to enhance the economic potential of using fish oil as a feedstock for biodiesel production in more remote areas that have a locally produced supply of crude fish oil.

A potential manufacturer of biodiesel in BC may be able to offer a regional producer of fish oil a market opportunity with secure volumes and competitive prices in return for a reliable and consistent supply of fish oil feedstock. Depending upon relative economics, there may exist opportunities for partnering and supply agreements. Factors for consideration by the potential biodiesel producer would include: the relative prices of fish oil, diesel fuel and other available biodiesel feedstocks; fluctuation, seasonality and shelf life of the fish oil supply. Advantages to the fish oil producer may include: firm pricing, less complex delivery logistics and relief from concerns regarding pathogen contamination in feed ingredients.

2.5 Rendered Animal Fats (Summary)

2.5.1 The Agriculture Industry in Canada

The agriculture and agri-food industry is a very important sector of the Canadian economy. It is the second largest manufacturing sector, the source of one in seven jobs, and is valued at $130 billion annually.[80] Due in large part to Canada's reputation as a producer of safe, high-quality food, the industry has seen a rapid growth in exports to a current level of about $23 billion annually.

The Canadian agriculture and agri-food industry can be segmented into a number of very important sectors such as cereal grains, fruit, vegetables, poultry, livestock and others that are inter-dependent. For the purposes of this report, this section focuses on the livestock and poultry segments as a potential source of fats that could be converted into biodiesel. In order to do so, this section presents a summary of the main issues and opportunities, with additional information to be found in **Appendix E – Potential for Rendered Animal Fats as a Biodiesel Feedstock in BC**.

2.5.1.1 The Cattle Industry

According to the Canadian Food Inspection Agency, the population of cattle in Canada has remained fairly stable over the last several years at about 14 - 16 million head, although a decrease of about 2 million head normally occurs during the winter months as animals are culled to reduce feeding costs. In general terms the Canadian cattle population is made up of about 15% dairy and 85% beef cattle.

In British Columbia the total cattle population averages approximately 80% beef and 20% dairy. In 2003, of the 477,300 cattle produced in British Columbia, 78% were exported live and only 11% were slaughtered within the province.

Based on Statistics Canada data, it is estimated that about 82% of the British Columbia dairy herd can be found on Vancouver Island (12%) and the lower Fraser Valley (70%) areas with much of the remainder in the Thompson-Okanagan.[81] Also based on Statistics Canada data, it is estimated that only 7.0% of the British Columbia beef herd can be found on Vancouver Island and the lower Fraser Valley areas with the majority in the Thompson-Okanagan, Cariboo and Peace River districts.

2.5.1.2 The Hog Industry

A second major component of the livestock industry in Canada is the hog sector. Although the total population of all types of pigs in Canada is similar to cattle at about 13 – 15 million, the production process is distinctly different with most hogs raised indoors in large barns. The hog industry differs markedly from cattle in several other key respects. The time from birth to market is significantly shorter, due in part to the lower weight at slaughter. In addition to being reared almost exclusively indoors, the average herd size per farm for pigs is significantly larger than cattle at 995 in 2001. Whereas about 21% of the live cattle inventory goes to market each year, the shorter production time for hogs means that the number of hogs marketed annually is about 190% of the inventory.

Statistics Canada reports that 86.4% of the British Columbia inventory of all swine was located in four regional districts in the Lower Mainland – Southwest area.[82], with most of the remaining swine concentrated in the Thompson-Okanagan and Peace River areas.

2.5.1.3 The Sheep and Lamb Industry

As of July 2003 the inventory of sheep and lambs in Canada totaled approximately 1.2 million head, which are concentrated in Alberta, Ontario and Quebec. The British Columbia herd totals about 6% of the national inventory. The British Columbia Ministry of Agriculture, Food & Fisheries (BCMAFF) estimates that approximately 80,000 sheep and lambs are slaughtered each year in the province.[83] This implies a turnover rate for the herd of about once per year.

Statistics Canada reports that 21.2% of the British Columbia inventory of all sheep and lambs was located in 7 regional districts on Vancouver Island and the Sunshine coast, with an additional 19.3% of all sheep and lambs in four regional districts in the Lower Mainland – Southwest area.[84] Most of the remaining sheep were concentrated in the Thompson-Okanagan and Peace River areas.

2.5.1.4 The Poultry Industry

In addition to red meat production, another major segment of the meat industry in Canada is the poultry sector, which is dominated by chickens and turkeys. Smaller quantities of ducks, geese, ostrich and emu also contribute to this sector on a regional basis. Statistics Canada's Census of Agriculture reports that in 2001 there were 126.2 million chickens of all types on Canadian farms, plus 8.1 million turkeys. Of these, 18.8 million chickens (14.9%) and 0.85 million turkeys (10.1%) were on farms in British Columbia.[85]

In 2002 the Canadian production of chickens and turkeys totaled in excess of 634 million birds, with concentrations in Ontario, Quebec and British Columbia. The British Columbia contribution totaled about 16% of the national production. Statistics Canada reports that 6.4% of the British Columbia inventory of all chickens and turkeys was located in 7 regional districts on Vancouver Island and the Sunshine coast, with an additional 83.9% of all chickens and turkeys in four regional districts in the Lower Mainland – Southwest area.[86] Although the remainder of the BC inventory is relatively small, it is concentrated in the Thompson-Okanagan area.

2.5.2 Slaughter and Inspection

The animal slaughter and meat processing industry in Canada is complex due to the different types of animals, a wide variety of meat products, cultural factors and geography. According to information available on the web site of the Canadian Food Inspection Agency (CFIA), there are more than 2500 federally licensed meat processing facilities in Canada, although separate licenses are issued for portions of the same physical plant location.[87] On a national basis, the CFIA condenses the active plants to 780 federally registered establishments producing meat and meat products, including 82 red meat establishments, 70 poultry establishments, 437 processing establishments and 191 storage facilities. In order to import or export meat products, a plant must have the appropriate federal license.

Within British Columbia, the CFIA has issued 204 licenses, of which 25 are for slaughter, 36 are for Boning and Cutting, and 54 are for Other Processing. In addition there are 20 federally licensed storage facilities in the province. Further subdividing the data, of the active 25 federal slaughter licenses in British Columbia, 3 are for cattle/calves, 3 for sheep/lambs/goats, 2 for swine, 9 for poultry and 8 for other purposes.

2.5.3 Rendering

The Canadian rendering industry is concentrated with plant ownership dominated by three companies: Rothsay (a division of Maple Leaf Foods), West Coast Reduction and Sanimal (formerly Alex Couture, Lomex and Fondoir Laurentide). Rothsay operates six rendering plants throughout central and Eastern Canada in Manitoba (1), Ontario (2), Quebec (1), Nova Scotia (1) and Newfoundland and Labrador (1).[88]

West Coast Reduction operates six plants throughout western Canada in British Columbia (2), Alberta (3) and Saskatchewan (1).[89] Sanimal operates three plants throughout Eastern Canada (plus others in the northeastern U.S.) in Quebec (3).[90] The ownership of the remaining 17 rendering plants is not listed on the web site of the national Renderers Association.[91]

According to the CFIA, 2 – 3 million tonnes of inedible by-products are processed annually at the 32 Canadian rendering plants referenced above. In addition to the livestock and poultry carcasses previously described, sources of raw material include offal, fish, fat trimmings, bones, other inedible tissues from slaughter facilities, dead stock, spent cooking fats and oils, and trim material from supermarkets and restaurants.

More than 50% of the products processed by renderers are protein meals, with the remainder being animal fats and fatty acids. According to the CFIA, Canadian rendering plants annually produce approximately 530,000 tonnes of Meat and Bone Meal (MBM) for use in animal meals, 270,000 tonnes of animal fats and fatty acids, and 75,600 tonnes of blood and feather meal. Most of the protein meals are used domestically, whereas a large proportion of the tallow and fat produced is exported.

2.5.4 The Feed Industry

According to the CFIA, in 2000 there were about 600 feed mills, 1300 feed retailers of livestock feeds and more than 100,000 farms feeding ruminants in Canada.[92] The breakdown of commercial feed production by livestock type is approximately 37% hogs, 29% cattle, 15% dairy, 16% poultry and 3% other. Approximately 68% of the feed mills are in Ontario and Quebec, with British Columbia accounting for only 3%. While some 200 feed companies own 520 of the mills, 169 feed mills (or 33%) are owned by 11 large feed corporations and account for about 70% of total annual production.[93]

In 1997 Canada adopted a mammalian-to-ruminant Feed Ban which prohibits the feeding of proteins from mammalian species to ruminant animals such as cattle. However, proteins derived exclusively from porcine (hogs) or equine (horses) animals and milk and blood proteins from all mammals, including ruminants, may be fed to all species including ruminants.

2.5.5 Bovine Spongiform Encephalopathy

Bovine Spongiform Encephalopathy (BSE, also commonly called mad cow disease) is one member of a group of slowly progressive neurodegenerative diseases collectively known as Transmissible Spongiform Encephalopathies (TSE) that infect a wide range of mammals including humans, cattle, deer and sheep. Although other TSE’s are known, such as in mink, there have been no reports of TSE’s in other common farm animals such as horses, swine, chickens or turkeys.

All TSE’s are invariably fatal. Although the causative agent has not been completely characterized, the preponderance of evidence points towards the protein-only or prion theory, which attributes infectivity to a structurally modified form of a normal prion protein found in the cell membrane. According to this theory the modified protein has the capacity to promote conversion of normal prion molecules to the abnormal form. The accumulation of the abnormal form prions interferes with normal cell function, eventually leading to death of the cell and accumulation of void spaces in brain and spinal cord tissues. The abnormal prion proteins are highly stable, resistant to heat, drying, ultraviolet and ionizing radiation and a wide range of common disinfectant chemicals.[94]

Like other TSE’s, BSE is characterized by long incubation periods, averaging 5-6 years. At the present time there is no live animal test for the disease, which can only be diagnosed by behavioral deterioration of the animal, followed by confirmation based on post-mortem analysis of the brain of the suspect animal.

For additional information on the impact of BSE on the Canadian market please go to **Appendix E - Potential for Rendered Animal Fats as a Biodiesel Feedstock in BC.**

2.5.6 The Potential Supply of Animal Fats

For the purposes of this study, one of the significant implications of the current BSE crisis in Canada is the extent to which animal fats may become available as feedstock for the biodiesel production process, particularly in British Columbia.

For practical purposes the majority of the animal fat potentially available will consist of materials from cattle, hog, sheep and poultry production. By species, approximately 61% is from poultry, 32% from swine and 6% from cattle sources. By census region, approximately 81% is in the Lower Mainland – Southwest area, 8% in the Thompson – Okanagan area, 5% in the Vancouver Island - Sunshine Coast area, and 2-3% in each of the Peace River and Cariboo areas respectively.

In total the amount of tallow and fat potentially available for biodiesel production in British Columbia amounts to about 12,400 tonnes/year (see Table 26):

Table 26: The Potential Supply of Animal Fats in BC (Kilograms/year)

	Cattle	Swine	Sheep	Poultry	Total	% by Region
Lower Mainland - Southwest	120131	3472676	15247	6480415	10088469	81.0%
Thompson-Okanagan	207381	187156	19624	590666	1004828	8.1%
Vancouver Island - Sunshine Coast	30773	82037	16754	435551	565115	4.5%
Peace River	132490	169645	12165	14314	328613	2.6%
Cariboo	156271	51833	8692	39690	256485	2.1%
Kootenay	49813	30955	2981	16362	100111	0.8%
Nechako	69164	14290	3208	5110	91772	0.7%
North Coast	1985	7654	471	1945	12054	0.1%
Totals	768007.9	4016246	79141.65	7584052	12447447	100.0%
% by species	6.2%	32.3%	0.6%	60.9%	100.0%	

Source: Statistics Canada, Livestock Census by Agricultural Region, www.statcan.ca/english/freepub/95F030XIE/tables/pdf Tables19, 20, 21, 23 & 24

2.5.7 Constraints

While the 12,400 tonnes/year of animal fats potentially available in British Columbia is impressive, enthusiasm for biodiesel production from it must be tempered by several realities, including:

- The local rendering industry, represented by West Coast Reduction in Vancouver, are well entrenched, with organized collection networks, established plants, adequate funding and well-developed markets for their finished products.
- Because the ownership of the BC rendering plants is private, reliable and publicly-available data is difficult to acquire; it is believed they are profitable and that in some cases the export markets for their products provides a greater financial netback than is likely from production of fuel.
- For similar reasons no reliable information could be found regarding prices paid to or charged by renderers for slaughter waste and mortalities in BC, nor was there any indication that rendered fats and tallow are traded or sold other than into international markets.

- The West Coast Reduction plant in Vancouver accepts feed from provincially licensed slaughter facilities on Vancouver Island and the lower Mainland, plus mortalities from the lower Mainland; slaughter wastes and mortalities from the Thompson-Okanagan area are trucked to Calgary for rendering whereas slaughter wastes and mortalities in the Cariboo region are disposed in local landfills.
- The diversion of animal fats in raw form from rendering, landfill or incineration to biodiesel production requires some form of rendering to make available in suitable form the purified fats, which in turn implies either the co-operation of existing renderers or establishment of competing facilities at considerable cost and competitive risk.
- In addition to rendering, there are currently five other acceptable methods in BC for disposal of slaughter waste and mortalities, including wildlife, pet food, compost, burial, landfill and rendering; of these in BC, rendering accounts for ~77% of slaughter waste and ~30% of mortalities.

As a consequence of the current BSE situation, it is possible that regulatory authorities might move toward a total ban on feeding animal proteins to all animals, as has been done in Europe. While such action would be highly disruptive for the rendering and feed industries, would likely raise costs for certain grains used as feed and reduce incomes for livestock farmers, and would probably further download animal collection and disposal costs from the rendering plants to the producers, it would potentially increase feedstock available for production of biodiesel.

Based on available literature, the rendering industry is well aware of these fundamental forces and has been assessing the biodiesel potential for several years, both as a defensive means to protect its entrenched position, as well as to provide a potentially profitable outlet for material that otherwise would represent a disposal cost.

2.5.8 Conclusions

Since the livestock, rendering and feed industries are highly integrated throughout North America, it is highly unlikely that regulatory or other forces will operate to create distinct differences between Canada, the United States or Mexico. Rather, a coordinated approach with major similarities is far more likely than independent and potentially conflicting actions. Since the BSE situation is still evolving, however, it is highly speculative at this time to predict the timing and extent of such actions.

This study has identified significant quantities of animal fats that are potentially available throughout BC with notable concentrations by species in poultry (61%) and by region in the Lower mainland – Southwest (81%). The majority (60%) of all slaughter waste and mortalities is rendered in four plants with most of the remainder either left for wildlife (25%) or burial (8%). To access the fat from these sources in a suitable form for biodiesel production will require additional rendering capacity, either by expansion of existing plants or establishment of new plants in competition. Based on the available information, such an investment would not be economically justified at this time unless major structural or strategic changes occur, such as might happen as a result of wider regulatory action in response to a continuing BSE situation.

Accordingly, it is prudent to discount the supply of animal fats in southwestern British Columbia as potential biodiesel feedstock for the near term. Once initial biodiesel production has been demonstrated from other feed sources, feedstock suppliers and product outlets have been established and favourable production economics have been demonstrated on a sustained basis, it will be reasonable to re-examine the issue and consider added feedstocks such as animal fats.

2.6 Oilseed Crops

In addition to producing biodiesel from waste fats, oils and greases (FOG), such as restaurant waste fryer oil and grease trap materials, biodiesel can be manufactured from oilseed crops such as canola and soybeans.

While British Columbia is a large province in total land area, the terrain is mostly mountainous with heavy forest cover that is unsuitable for agriculture. As a result, of the total 36.1 million hectares of land devoted to all crops in Canada, only about 585,644 ha. or 1.6% of the total is in B.C.

There are six oilseed crops grown in Canada that have potential to produce oil products suitable for biodiesel production. Saskatchewan is the largest total oilseed producer, followed by Alberta, Manitoba and Ontario. With less than 1% of the Canadian total, British Columbia ranks sixth in terms of land area devoted to oilseed crops. Of the six crops grown nationally, canola accounts for 66% of the total land area, followed by soybeans at 19% and flaxseed at 12% (see Table 27).

Table 27: Canadian Oilseed Crops (Hectares of Production)

Province	Canola	Flaxseed	Soybeans	Mustard seed	Sunflowers	Safflower	Total	% of total
BC	23,548	23	0	0	11	0	23,582	0.4
AB	1,076,670	16,276	36	23,114	654	370	1,117,120	19.4
SK	1,906,171	472,437	359	132,550	7,486	0	2,519,003	43.7
MB	757,744	176,656	20,249	6,490	61,743	0	1,022,882	17.7
ON	14,746	802	909,922	0	449	0	925,919	16.1
QC	3,832	471	148,070	0	147	2	152,522	2.6
Canada	3,782,906	666,673	1,082,547	162,176	70,561	581	5,765,444	100.0

Source: Statistics Canada, 2001 Census of Agriculture

Within BC the production of oilseeds is dominated by canola grown in the Peace River region (>95%). The area of land devoted to production of oilseed crops in the Vancouver Island and lower Fraser Valley regions of BC is insignificant (<0.03%) (see Table 28).

Table 28: British Columbia Oilseed Crops (Hectares of Production)

Region	Canola	Flaxseed	Soybeans	Mustard seed	Sunflower	Safflower	Total
Vancouver Island-Coast	0	0	0	0	2	0	2
Lower mainland-southwest	0	0	0	0	4	0	4
Kootenay	692	0	0	0	0	0	692
Peace River	22,552	0	0	0	0	0	22,552
Total BC	23,548	23	0	0	11	0	23,582

Note: totals may not add due to data suppression by Statistics Canada for confidentiality reasons
Source: Statistics Canada, 2001 Census of Agriculture

In addition to the land currently devoted to production of oilseed crops, there is some potential to increase production by conversion from other crops and by bringing land not used for agriculture into production. For either of these situations to occur, the oilseed crop will need to displace the current land use, implying competition on a netback price basis compared to alternative uses. In addition, farmers potentially would have to invest in new seeding and harvesting equipment, and the industry would need to make the capital investment in crushing plant and trucking equipment to enable the extraction of the oil. Furthermore, there will need to be a viable livestock feed market, within economic transportation range, for the crushed oilseed meal remaining after oil extraction. While thorough analysis of these factors is beyond the scope of this study, it seems highly probable that a significant expansion of oilseed production for biodiesel, outside the Peace River area, is unlikely.

A second type of possibility for producing biodiesel from oilseed crops has to do with utilization of oil that does not meet the minimum quality necessary for human food. While this might provide an economical feedstock for biodiesel, by its nature, this source is uncertain in supply, both in terms of quantity and time. Unless a biodiesel producer wishes to compete for supply with existing oil markets, the operators of crushing plants have a strong incentive to focus on product quality in order to maximize their revenues. This may minimize the available supply for biodiesel.

Accordingly, the potential to produce biodiesel from oilseed crops in BC is extremely limited, particularly in the Vancouver Island-Coast and lower Fraser Valley regions. This situation seems unlikely to change in the near future due to the limited amount of agricultural land available, the vast majority of which is already in productive use for high value livestock and crop purposes.

2.6.1 Conclusions

Oil seed crops may prove to be viable in north-eastern BC, however further analysis will have to be conducted in that region. Oil seed crops do not appear to be grown in other regions of BC in a volume necessary to support a biodiesel plant.

2.7 Total Estimated Volumes for British Columbia

The potential B.C. biodiesel feedstock volumes from major industries is estimated at approximately 125 MM litres/year (see Table 29). It must be realized, however, that this is a highly theoretical value, as each of these feedstocks, with the exception of brown grease, is already used for competing purposes.

Table 29: Total Estimated Theoretical Volumes of B.C. Biodiesel feedstocks

Feedstock Type	Estimated Volume (million litres)	Estimate Year
Yellow Grease	21.4	2004
Brown Grease	9.3	2004
Fish Oils	50.0	2001
Rendered Animal Fats	14.4	2001
Agriculture Oils	29.8	2001
Estimated Total Major Feedstocks	124.9	

Notes: Rendered animal fat volume based on 1.90 lb./litre. Agricultural oils based on 3.0 tons/Ha seed @ 40% oil averaging 1.90 lb./litre

2.8 Future Potential Feedstock Overview

This study has focused mainly on recycled fats, oils and greases from aquaculture, agriculture and food service establishments. In addition there are the many well known virgin crop sources such as soybeans, canola, corn and sunflowers. There are also many less well-known sources that could potentially be grown in non-food crop environments that we touch on briefly here.

2.8.1 Industrial Mustard Seed

2.8.1.1 Introduction

In order for the biodiesel industry to continue to grow and have a significant impact on the diesel market, economic factors associated with the high cost of current feedstocks as well as their limited production potential need to be addressed.

It is for this reason that the biodiesel industry is looking towards the research that is being performed on developing a high fat content (25-40%), non-food grade mustard seed that will cost less than US. 10¢ per pound.

For an oil to be produced at this low cost, the meal by-product must have a value of US 12¢ per pound or more. The key development that makes industrial mustard so promising is that the defatted meal (after the oil is removed) can be used as an organic pesticide without further processing. The market for organic pesticides is growing as a result of more demanding consumers and more environmentally conscious farmers. This trend is further reinforced by the deregistration of several commercial pesticides that pose significant environment and health dangers to society.[95]

This inedible mustard can be grown in rotation with dry-land wheat production without irrigation, and has shown that in rotation, wheat yields have increased as much as 20%. The mustard crop is planted and harvested with wheat equipment. The crop has a high biomass residue yield and a deep tap root, and the residues (including the roots) provide an allopathic benefit to subsequent crops. Intercropping, and double cropping, may offer attractive pesticide reducing benefits. Mustard appears to be resistant to many of the pest common to canola and other brassicas.[96]

Currently, there is almost no industrial mustard seed grown in British Columbia.

2.8.1.2 Industrial Mustard Seed Use

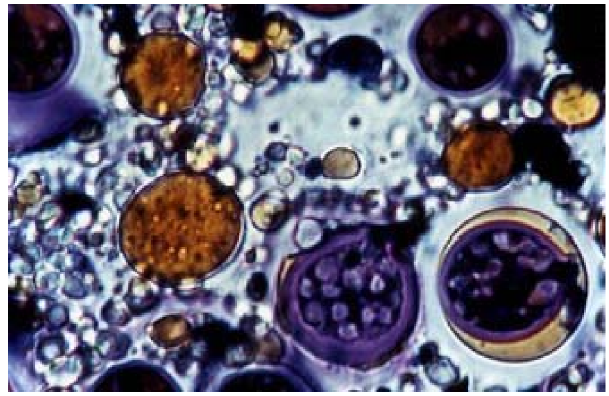
One of the first companies to begin development of an industrial mustard seed industry to support the biodiesel industry is Blue Sun Biodiesel. Colorado's largest producer of diesel fuel from vegetable oils recently launched a mustard seed campaign. Fort Collins-based Blue Sun Biodiesel envisions a mustard seed-based biofuels industry producing $178.5 million a year in new income and generating 950 jobs.

To reach this goal Blue Sun recently formed a growers' co-op in Colorado - with a second in Nebraska - in which members can purchase an equity stake in the fuel company and secure the right to sell their mustard crop. Each farmer must invest a minimum of $5,000. In exchange, the farmer can grow up to 200 acres of mustard, sell it to Blue Sun, and receive an annual dividend on the investment.

2.8.1.3 Conclusions

With Canada's large wheat production industry, there is vast potential for industrial mustard to be grown for the biodiesel industry. The organic pesticide market for the meal by-product would need to be developed prior to adoption, in order for the crop to be economically viable for the farmers.

2.8.2 Algae



2.8.2.1 Introduction

Photosynthesis is the key to organisms making use of direct solar energy. These organisms including plants, algae (microalgae and seaweed), and some photosynthetic bacteria, use energy from the sun to combine water with carbon dioxide (CO2) to create biomass.

While the mechanism of photosynthesis in microalgae is similar to that of higher plants, they are generally more efficient converters of solar energy because of their simple cellular structure. In addition, because the cells grow in aqueous suspension, they have more efficient access to water, CO2, and other nutrients. For these reasons, microalgae are capable of producing 30 times the amount of oil per unit area of land, compared to terrestrial oilseed crops.[97]

2.8.2.2 Production and Costs

From 1978 to 1996, the U.S. Department of Energy's Office of Fuels Development funded a program to develop renewable transportation fuels from algae. The main focus of the program, know as the "Aquatic Species Program" (or ASP) was the production of biodiesel from high lipid-content algae grown in ponds, utilizing waste CO2 from coal-fired power plants.[98]

While its history dates back to 1978, much of the research from 1978 to 1982 was focused on using algae to produce hydrogen. The program switched emphasis to other transportation fuels, in particular biodiesel, in the early 1980s. As far as we could determine no study of a similar nature has been conducted in Canada.

The National Renewable Energy Laboratory's (NREL) research focused on the development of algae farms in hot desert regions, using shallow salt water pools for growing the algae. The goal of the study was to research the feasibility of high oil yield algae production in open ponds in California, Hawaii and New Mexico. Based on results from six years of tests run in California and Hawaii, 1,000 m2 pond systems were built and tested in Roswell, New Mexico. Single day productivities reported over the course of one year could be as high as 50 grams of algae per square meter per day in New Mexico. This volume was not consistent, however, and although the desert conditions of New Mexico provided ample sunlight, temperatures regularly reached low levels, especially at night.[99]

2.8.2.3 Biodiesel Potential

As the conditions of climate, land, water and CO_2 resources for optimum algae production became evident, the ASP regularly revisited the potential for producing biodiesel from the algae. Analysis indicated that under the appropriate conditions two hundred thousand hectares (~780 sq. miles) of land could produce the necessary algae for one quad (10 billion gallons) of fuel. This is less than 0.1% of climatically suitable land areas across the U.S. therefore algae could easily supply several "quads" of biodiesel—substantially more than existing oilseed crops could provide.[100]

Due to a number of factors associated with the above resource requirements and the technology requirements to ensure minimum algae volumes, NREL "projected costs for biodiesel which are two times higher than current petroleum diesel fuel costs".[101]

The research program was discontinued in the mid-1990s. At the time genetic engineering of algae was being studied to increase oil synthesis volumes. Another area of research interest was the use of microalgae ponds for the treatment of municipal and other wastewaters, with the microalgae providing dissolved oxygen for bacterial decomposition of the organic wastes.[102] NREL anticipates the research will be re-established.

2.8.2.4 Conclusions

Although Canada has algae in its waters, the volumes necessary to become a feasible biodiesel feedstock, and the necessary conditions (continually hot) and cost to grow that volume, indicated by the NREL study, are likely to preclude Canada at this time.

2.9 Reagents

2.9.1 Methanol

Both methanol and ethanol can be used in processing biodiesel, which are chemically referred to as methyl and ethyl esters respectively. Methanol is the most common alcohol used to process biodiesel due to cost, availability, and ease of use. Ethanol has also been used successfully, however, it inherently has more water content than methanol and must be purified prior to use.

Methanol is a colorless, odorless and nearly tasteless alcohol with the simplest chemical structure of all the alcohols. Most of the world's methanol is being produced using natural gas as a feedstock, however, the ability to produce methanol from renewable biomass resources is growing in interest. Biomass resources include crop residues, forage, grass, crops, wood resources, forest residues, short-rotation wood energy crops and the cellulosic components of municipal solid waste. As a renewable resource, biomass represents a potentially inexhaustible supply of feedstock for methanol production. Current natural gas feedstocks are so inexpensive that even with tax incentives renewable methanol has not been able to compete economically. Technologies are being developing that may eventually result in commercial viability of renewable methanol.[103]

Most lifecycle GHG analyses for biodiesel are done based on the production of biodiesel from natural gas derived methanol.

Methanol is the most volatile component of the biodiesel production process, and for this reason, zoning requirements for light or heavy industrial use may apply. Protected, double walled storage tanks will be necessary for its storage.

2.9.1.1 Suppliers

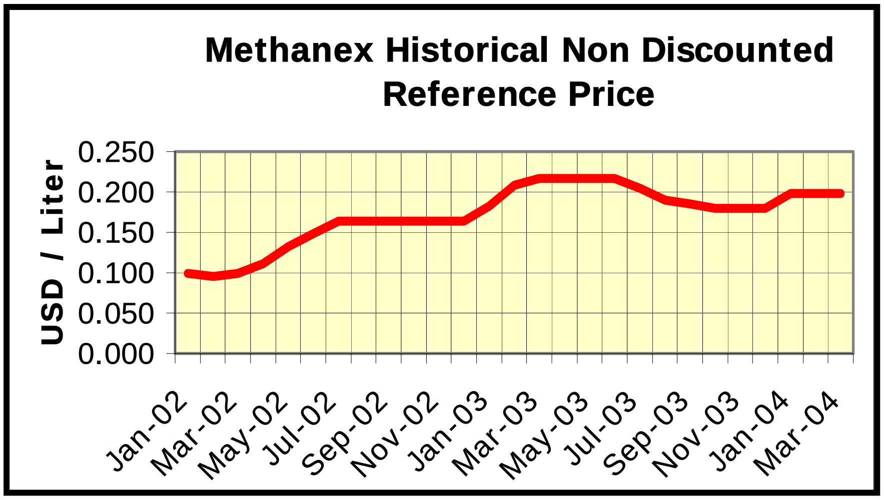
Methanex is the world's largest methanol manufacturer and supplier. Their head office is in Vancouver, B.C. Methanex has a production plant in Kitimat, B.C. with a production capacity of 170 million gallons per year.[104]

Celanese Canada Inc. is also a supplier of methanol. Their Canadian production plant is in Edmonton, Alberta with a production capacity of 255 million gallons per year.[105]

2.9.1.2 Market Cost

The Methanex non-discounted US reference price for April 2004 is $249 per tonne (~Cdn.$0.26/litre) (see Figure 4). Methanex's average realized price for the 6 months ended June 30, 2003 was $232 per tonne (~C$0.25/ litre) and for the 12 months ending December 31, 2002 it was $155 US per tonne (C$0.18/litre).

Figure 4: Methanol Two Year Historical Pricing Chart



Source: www.methanex.com/methanol/Historical_Pricing.pdf

2.9.1.3 Estimated Quantities Needed

In the transesterification process, more methanol is used than is needed in order to ensure a complete reaction, and to speed up the reaction. Generally methanol volumes used tend to be around 18-22% of the volume of oil. The approximate volume of methanol consumed in the process ~12% of the volume of oil with the remaining % being recovered and re-used. Acid esterification as a pre-process to base transesterification may require significant volumes of methanol depending on FFA content. This excess methanol must be recovered in order to be cost effective and environmentally sustainable.

2.9.2 Catalysts and Other Chemicals[106]

Three types of base catalyst can be used to produce methyl esters (biodiesel) in the transesterification process; namely sodium methoxide ($NaOCH_3$), sodium hydroxide (NaOH), and potassium hydroxide (KOH). Although NaOH is cheaper, KOH is often used because it dissolves more readily in the methanol and the co-product created from the process can be sold as a fertilizer, whereas there is no market for the co-product if NaOH is used. In addition, the crude glycerine resulting from a KOH catalyst contains dissolved soaps that are "softer" then sodium soaps, thus the glycerine viscosity will be lower at room temperature, sometimes making it easier to handle.

Sodium methoxide is normally used with seed oil feedstocks. It is considerably more expensive than potassium hydroxide (about 2 to 2.5 times the KOH cost), but offers significant operating advantages, the primary being that it is an extremely "dry" system and contains no moisture. Both KOH and NaOH produce moisture when they are added to methanol, via the reaction of the sodium or potassium to form a methoxide with con-current production of water, as illustrated in the following equation:

$$NaOH + CH_3OH \rightarrow NaOCH_3 + H_2O$$

Water in the catalyst/methanol mixture has the potential to increase the formation of soaps in the transesterification reaction. These soaps tend to report to the crude glycerine phase and will enable esters to "dissolve" into this phase. This can have a negative impact on process yield, especially if a facility is using transesterification only and does not recover dissolved soaps or esters from the crude glycerine.

Due to the high cost of methoxide, it is typically limited to use with feedstocks containing less than about 0.5% FFA. Thus, for consideration of this material with typical used oils, a degree of oil pre-treatment to limit FFA would be required. As technology progresses, it is anticipated that methoxide may find future use with used oil feedstock systems.

Sulphuric acid can be used to esterify the free fatty acids in used cooking oils or other low to high FFA feedstocks.

Phosphoric acid is often used to neutralize the base catalyst in the glycerine co-product. As an alternative, if acid esterification is used as a pre-process, the waste sulphuric acid can be added to glycerine co-product for the same purpose.

See Table 30 for pricing of these reagents. (Sodium methoxide was not included as it is not a suitable catalyst for processing low-high FFA oils)

Table 30: Catalysts and Other Chemicals, Feb. 2004 Sample prices

Chemical	Average Price (CDN $)*
Potassium Hydroxide / Caustic Potash KOH 90%	$2.20/kg @ bulk rate
Sodium Hydroxide / Caustic Soda NaOH 96-99%	$1.85/kg @ bulk rate
Sulphuric Acid H2SO4 93.2%	$0.32/kg @ bulk rate
Phosphoric Acid H3PO4 75%	$1.41/kg @ bulk rate

These are spot prices only and will fluctuate due to market variability. Prices are F.O.B., B.C. supplier and do not include tax. Price is the average of two major chemical suppliers in BC.

2.10 Mandatory Requirements and Critical Success Factors

The critical success factors for feedstock are to ensure:

- That a thorough and realistic assessment of feedstock volumes is conducted using several methodologies to estimate each potential feedstock as a crosscheck for accuracy. This should include sampling surveys;
- That initial feedstocks targeted can be processed readily, with no in-house requirement for complex pre-processing or requirement for yet-to-be-developed technology. Future growth plans may incorporate more problematic feedstock opportunities;
- That source-related, seasonal or other fluctuations in the supply of each feedstock are examined and considered in production planning and overall strategy;
- That potential changes in the quality or consistency of targeted feedstocks are thoroughly investigated and that the ramifications on process technology selected and on end product characteristics are carefully considered;
- That the costs and related logistics of acquiring targeted feedstocks are examined strategically, including: market trends, forecasts and fluctuations in commodity feedstock prices; potential market shifts or legislative impacts; current disposition of targeted feedstocks and the strategic importance of these materials to existing processors; contractual arrangements or inherent loyalties that may apply within existing channels; anticipated competitive reactions and contingency strategies.

- That strategies both for cooperation with key players in the current channels of feedstock disposition and for competition with these companies are developed and explored using SWOT analysis before the best option is selected;
- That strategies such as contractual arrangements or incentives are developed to stabilize feedstock volumes and costs in order to reduce the overall risk profile of the biodiesel project;
- That reagent costs and supply options are thoroughly investigated and that strategies are developed to stabilize costs and to ensure consistent supply as needed;

2.11 Conclusions

This section has shown that although the study focus is on recycled fats, oils and greases, biodiesel can be produced from a wide variety of potential feedstocks.

- From the major feedstock sources studied here there is a high-end potential of **125 million litres** of biodiesel in BC. 125 million litres is ~4.5% of the total diesel usage in the province and 11.4% of the total on road diesel market.
- 125 MM litres would **reduce GHG emissions by over 2,451,000 tonnes**[107] .
- The average BC Transit bus in the CRD consumes ~33,640 litres of diesel fuel/year[108]. 125 million litres of feedstock would **run 3,716 BC Transit buses on pure biodiesel for a full year** or the **equivalent of 18,580 on a B20 blend for a full year**.
- At a B5 mix this 125 million litres would blend with upwards of **2.5 billion litres of low-sulphur petro diesel, virtually the entire annual diesel supply in BC**.
- There are 21.4 million litres of yellow grease biodiesel potential in BC. This means 636 BC Transit buses could run B100 biodiesel or 3180 buses could run B20 throughout the year **based on just yellow grease alone.**
- At a B5 mix this 21.4 million litres would blend with upwards of 428 million litres of petro-diesel.
- **21.4 million litres of yellow grease would create 419,000 tonnes of GHG reductions**[109].
- There are many potential feedstock sources in B.C., however, the majority are currently in developed market streams.
- There is a number of sources of information that will assist a regional project to obtain, at least start-up information, on the types and volumes of the potential feedstocks for that region.
- There is a need to gather detailed information on potential feedstock volumes before a realistic analysis can be conducted. These details will need to be established through direct communication with the potential sources and providers within a region.
- There are feedstocks that may become more promising, once a plant has been established using a region's premier feedstock.
- There are well established reagents required in the biodiesel process.
- There is a need to establish long term contracts with feedstock and reagent suppliers to ensure the economic analysis remains sound.

3 MANUFACTURING PARAMETERS

3.1 Purpose of this Section

The purpose of the Manufacturing Parameters section of this document is to evaluate the available biodiesel manufacturing options. This includes a detailed description of processing techniques and technologies, a list of potential vendors, and handling recommendations for biodiesel manufacturing by-products.

This section also examines at what to look for when determining possible plant locations, and the requirements for setting up a plant in BC.

3.2 Biodiesel Processing Options

The production of biodiesel, or alkyl esters, is well known. There are three basic routes to ester production from oils and fats:[110]

- Base catalyzed transesterification of the oil with alcohol.
- Direct acid catalyzed esterification of the oil with methanol.
- Conversion of the oil to fatty acids, and then to Alkyl esters with acid catalysis.

The majority of the alkyl esters produced today are done with refined oils using base catalyzed transesterification, as it is the most economic for several reasons:[111]

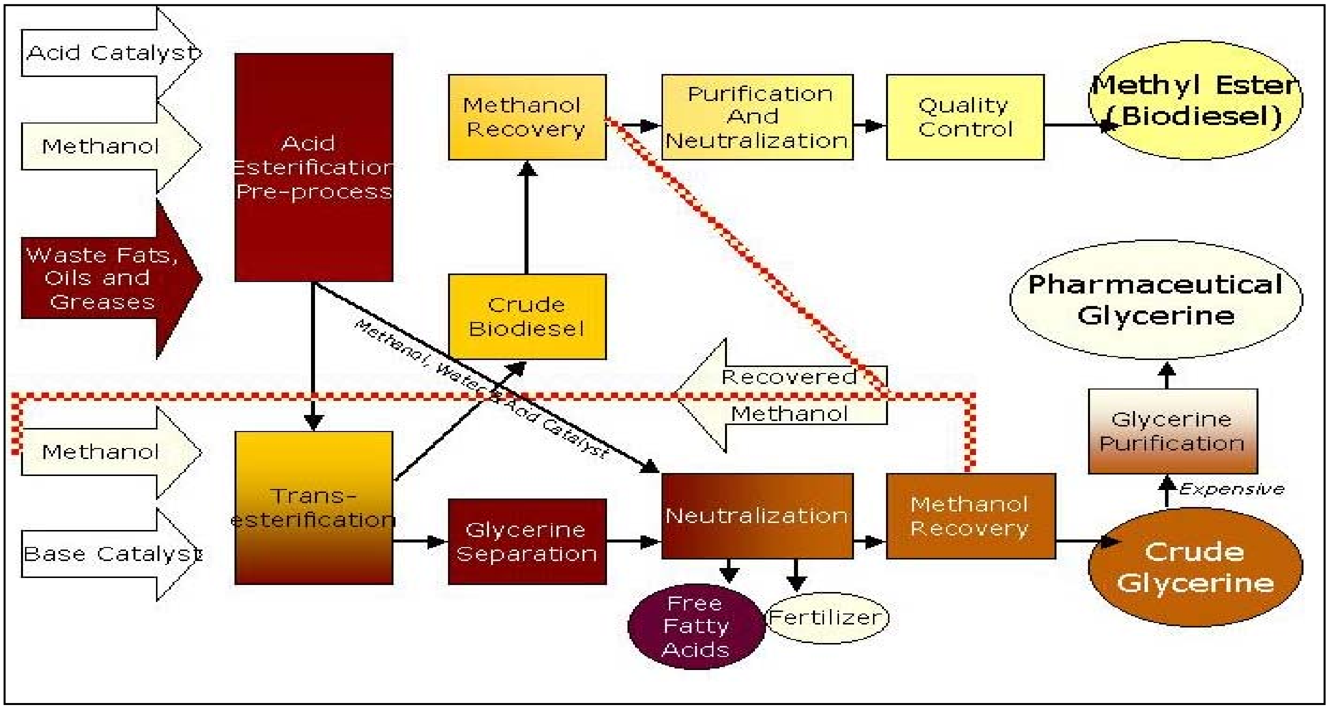
- Low temperature (up to 150F) and low pressure (atmospheric up to about 20 psi).
- High conversion (98%+) with minimal side reactions and reasonable reaction times.
- Direct conversion to methyl ester with no intermediate steps.
- Exotic materials of construction are not necessary.

The focus of this study concentrates on low to high FFA feedstocks. Most of the processing technologies analyzed are able to convert these feedstocks into methyl esters. There are currently three methods being used commercially to produce biodiesel from low to high FFA feedstocks.

1. Straight base catalyzed transesterification.
    - Simple inexpensive process as no pre-processing is used
    - Low to high yield losses due to the formation of soaps from unreacted FFAs. Yield losses are approximately double the % of FFAs.
    - Increased waste costs.
    - Difficult quality control issues.
    - Limit on amount of allowable FFA in the feed.
2. FFA removal (caustic washing) followed by straight base catalyzed transesterification:
    - Purifies feedstock allowing for efficient processing and good quality control.
    - An equal amount of clean oil tends to be lost with the FFAs in the form of soap, resulting in a significant loss in yield (depending on FFA content).
    - FFAs must be sold (can be difficult to find market), or straight acid esterified into methyl esters (additional process equipment) in order to be viable.

3. Acid esterification followed by base transesterification with low or high FFA greases and fats (see Figure 5 for process flow diagram of this processing option):
   - Results in high yields as acid esterification pre-process converts FFAs to methyl esters.
   - Requires simple additional pre-processing equipment.
   - Good quality control.
   - Process can be adjusted to suit FFA content.
   - Requires high ratios of methanol that must be recovered to be viable.
   - Process produces water that must be continuously removed to ensure complete reaction.

Figure 5: Biodiesel Process Flow Diagram Using Low-High FFA Feedstocks



3.3 Batch vs. Continuous Process Technology

3.3.1 Batch Systems

Straight batch systems are usually made up of a series of tanks (4-5) in which each phase of production is completed before being pumped to the next phase. This technology is relatively simple and less automated (although it can be made highly automated) than the continuous flow process.

Generally the process operates by a series of valves, pumps, and mixers. Each batch can take up to 5 days to complete, while several batches can be made in a continuous process. Batch systems require more space for the extra processing vessels.

These systems offer the flexibility of a varied feedstock source as each batch can be altered depending on the FFA level of the feedstock, while also offering the flexibility of troubleshooting during the processing stage. Batch systems typically only require one 8-hour shift per day.

3.3.2 Continuous Systems

Continuous flow systems are highly efficient and quick at processing high quality feedstocks with a low level of FFA (less than 0.5%). They are best suited to more centralized, large capacity facilities, producing well over 10 million litres per year where the economies of scale begin to take effect.

These systems are highly automated with excellent quality control. Continuous systems require operations 24 hours/day in order to maintain efficiencies. Many of the new continuous systems being developed are able to process high FFA feedstocks (a loss in plant capacity will be experienced with some technologies), however, these plants still require at least 10MM litres/year to be economically viable. Large rendering companies are able to make use of these new multi-feedstock continuous flow technologies effectively.

3.3.3 Hybrid Systems

There are many new companies that are using hybrid systems that utilize a batch acid esterification pre-process for low to high FFA content feedstocks (5-30%). This creates a consistent feedstock that can then be fed into a continuous transesterification system

Another version of a "hybrid" type system involves the use of continuous esterification, followed by batch transesterification reaction, and the resulting ester/glycerine processed continuously in downstream processing equipment. In this instance, only the transesterification reactor is batch, and overall "continuous" response is achieved via the use of surge tanks ahead of and following the TE reactor. Depending on the size of the facility, this approach can be as cost effective as a fully continuous system, for example, plants in the range of 10 million to 30 million litres per year production rates should carefully evaluate this approach from an overall economic comparison standpoint (compared to full continuous).[112]

3.4 Plant Manufacturing Options and Analysis

The number of biodiesel process technology companies in the world is steadily growing. Some companies offer pre-made turn-key plants, some will custom build a turn-key plant to suit specific customer needs, while others offer engineering services for a locally built, custom plant. All options have advantages and disadvantages.

Most of the high-tech biodiesel plant manufacturing companies only offer plants that are economically feasible for more centralized, large-scale production using a continuous process. In order to reach these economies of scale, these plants operate mostly on virgin oils. The exception to this is large rendering plants that already have an abundant supply of cheaper used oils and rendered animal fats.

The following list was made to assist with identifying potential plant manufacturers and design consultants. This is by no means a complete list. Many new companies will enter this market during or after this report has been completed. Although much effort was made to identify potential companies, some may have been missed.

3.4.1 Biodiesel Process Technology Manufacturers and Consultants

BDT Biodiesel Technologies (www.biodieseltechnologies.com)

The original manufacturer of the small scale, (200, 500 and 1000 litres/day), continuous flow, turn-key 'Compact Production Unit' (CPU) developed at the University of Graz in Austria. For low-high FFA feedstocks, the purchase of the additional VOPUX unit is required. This technology has been licensed to many other companies who market it under their own name and offer it at inflated prices.

Biodiesel Industries (www.pipeline.to/biodiesel)

Manufacture a turn-key compact 'Modular Production Unit'. Topia Energy Inc. has exclusive distribution rights for this plant in Canada. One MPU has a maximum capacity of 11.36 million litres/year. Proven to run effectively on only yellow grease.

There is exclusivity in purchasing MPUs: Biodiesel Industries sells and licenses the units into exclusive territories to qualified affiliates interested in becoming part of a mutually supportive network of biodiesel producers worldwide. Support for production, marketing and operations is part of the package[113].

Biodiesel International (www.biodiesel-intl.com)

Manufacture large scale, multi-feedstock, continuous flow plants. Smallest plant the manufacture is ~6.8million litres/year. In order to process low-high FFA feedstocks, the additional purchase of an "oil purification" unit will be required.

Biox Corporation (www.bioxcorp.com)

Manufacture large scale, multi-feedstock, continuous flow plants using proprietary process capable of significantly reducing operating costs. Biox plants are not available at any less than 7.5 million litres per year and Biox only works with companies that already have access to abundant feedstock supplies at a beneficial price or extensive distribution.

Plants will be leased to the end-user and will be charged a royalty on all throughput. Potential partners will be expected to provide a covenant satisfactory to Biox to guarantee the value of the lease. Biox will operate and maintain the plants through a worldwide systems manager.

Bratney Companies (www.bratney.com)

Manufacture large scale, continuous flow plants.

Crown Iron Works (www.crownironworks.com)

Manufacture large scale, continuous or batch plants.

Ekoil Biodiesel (www.ekoil.sk), manufactures plants that range from 6-12MM litres/year.

Energea (www.energea.at), manufacture large scale, continuous flow turn-key plants.

Lurgi PSI Inc. (www.lurgi.com), manufacture large scale, continuous flow plants.

Pacific Biodiesel (www.biodiesel.com)

Manufactures small scale batch configuration plants with 500,000, 1.5MM, 3MM and 6MM litres/year capacities. Proven to run effectively on only yellow grease for 8 years.

Superior Process Technologies (www.superiorprocesstech.com)

Manufactures various configurations of plants at various capacities to suit feedstocks. Smallest plant 3.8MM litres/year using a combination batch/continuous process.

Westfalia Separator, Inc. (www.wsus.com), manufactures large scale, continuous flow plants.

3.4.2 Decision Making Criteria and Parameters

In order to assist in the assessment of the various process technology companies, the following questions were compiled:

Company Background / Experience

- ❖ How long has the company been around? (This is an emerging industry, so many are very new).
- ❖ How many plants has the company set up? Where and for whom?

Processing Technology

- ❖ Continuous or batch process?
- ❖ Multiple feedstocks processing ability?
- ❖ Methanol recovery?
- ❖ Free fatty acid (FFA) processing ability?
  - Remove FFA prior to transesterification?
  - Acid esterifies FFA into methyl esters?
  - Straight transesterification without preliminary FFA treatment?

Plant Offering

- ❖ Capacities / capital cost?
- ❖ Dimensions of plant, storage and lab (ft^2)?
- ❖ Plant growth / expansion potential?
- ❖ What's included / not included?
  - Warranty?
  - Storage containers? - WVO, methanol, biodiesel, and glycerine.
  - Staff training - how long?
  - Spare parts/equipment?
  - Lab equipment?
- ❖ Environmental considerations – potential wastes or emissions

Operating Costs

- ❖ Energy requirements? – Heat source? Electric, gas, biodiesel, glycerine phase?
- ❖ Staffing requirements?
- ❖ Plant operating time requirements (hours/day/week).
- ❖ Water requirements? – Ratio of water / biodiesel.

3.5 Plant Siting, Permitting and Legal Analysis

Biodiesel production plants must be located within appropriately zoned areas. Contact the local city or municipality for information on zoning by-laws. In general, commercial zones will meet the requirements. In some cases light industrial zones may qualify. Once a site is identified, the next focus is on the necessary permits.

There are several types of permits that are needed for biodiesel production facility and these are very site specific. Some permits that need to be considered are as follows: building, transportation of hazardous goods, storage and handling of hazardous goods, air, waste water, outdoor containment and refuse.

The cost of the permits varies depending on location.

Building permits

Sufficient information must be provided to the municipality that demonstrates construction will conform to the BC Building Code and whether adjacent properties will be affected. The plans will need to be drawn to scale and indicate the nature and extent of the construction.

Hazardous Materials

Many of the materials used in the processing of biodiesel, such as alcohols, acids and catalysts, are classified as hazardous materials. Transportation of these materials is covered in the Transport Canada's Dangerous Goods Act. For more information, check with Transport Canada on permits.

In British Columbia, receiving, storage and handling procedures of hazardous materials and the quality of these materials is covered under Fire and Building code regulations. This is the responsibility of the Ministry of the Attorney General. No permit is required unless there is a discharge of these materials to the environment. If this is the case, a permit from the Ministry of Water, Land and Air Protection will be required. The municipality will also need to be contacted to review the impact on local sewers and landfills.

Note, to comply with the Workers Compensation Board and Workplace Hazardous Materials Information System (WHMIS) requirements, storage and handing procedures of hazardous materials will need to be defined. Permits are not required but an inspection by the fire department will need to be conducted to ensure compliance to the standards.

WHMIS is the agency responsible for occupational safety and health of employees. This agency requires employers to ensure that controlled products used, stored, handled or disposed of in the workplace are properly labeled. It is also this agency that states that Material Safety Data Sheets are made available to workers, and workers receive education and training to ensure the safe storage, handling and use of controlled products in the workplace.

Air Quality Permits

Air quality permits in British Columbia are regulated by the Ministry of Water, Land and Air Protection. The primary concern of the air quality district regarding biodiesel production is the potential discharge of volatile organic compounds (VOCs). Although biodiesel itself has a very low potential for VOC emissions the alcohols used in production, if not handled properly, can emit significant VOC's. As a result, the Ministry may require a review of the plant design.

Waste Water Permits

The need for water permits depends on the location. Contact The Ministry of Water, Air and Land if the plant is located within an area that it is unable to connect to a local sewer system. Otherwise, contact the local municipality for information. See Section 3.7 for further analysis.

http://wlapwww.gov.bc.ca/epdiv/authorization/index.html

Outdoor containment / Storage tank permits

Depending on your jurisdiction, a permit might be needed for spill protection. Contact the local municipality for more information.

Refuse

Review requirements with the local municipality. Note: excessive moisture content might affect the permit needed and the fees that need to be paid.

In summary, although public awareness of biodiesel in BC is growing, most of the regulators are still unfamiliar with regulation requirements for biodiesel. As a result, it is recommended that permit applicants work closely with the proper issuing authority to ensure timely processing.

3.6 Process Co-products

The glycerine co-product once removed from the methyl esters contains glycerine, methanol, soaps and the catalyst. Depending on the feedstock and process used the ratios of these will vary. Low FFA feedstock will result in less soap in this co-product. If just base transesterification is used on low – high FFA feedstock, the amount of soap in the co-product will increase accordingly. An Acid – base process can reduce the soaps significantly on low – high FFA feedstocks.

There are a few options for dealing with this crude co-product:[114]

1. It can be burned as a process heat source using special high temperature burners (unless it's properly combusted at high temperatures it will release acrolein, which is highly toxic).
2. It can be composted (excess methanol should be recovered prior to).
3. If the ester processing stages have converted essentially all of the FFA and triglyceride into methyl esters, and there are minimal unreacted FFAs in the co-product, the material can be neutralized, the methanol recovered and the resulting glycerine sold as a crude material to an existing glycerine refinery.

If desired, and there are significant unreacted FFAs, adding phosphoric acid (85%) to this co-product mix converts the soaps back into FFAs and separates it all into three distinct layers, with catalyst-phosphorus on the bottom (normally as a crystalline salt material), glycerine-methanol in the middle (saturated with salt), and FFAs (with any previously dissolved ester) on the top. [115] (see image on right)

separated co-product

The methanol can then be recovered from the glycerine layer. The result is crude glycerine of about 80-90% purity. It's a more attractive product for glycerine refiners than prior to FFA recovery. Getting it purer than this takes a great deal of energy. If the methanol is recovered from the co-product mix prior to separation, the separation of the FFAs and the catalyst becomes more difficult.[116]

3.6.1 Glycerine / Glycerin / Glycerol

Although most of the attention of the biodiesel industry focuses on the biodiesel fuel itself, up to 10% of the product created in the processing of the fuel is glycerine. This is a significant amount that will need to be considered one way or another.

> "*Glycerine in its pure form is a viscid, colorless liquid possessing a somewhat sweet taste. It solidifies to a white crystalline mass and it boils at 170 C. In an atmosphere of steam it distills without decomposition under ordinary barometric pressure. It dissolves readily in water and alcohol in all proportions, but is insoluble in ether. It possesses considerable solvent powers, whence it is employed for numerous purposes in pharmacy and the arts. Its viscid character, and its non-liability to dry and harden by exposure to air, also fit it for various other uses, such as lubrication, and enabling it to blend with either aqueous or oily matters under certain circumstances. It a useful ingredient in a large number of products of varied kinds.*" [117]

Biodiesel processing creates a crude form of glycerine. Potential outlets for this material will depend to some extent on the degree of treatment at the biodiesel facility. To a large extent, the biodiesel plant size (i.e. amount of co-product crude material) produced will set the degree of crude treatment that is economically feasible.[118]

It should be noted that there are significant sources of crude glycerine materials available from other types of processing operations, such as fat splitting, soap making, and the like. These other sources are well established, and the crude quality is, in general, superior to that produced in a biodiesel facility (primarily lower organic contamination and lower dissolved salt content). Thus, from an overall desirability standpoint, crude materials from biodiesel operation are at the lower level, and thus will be the lowest valued. It is important then to realistically consider this fact when evaluating the co-product potential of this material in any economic analysis.[119] See section 4.10 – Glycerine Market for details

3.6.2 Free Fatty Acids

Treatment of the initial glycerin-containing phase from the transesterification reaction with an acid, such as phosphoric, will result in the conversion of any fatty acid soaps (formed in the reaction via the reaction of a portion of the base catalyst with any FFA contained in the feed oil) back to a free fatty acid form. Once the soaps have been neutralized, the solubility of the fatty acid and any previously dissolved esters is reduced and a separate liquid phase is formed that can be removed (via settling) from the glycerine phase. Depending on the concentration of the glycerine and amount of catalyst present, a salt phase can also form that will settle from the glycerine material.[120]

Using single stage base transesterification on used cooking oils will result in high levels of waste FFAs, as the process is not able to transesterify these acids. An Acid esterification pre-process will increase yields resulting in lower amounts of waste FFAs. The amount of FFA will depend on the process used and the quality of the feedstock.

The options that exist for the FFAs once they have been separated from the glycerine and catalyst are:

- Use straight acid esterification to convert them to methyl esters (time consuming and may need more than one stage).
- Burn at high temperatures for process heat using high temperature burner.
- Find buyer – used as a lubricant, animal feed.
- Compost.

3.6.3 Sodium Phosphate / Potassium Phosphate[121]

Depending on the catalyst used for the biodiesel reaction, using phosphoric acid to separate the co-product results in a catalyst layer that settles to the bottom under the glycerine layer (sodium phosphate if sodium hydroxide catalyst is used, and potassium phosphate if potassium hydroxide catalyst is used).

Large scale biodiesel operations often use potassium hydroxide, KOH, as the catalyst, because the potassium phosphates left after separation can be sold as a fertilizer. It's said that the sodium phosphate you're left with if you use sodium hydroxide is nothing but a "useless salt".

Sodium is in fact also a plant nutrient, and almost as much of it is required as potassium, however, farmers who use chemical fertilizers don't know much about this, as their advice mostly stems from the chemical fertilizer companies. They will pay for potassium fertilizer, but not for sodium.

The catalyst, whether sodium or potassium, can safely be composted. In many ways this is a better option for both catalysts as too much of either sodium or potassium, or of any nutrient for that matter, directly applied to the soil can cause soil imbalances that can ruin the soil structure and leave other nutrients unavailable to plants. As a minor constituent in composting, this won't happen, any excesses are buffered.

As a further point of consideration, while the phosphate salt, from say KOH catalyst, is technically a fertilizer, the potential amounts involved, even with fairly large biodiesel production rates, is extremely small compared to current commercial fertilizer volumes. This plus the fact that the material will contain some level of entrained glycerine (as “moisture”) typically will limit its potential value.[122]

Unfortunately, attempting to up-grade the material so that it would be accepted as a “conventional” fertilizer typically results in costs that are well in excess of any value that might be received, due purely to economies of scale. Thus, from a practical economic standpoint little, if any, value is generally attributed to this material. In some circumstances, giving the salt to local farmers at no cost is the most attractive route, especially if there are solid waste disposal costs that might be incurred.[123]

3.7 Waste Water

The issue of water usage and disposal will need to be addressed for each region, particularly during the hot summer months when drought conditions may occur. Water is involved in biodiesel production in many ways, depending on feedstock type:

- First, there is water in some of the raw feedstocks used to make biodiesel. The feedstocks being addressed in this study will all have various levels of water content. Yellow grease contains anywhere from 1.5% to 10% water. Grease trap oils contain from 25% to 75% water.[124]
- Second, the process of reacting biodiesel (especially using acid esterification pre-processing) produces small amounts of water.
- Third, washing the biodiesel with water to remove salts and soaps accumulated during the catalysis/transesterification process.

Water is not consumed by the washing phase of the biodiesel production process, it is only used as a medium to dissolve impurities, which will most certainly effect the quality of the fuel and it's ability to meet the ASTM standard.

The ratio of wash water to biodiesel varies within the industry, ranging from 3:1 to 1:10. The quality of the feedstock, and process used will affect the necessary volumes of water needed to clean the biodiesel. The cost of water and the "disposal" of the resulting wash water do not significantly impact the price of biodiesel, however, as a conservation measure, with the production of an environmental product, the least amount of water used the better. Lower water consumption levels can be achieved by ensuring that the majority of the glycerine compounds are removed from the biodiesel prior to washing. Residual glycerine in the water wash tends to form emulsions that encapsulate the biodiesel and requires greater amounts of water to effectively complete a thorough washing.[125]

The resulting water from biodiesel production can be placed into the wastewater treatment stream at minimal expense. Waste water could be used for agricultural irrigation if geographically feasible[126], however, biodiesel production processes which use potassium hydroxide as a catalyst instead of sodium hydroxide will have better luck proposing this solution to farmers for perception reasons stated earlier. This would potentially have appeal if the potassium salt were dissolved in the water, then sprayed onto the land.

3.8 Mandatory Requirements and Critical Success Factors

The Mandatory Requirements and Critical Success Factors for Manufacturing are to ensure:

- That the "pros" and "cons" of a variety of process options are investigated and evaluated with respect to the volumes and characteristics of feedstocks, end products and by-products capital and operating costs, production flexibility, and the ability to meet required finished product specifications on a consistent and reliable basis. This includes an analysis of batch vs. continuous processing and an assessment of quality control systems and methodologies. In general, simplicity and flexibility are desirable.
- That the "pros" and "cons" of acquiring a modular "turn-key" system vs. a custom designed and fabricated facility are investigated and evaluated.
- That the selected plant is capable of processing low-high FFA feedstocks efficiently and without a loss in yield.
- That the selected plant will provide cost-effective expandability to handle projected growth in feedstocks, new sources of feedstocks and growth in market demand.
- That the selected technology will present no unusual siting problems, and that all necessary permits can be obtained.
- That all waste products can be handled to meet the requirements of the license and local legislation.

- That an appropriate plant location is selected, taking into consideration feedstock supply sources, manufacturing (zoning, access, space for process equipment and feedstock/finished product storage, collection equipment storage), product distribution and customer locations.
- That the production process be supported by developing internal testing, record keeping and sample storage capability for quality assurance for both feedstocks and finished product (it may also be prudent to develop a back-up relationship with a third party laboratory for verification and potential dispute resolution).
- That a cost analysis is undertaken to determine the best payment method for plant technology – capital vs. licensing.
- That the adequate training, technical support and warranty/performance guarantees are offered.

3.9 Conclusions

This section has shown biodiesel plant/equipment manufacturing is a well established, rapidly growing industry in many parts of the world. The manufacturing technology:

- Offers a standard methodology for producing biodiesel, however, many options are possible within the primary processing strategy. There are no technical roadblocks to manufacturing biodiesel using common feedstocks.
- Can be influenced by feedstock type, volume, quality, and delivery schedule.
- Can be affected by biodiesel standards for a specific country, impacting both the quality control processing and preprocessing requirements.
- Can include a number of by-product processing options for methanol recovery, glycerin, fertilizer and water.
- May be influenced by the budget available for monitoring technology and operations personnel.
- Will be influenced by the anticipated growth of the plant and therefore the modularity of the equipment offering.
- Will depend on the offering of the selected manufacturer. This is driven by the parameters that were used to select the vendor and that vendor's technology/service offerings.

In addition, a manufacturing plant's capital and operating costs, and location, will be affected by the technology, and by the established municipal bylaws, zoning, tax and permitting requirements.

4 MARKET / DISTRIBUTION EVALUATION

4.1 Purpose of this Section

The purpose of the Market and Distribution Evaluation section of this document is to: assess potential market size; analyze market segments; review distribution options; establish market development priorities and related strategies; and review marketing, sales & distribution requirements.

4.2 Market Size

The market research undertaken for this project focused primarily upon diesel fuel used in road transportation. B100 may also be mixed with furnace oil and used in a variety of other applications. These potential markets are explored further in Appendix I. Table 31 provides details of diesel fuel volume sales by provincial taxation category for the years 2001/2002 and 2002/2003.

Clear diesel is used exclusively for road transportation. Clear diesel is subject to additional transit-related taxes on a regional basis. Marked diesel is used in off-road engine applications. Marine diesel is sold for use in marine vessels.

Table 31: Diesel Fuel Volumes BC/Regional

Provincial Diesel Tax Category	**Total Sales in Litres**	
	Aug/01-Aug/02	**Aug/02-Aug/03**
GVTA – Clear Diesel	265,825,194	277,638,280
BCTA – Clear Diesel	33,246,715	34,034,553
Balance of BC – Clear Diesel	1,023,195,997	1,112,662,177
Total Clear Diesel	1,322,267,906	1,424,335,010
Marked Diesel	928,825,574	987,216,281
Marine Diesel	395,922,782	404,045,090
Total M. and M.Diesel	1,324,748,356	1,391,261,371
Total Diesel Use in BC	2,647,016,262	2,815,596,381

Source: BC Ministry of Revenue

4.3 Market Segments

There are several ways that the diesel fuel market may usefully be segmented. These include:

- ❖ Segmentation by End Use Category
- ❖ Segmentation by End User Volume & Infrastructure
- ❖ Segmentation by End User Performance Criteria

4.3.1 Segmentation by End Use Category

As noted in the introduction to this section, B100 may potentially be used in a variety of applications. Primary uses include: Road Transportation; Off-Road & Marine Engines; and Furnace Oil. Several differences exist between the segments with respect to seasonality, marketing and distribution challenges, but a key difference that dramatically impacts market pricing and potential margins involves the taxation of these fuels by federal and provincial authorities.

The Federal Excise Tax Act imposes taxes on gasoline, diesel and aviation fuels. The definition of diesel fuel includes any fuel oil that is suitable for use in internal combustion engines of the compression-ignition type, other than any fuel oil that is actually used as heating oil. Diesel fuel used in the generation of electricity is also exempt. The current federal excise rate applicable to diesel fuel is $0.04/litre. This tax is payable by the manufacturer or producer at the time the fuel is delivered to a purchaser or at the time of delivery of the gasoline or diesel fuel to a retail outlet by the producer or manufacturer.[1] Biodiesel has been exempted from federal excise tax. As compared to conventional diesel fuel, this provides B100 with an advantage of $0.04/litre for internal combustion engine applications.

British Columbia provincial authorities do not tax furnace oil used for residential heating. For marked (colored) diesel used in off-road or marine engine applications, the province applies a tax of $0.03/litre. Marked diesel purchased by farmers and First Nations is exempt from this tax. Adding the pre-GST components of federal and provincial taxes, the combined tax rate is zero on furnace oil used for residential heating and $0.07/litre for marked diesel. Interested parties within the Province of BC are preparing to apply for exemption from provincial fuel tax for B100. Using the model of ethanol, which has been granted tax-exempt status in BC, the provincial exemption would be applied only to clear diesel (on-road) applications. Under these circumstances, B100 would have no advantage based upon tax policy in the residential heating oil segment and would have a $0.04/litre advantage (federal excise only) in marked diesel applications. The Province of BC applies several tax components to clear diesel fuel used for road transportation. If exemption from these taxes is approved for biodiesel as a qualifying alternative fuel (assumed for the purpose of this study), B100 would enjoy a cost advantage over conventional clear diesel fuel of $0.15/litre - $0.21/litre (depending on the region) based upon provincial exemptions and $0.215/litre based upon combined federal and provincial exemptions. The specific tax components applicable to the 3 fuel tax regions in the province that would be exempted are shown in Table 32. This favourable tax treatment offers significantly higher price-point and margin opportunities for biodiesel in the road transportation segment.

Table 32: Provincial Road Tax Components to Be Exempted

Fuel Tax Allocation	Effective Date	Greater Vancouver Transportation Service Region	Victoria Regional Transit Service Area	Remainder of the Province
BCTFA	March 1, 2003	6.75¢ / litre	6.75¢ / litre	6.75¢ / litre
TransLink	April 1, 2003 April 1, 2005	11.5¢ / litre 12.0¢ / litre	nil	Nil
BC Transit	Current	Nil	2.50¢ / litre	Nil
Province Diesel	April 1, 2003 April 1, 2005	2.75¢ / litre 2.25¢ / litre	8.25¢ / litre	8.25¢ / litre
Total Tax Diesel	March 1, 2003	21.00¢ / litre	17.50¢ / litre	15.00¢ / litre

Source: BC Ministry of Provincial Revenue Tax Bulletin 099 Revised Feb 2003

[1] Department of Finance Canada - http://www.fin.gc.ca/susdev/sdscat_1e.html#1.1_Federal

4.3.1.1 Road Transportation (Clear Diesel Fuel)

The information summarized in Section 4.2 concerning the volume sales of diesel fuel is reliable in terms of setting an overall picture, but not very useful in terms of identifying target fleets which might be interested in purchasing biodiesel. Detailed information concerning individual fleets is required in order to select appropriate target fleets and to develop the level of information necessary to substantiate estimates of plant capacity and financial viability.

To address this issue, a regional survey will need to be performed from the various categories outlined in the following sections. Details concerning the number of diesel powered vehicles in each fleet, the estimated total annual diesel fuel consumption, pricing, suppliers and location of fueling will need to be investigated.

The pricing of clear diesel fuel for the transportation sector is derived from three major cost/profit elements plus applicable taxes. These are: crude oil costs; the refiner's operating margin; and the marketer/distributor's margin. MJ Ervin and Associates, a private market intelligence firm specializing in the petroleum-based fuel sector, track retail pump prices and key components for diesel fuel in selected cities across Canada. Table 33 provides a breakdown for Vancouver based upon average costs/prices for the first 11 months of 2003. Major swings in retail pump prices are usually the result of fluctuations in the cost of crude oil rather than other factors. In the Greater Vancouver area, provincial taxes applied total $0.21/litre as opposed to the $0.175 applicable in the Victoria region and the $0.15 for the rest of the province. As a result, pre-GST tax components total $0.25/litre in Vancouver vs. $0.215/litre for Victoria and $0.19 /litre for the rest of the province. (note: 2003 average does not total to this difference due to changes in taxation that took effect March 1st, 2003).

Table 33: Retail Diesel Pump Price Average 2003 (11 Months)

VANCOUVER Pump Price	**72.28**
Crude Costs	27.42
Refiner Operating Margin	8.35
Marketing Operating Margin	7.42
Taxes	29.10
Tax Components: Federal Excise	4.00
GST/HST	4.74
Provincial (apportioned to various agencies)	14.36
Added Tax in the Greater Vancouver Transit Area	6.00

Source: Ad Hoc Report – MJ Ervin & Associates

The pre-tax price for higher volume bulk sales of diesel fuel (generally including crude costs and refiner's margin but excluding marketing margin) is typically referred to as the "rack rate". The rack rate fluctuates significantly with crude costs and is used as a benchmark in pricing for high volume diesel fuel purchasers such as large fleet users and independent distributors. Depending upon contract provisions, large fuel users will pay somewhat higher or lower prices than quoted spot rack rates. Table 34 shows average rack rates applicable for Vancouver, Nanaimo and Victoria (only regions in BC broken down by MJ Ervin & Assoc.) for the first 11 months of 2003. The degree of fluctuation in spot prices is evident from the high/low price-points indicated over the period.

Table 34: 2003 Diesel Fuel Rack Rate Averages

2003 (11 Months) RACK RATES			
Location	**Average**	**High**	**Low**
Vancouver	35.5	51.6	29.9
Nanaimo	36.2	52.1	30.6
Victoria	36.3	52.1	30.8

Source: Ad Hoc Report – MJ Ervin & Associates

4.3.1.2 Off-Road & Marine Segment

For the province of BC, total marked (off-road) diesel sales were over 987 million litres in 2002/2003 (Table 31). As noted in Section 4.3.1, this segment offers a less favourable alternative fuel tax advantage ($0.04/litre vs. $0.19/litre - $0.25/litre) as compared to the road transportation sector.

The marine fuel sector is dominated by some of the larger fleets (BC Ferries, Canadian Coast Guard and the Department of National Defense); however competitive pricing within this sector is made more difficult by the negotiating power associated with these fleets and by the lower relative tax advantages that apply as compared to road transportation (assuming biodiesel tax exemption).

4.3.1.3 Furnace Oil Segment

The residential furnace oil segment offers no tax-based advantage to tax exempt alternative fuels (such as biodiesel may become). Conventional fuel is already exempted from federal excise and provincial taxes. This segment carries the additional disadvantage of being purely seasonal. This seasonality also tends to be inverse to restaurant derived FOG feedstock supply, which typically increases during the summer months as tourist traffic drives up activity in the food service sector. Despite these negative factors, this segment merits further investigation. Individual consumers who are socially conscious may be willing to pay a premium for an environmentally friendly fuel, providing a potentially profitable niche marketing opportunity. Several fuel distributors that serve the commercial road transportation segment are also leading suppliers in this sector, providing opportunities to piggy-back a furnace oil program on top of a relationship that is primarily focused upon vehicle refueling.

Average rack rates for furnace oil in Vancouver, Nanaimo and Victoria are shown in Table 35. Rack rates fluctuate primarily with crude oil costs.

Table 35: 2003 Regional Furnace Oil Rack Rates

2003 RACK RATES CENTS/LITRE			
LOCATION	**AVG**	**HIGH**	**LOW**
Vancouver/Furnace Oil	34.9	50.9	29.2
Nanaimo/Furnace Oil	35.5	51.4	29.9
Victoria/Furnace Oil	35.6	51.4	30.1

Source: Ad Hoc Report – MJ Ervin & Associates

4.3.2 Segmentation by End User Volume & Infrastructure

A second important form of segmentation reflects the price/volume curve. Not surprisingly, the largest consumers of fuel have the negotiating leverage to contract for significantly lower fuel prices than smaller operators. For example BC Transit currently has a contract with a fuel supplier for $0.53/litre. Table 36 provides a breakout of the components that make up the after-tax price paid. Like all diesel fuel users in the BCTA region, BC Transit pays the $0.025/litre Transit Tax surcharge, but this is rebated back to provide a net cost of $0.505/litre (a partial rebate of GST is also received, but this rebate would apply to both conventional diesel fuel and biodiesel). As shown in Table 36, a price of $0.475/litre for B100 in a 20% blend with standard diesel fuel would provide a blended product at a cost of $0.5057/litre, a difference of less than 1.5% as compared to the benchmark conventional fuel price. The impact of a tax exemption for biodiesel is shown clearly by comparing this "cost-neutral" pricing to the netback price for conventional diesel fuel of $0.2803/litre before applicable taxes. It is also interesting to compare this netback price to the average rack rate for diesel fuel in Victoria (11 months 2003) of $0.363 reported in Table 36. This comparison shows the impact of negotiating power and the relatively slim margins earned by suppliers of conventional diesel fuel on such large volume contracts.

Table 36: Large-Scale Transit Fuel Price

Cents per Litre	**53.00**
Less 7% GST Component	3.47
Net Before GST	49.53
Less Federal Excise	4.00
Less BCTFA	6.75
Less Provincial Diesel	8.25
Less BC Transit	2.50
Netback Price Before Taxes	28.03
Actual Cost to BC Transit	50.50
Assumed "Cost Neutral" Price for Biodiesel	**47.50**
7% GST	3.33
Price Taxes In	50.83
Biodiesel Component Price for 20% Blend	10.17
Diesel Component Price for 80% Blend	40.40
Net Cost to BC Transit for Biodiesel per Litre	50.57

A more typical medium-sized commercial fleet pricing range is shown in Table 37 using the price of $0.605/litre. This assumes a fleet of ~20 diesel powered trucks consuming 250-300,000 litres of diesel fuel per year (as compared to BC Transit's 6.6 million litres/year in the BCTA region and 15.8 million litres/year in the province). Table 37 provides a breakdown of cost elements in this conventional fuel price and calculates a cost-neutral price of $56.50/litre for B100, leveraging the anticipated tax exemptions for biodiesel fuel.

Table 37: Medium-Sized Commercial Fuel Price

Cents per Litre	**60.50**
Less 7% GST Component	3.96
Net Before GST	56.54
Less Federal Excise	4.00
Less BCTFA	6.75
Less Provincial Diesel	8.25
Less BC Transit (BCTA region only)	2.50
Netback Before Taxes	35.04
Assumed "Cost Neutral" Price for Biodiesel	**56.50**
7% GST	3.96
Taxes In	60.46
Biodiesel Component Price for 20% Blend	12.09
Diesel Component Price for 80% Blend	48.40
Net Cost for Biodiesel per Litre	60.49

At the highest end of the pricing structure is the average pump price profile of $72.28/litre shown in Table 33. This price level is typically referred to as "automotive diesel" and is usually applied to individual consumers operating diesel pick-up trucks or cars. These consumers do not purchase under negotiated contracts and refuel at retail outlets on an ad-hoc basis.

4.3.3 Segmentation by End User Performance Criteria

A third significant form of segmentation is based upon the performance measurement factors and decision criteria that apply within different classes of fuel users. Organizations that measure their performance based solely upon financial results and factors that contribute directly to bottom line enhancement are less likely to become early adopters of biodiesel. These organizations might be referred to as "Limited Orientation Fleets". Although biodiesel has been proven to be successful in many jurisdictions, there remains an element of perceived risk in its adoption as a major component of a fleet refueling program. The introduction of biodiesel requires a modest investment in training and in management attention. In addition, biodiesel usually carries a premium price as compared to conventional diesel fuel. These factors present obstacles unless the social and environmental benefits of adopting biodiesel are factored into the fleet user's decision making process. For organizations that use a "triple bottom line" evaluation system, these external benefits are formally considered in both decision making and performance evaluation.

"Triple Bottom Line Fleets" focus not just on the economic value they add, but also on the environmental and social value they add – and destroy. At its narrowest, the term 'triple bottom line' is used as a framework for measuring and reporting corporate performance against economic, social and environmental parameters. At its broadest, the term is used to capture the whole set of values, issues and processes that companies must address in order to minimize any harm resulting from their activities and to create economic, social and environmental value. This involves being clear about the company's purpose and taking into consideration the needs of all the company's stakeholders – shareholders, customers, employees, business partners, governments, local communities and the public.

Triple bottom line organizations should be targeted on a priority basis for the early adoption of biodiesel programs. These organizations tend to have a significant component of public ownership and accountability to their communities. They include:

- Transit systems
- Municipal and regional government operations
- Federal and provincial government operations
- Crown Corporation fleets
- Fleets under contract to government operations

In the case of federal government fleets, managers are not only encouraged to consider the use of alternative clean fuels, but are mandated to do so under the Alternative Fuels Act of 1995.[127] A key provision of this act states that

> "*Where it is cost effective and operationally feasible to do so, a Crown corporation shall use an alternative fuel in the operation of any motor vehicle capable of operating on such a fuel*". The Act states that *"alternative fuel" means fuel that is (a) for use in motor vehicles to deliver direct propulsion, (b) less damaging to the environment than conventional fuels, and (c) prescribed by regulation, including, without limiting the generality of the foregoing, ethanol, methanol, propane gas, natural gas, hydrogen or electricity when used as a sole source of direct propulsion energy*.

Generally, as can be seen in other jurisdictions where biodiesel is available, the triple bottom line fleet operations show the greatest interest in biodiesel and will provide the highest level of cooperation in assisting with preliminary market research and then initial implementation of biodiesel within their region.

4.4 Distribution Channels

Distributor margins in the conventional diesel fuel industry are low and are subject to severe competitive pressures. Distributors who are potentially interested in marketing and selling a biodiesel product are seeking enhanced margin opportunities, but are also focused upon gaining market share by appealing to the environmentally conscious niche segment. Using distributor channels rather than direct sale and delivery to fleet customers will reduce the gross profit margin available to the biodiesel manufacturer. This must be balanced against the contribution and services that good quality distributor partners can provide, including:

- Ownership and operation of strategically located fuel storage and refueling infrastructure including both retail and cardlock stations
- Ability to add blending infrastructure with relatively low cost and complexity
- Possession of existing permits, zoning approvals and licenses to store and dispense petroleum based fuels and fuel blends
- Relationships with significant fuel users and an understanding of how to prioritize and market to high priority fleet targets
- Understanding of the local competitive environment and development of competitive strategies
- Extension of trade credit to fuel users and bearing of the related credit risk

Three scenarios may be considered: a direct-only sales/distribution strategy; a distributor-only sales/distribution strategy; and a blended direct and distributor strategy

4.4.1 Direct Sales & Distribution

The strategy of taking on the full responsibility for distribution and sale of the biodiesel product may maximize the gross margin potential available to the biodiesel manufacturer, but would involve:

- Purchase of one or more trucks to distribute B100

- Purchase of petroleum diesel and blending equipment to produce B20
- High capital cost of truck(s), blending facility, extra tankage
- Extra regulatory issues (truck licensing and permits) and truck maintenance
- Creation and maintenance of an accounting system to invoice the full spectrum of customers
- Direct responsibility for hiring, training and administering unionized drivers
- Possible creation of a wholesale/retail fuel dispensing infrastructure.

Purchasing diesel for in-house blending is essentially technically simple but financially risky. For example, it entails:

- Competing on diesel cost with the fully integrated petroleum refiners, which means that the biodiesel producer would have a cost disadvantage on 80% of blended product cost
- Competing with the fully integrated petroleum refiners on the basis of displacing 100% of the market volume that moves to B20 rather than 20%

Similarly, development of a retail fuel dispensing/distribution infrastructure is not a technical challenge, but is excessively costly, complex and risky since:

- It is a highly competitive industry segment with low margin returns
- Siting, approvals, licensing etc. can become extremely complicated, costly and time consuming
- A single product offering (biodiesel) would not likely generate a sufficient revenue base to provide an attractive payback
- Such a strategy must take on the full burden of marketing in order to establish market share but starting with no brand recognition
- The likely competitive reaction from the fully integrated petroleum refiners and existing fuel distributors with multiple products would be extreme
- The high risk/low return profile of this option would make it impossible to finance.

4.4.2 Distributor Sales & Distribution

The strategy of passing full responsibility for distribution and sale of the biodiesel product to one or more distributors would depress the gross profit margin potential available to the biodiesel manufacturer and could make the blended product too expensive to compete in high-volume, low-margin fuel use segments. In counterbalance, the use of established distributors can offer the following advantages:

- Lower risk due to less capital investment and lower complexity since the fuel distributor has an existing fleet of suitable trucks
- Since the fuel distributor has existing tanks, trucks and drivers, it can carry-out the blending and distribution using its equipment to supply an established network of wholesale/retail product outlets
- An established fuel distributor will have a network of clients and established billing procedures which will simplify entry for the biodiesel producer
- An established fuel distributor may be able to tap into premium price wholesale/retail markets for biodiesel (e.g. a “green” market) due to advertising, branding, sales force and key locations
- An established fuel distributor will always have access to a better price for petroleum diesel for blending than will a new biodiesel producer due to the volume of its existing business

- ❖ An appropriate fuel distributor will have access to alternative markets such as home heating fuel oil which offer an additional volume, different price market with seasonal considerations and possibly greater environmental sensitivity that can take full advantage of the social/environmental benefits of biodiesel

4.4.3 Combined Direct & Distributor

A strategy that could leverage the advantages of both scenarios for the manufacturer would be to use distributors to penetrate those market segments that have lower volumes, higher price-points and less in-house infrastructure while retaining those segments for direct sale that have higher volumes, lower prices, and in-house blending/refueling capability.

4.5 Market Development Priorities & Related Strategies

The following market development priorities and strategies may be derived from the information and analysis presented in this section:

1. Prioritize non-commercial fleet market segments with Triple Bottom Line (TBL) performance mandates.
2. For the largest TBL fleets with in-house refueling and potential fuel blending capabilities, use a direct sales approach, delivering B100 to the end user's site for blending by the customer with diesel fuel purchased under their existing contracts. Elimination of a distributor middleman should allow for competitive pricing with viable manufacturer's margins. Contract for delivery haulage with a local transport company.
3. Pursue commercial Limited Orientation (LO) fleets and smaller TBL fleets that do not have in-house fueling infrastructure through distributor partners. These fleets tend to consume lower volumes and to pay higher prices, providing sufficient margin to share between distributor and manufacturer. The LO fleets will require additional relationship selling and marketing to penetrate. Distributors should be positioned to accomplish this over time. Smaller commercial accounts also carry higher credit risks. Distributors are better equipped to deal with these issues.
4. Pursue discussions with regional fuel distribution companies regarding potential distribution relationships. During the course of these discussions, also explore the potential furnace oil market. Since these regional distributors do not tend to secure contracts to service high volume TBL accounts, the possibility of competitive conflict between direct and distributor segments should be minimal. The potential for product differentiation and for incremental market share will be of significant interest to regional distributors seeking to pull environmentally conscious consumers away from major integrated refiner/marketers.

4.6 Sales & Marketing Requirements

Detailed sales & marketing requirements are typically dealt with during the development of a comprehensive business plan. If the strategies presented in Section 4.5 are implemented, the requirements for sales and marketing at the manufacturer's level may remain fairly modest.

TBL fleets that will be direct sales accounts already have a predisposition towards the use of environmentally friendly alternative fuels and are limited in number. This reduces the up-front sales and marketing challenge and emphasizes customer service over advertising and promotion. The use of annual supply contracts will assist in reducing day-to-day sales requirements.

Distributor partners will undertake the bulk of the sales effort directed towards small-to-medium sized commercial LO accounts. For larger targeted fleets in this sector, joint sales calling will be required. Distributors will expect biodiesel manufacturer marketing programs to be made available, including product literature, targeted advertising, and point-of-sale materials. Distributor sales personnel will also require training and indoctrination by the biodiesel manufacturer.

In cooperation with distributor partners, every effort to obtain maximum exposure through well-focused public relations and public outreach programs should be undertaken.

4.6.1 Engine Warranties and Biodiesel

To reduce the risk perceived by targeted fleet consumers, it is important that promoters of biodiesel be conversant with issues related to the performance of biodiesel blends in specific engine types, and with the impact upon engine warranties. Manufacturer warranties cover defects in material and workmanship of the engine. Those warranties extend to Biodiesel as long as the fuel sold meets the specification of the fuel specified for the engine type. Biodiesel standards surpass all the engine manufacturer's fuel specifications for warranty purposes.

For detailed statements on biodiesel by major diesel engine manufacturers, visit: www.biodiesel.org./resources/fuelfactsheets/standards_and_warranties.shtm.

4.6.2 Seasonal Variability

As stated earlier in this report, due to the nature of the tourism industry and its effect on the volume of yellow grease supply, seasonal variability's will need to be assessed. Most of variability for the will occur during the summer months when restaurants are busier due to an increase in tourists. A few localized locations may be busier during the winter months from the winter sports industry. An analysis will need to be performed to determine the most appropriate capacity for the plant being built to allow for this variability. Additionally, markets will need to be developed during the times of higher production, as it is unrealistic to store large volumes of biodiesel on site. Some examples for shedding the additional summer supply are:

- Supplying fleets that have increased operations during the summer would be ideal.
- Encouraging fleets to use higher biodiesel ratio blends during this period would absorb some of the additional feedstock, as the issues with cold flow properties of biodiesel are eliminated during the warmer months.
- Marketing to mining operations as many are in higher production during the summer months.

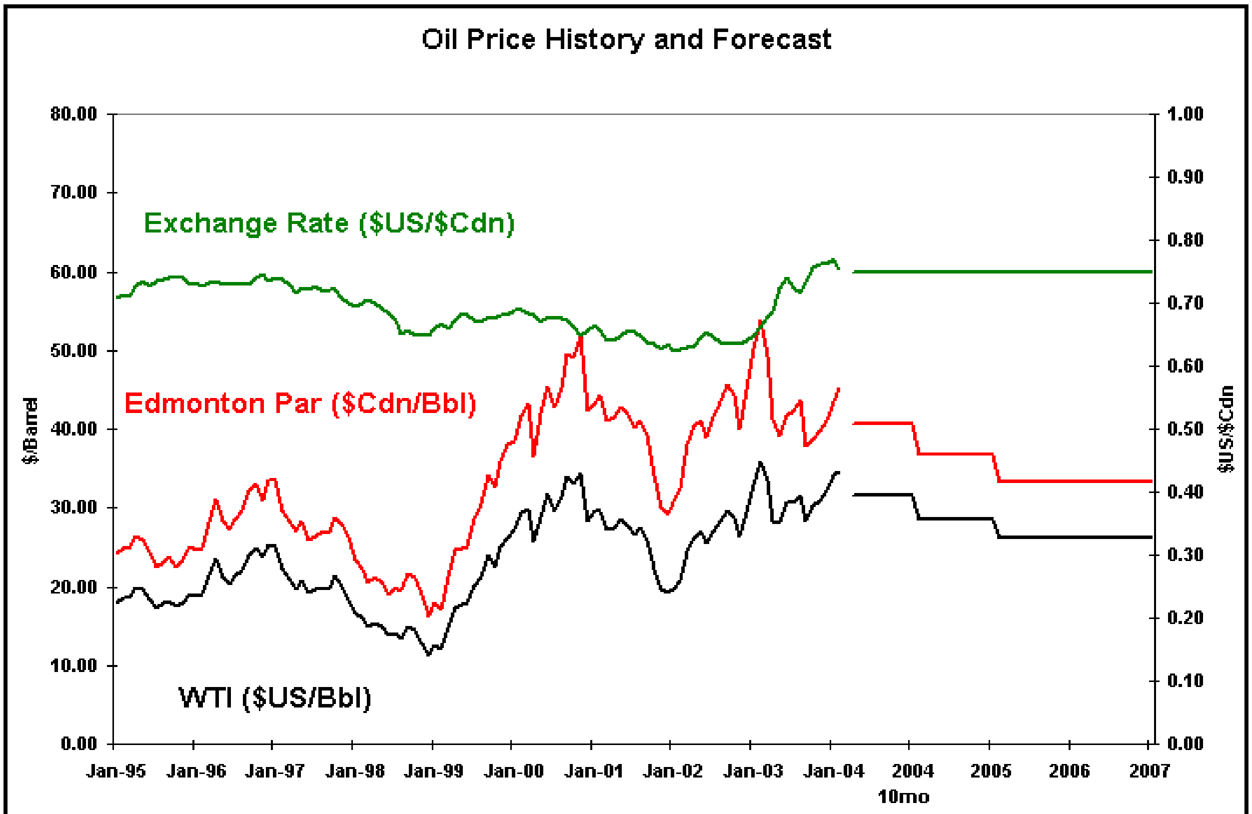
4.6.3 Projecting Competitive Diesel Fuel Pricing

The market price of diesel fuel is strongly correlated to the refiner's cost of crude oil after deducting taxes. Marketing margins tend to be relatively stable over time as compared to other input factors. The price of crude oil in Canada is referenced to internationally accepted standards such as West Texas Intermediate (WTI), net of transportation costs and quality adjustment factors (e.g. gravity, sulphur, etc.)

The price of crude oil to the refiner is highly volatile over long periods of time. Crude oil prices have been driven largely by international geopolitical forces, but are also influenced (at least in the short term) by finished product inventory fluctuations, refinery rationalizations, economic performance, etc. Another major driver of crude oil price is the deteriorating balance between the US, which imports ~60% of its energy requirements, and OPEC which controls ~30% of the low cost/high volume crude oil production destined for export to the US. Many if not all of the foregoing factors are inherently unpredictable except in the broadest sense. Forecasters have a tendency to assume steady state in the absence of obvious change factors and often are cautious in the sense that current prices are frequently thought to be near a high point from which they will soften. However, the international oil market is highly dynamic and has produced prices that have differed widely from forecasts. Any price forecast should be treated with extreme caution and used only as a base case on which to launch sensitivity analyses.

Despite the inaccuracies inherent in forecasting methodology, biodiesel project proponents are encouraged to review and assess the impact of forecast oil prices that may drive competitive pricing by conventional diesel fuel suppliers. Two sources of analysis and forecast projections that may be accessed without charge are Sproule & Associates (web: http://www.sproule.com/prices/defaultprices.htm) a Canadian consulting firm specializing in the petroleum applications and the US Energy Information Administration (web: http://www.eia.doe.gov/). The price forecast by Sproule released in March 2004 is shown in the chart below.

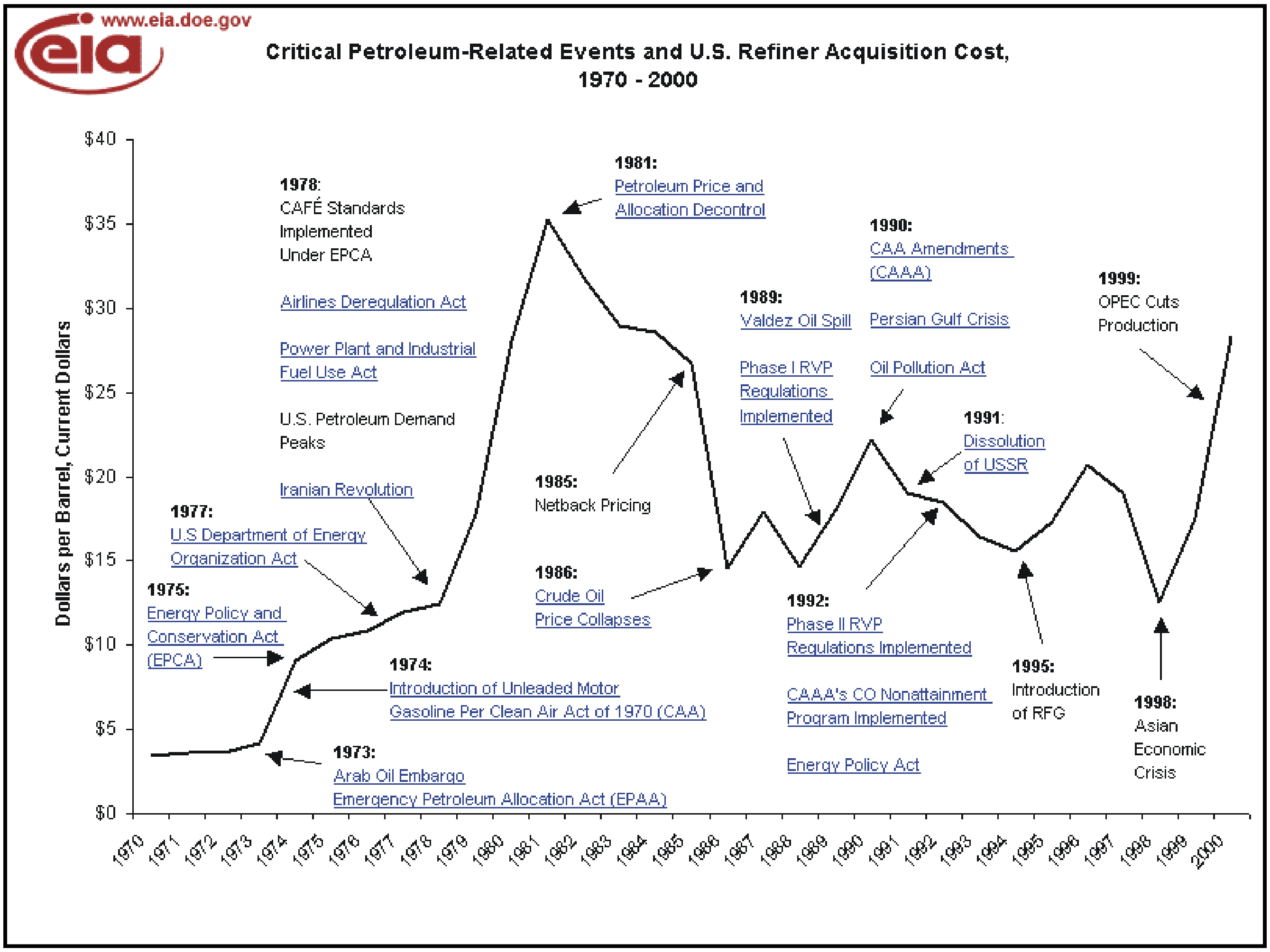
Figure 6: Oil Price History and Forecast



Source: Sproule & Associates

The volatility of crude oil prices, and the relationship between price swings and geopolitical events is illustrated in the following chart developed by the US Energy Information Administration.

Figure 7: Critical Petroleum-Related Events and US Refiner Acquisition Cost



4.7 Storage

In general, the standard storage and handling procedures used for petroleum diesel can be used for biodiesel, however, Transport Canada does not consider biodiesel to be a hazardous material[128]. For this reason, the double walled storage tanks required for diesel fuel, are not required for biodiesel.

Biodiesel fuel should be stored in a clean, dry, dark environment. Acceptable storage tank materials include aluminum, steel, fluorinated polyethylene, fluorinated polypropylene and Teflon. Copper, brass, lead, tin, and zinc should be avoided.[129]

All fuels, including diesel, have a shelf life. This is also true with pure biodiesel (B100), and biodiesel blends. Industry experts recommend that biodiesel be used within a year of purchase to ensure that the quality of the fuel is maintained. This is not expected to be an issue in practice.[130]

4.8 Blending

Although biodiesel can be run in any diesel engine as a neat fuel (B100), biodiesel is likely to be blended with diesel fuel for several reasons.

1. Due to its higher production costs and lower production volume potential it is likely to be used as an additive to traditional diesel fuel rather than a replacement;
2. There are concerns that running on B100 can result in gelling problems in very cold weather, and possible fuel hose incompatibility. This can further be avoided when running on a blend of B20 or less, although these two concerns can easily be addressed.

   For cold weather concerns, there are several options such as the addition of cold weather fuel conditioners, installing a simple inline fuel heater, or parking the vehicles in a heated garage overnight. If the fuel lines are found to be made of an incompatible material (typically in vehicles older than 1997), the fuel lines can be easily replaced with viton hoses for less than $100.
3. While the US ASTM standard is for pure biodiesel, the typical US biodiesel blend is about 20% (i.e. B-20), based on the revised 1998 EPAct regulations, and many diesel engine manufacturers have made acceptance statements based on this current “conventional” ratio.

Biodiesel is slightly heavier than petroleum diesel and has a specific gravity of 0.88 compared to petroleum diesel at 0.85. Biodiesel should be splash blended on top of petroleum diesel, otherwise, the fuels may not mix properly. Mistakes, where proper mixing does not occur, can be corrected by the following options:[131]

- ❖ Agitate the fuels together,
- ❖ Pump the fuels out into a tank truck and then pump them back down together,
- ❖ Ignore the problem if there are no concerns about solvency, material compatibility, or cold weather, since biodiesel can be burned as a 100% pure fuel.

Biodiesel blends will not separate in the presence of water, however, for good housekeeping and tank/fuel maintenance, water in the storage systems should be monitored and minimized.[132]

4.9 Biodiesel Standards

The key quality control issue with the production of biodiesel involves the complete (or nearly complete) removal of alcohol, catalyst, water, soaps, glycerine, and unreacted, or partially reacted, triglycerides and free fatty acids. Failure to remove or minimize these contaminants causes the methyl ester product to fail one or more fuel standards. [133]

Many countries in the world have developed biodiesel standards (see Table 38).

Table 38: Comparison of the world biodiesel standards [134]

		Austria	Czech Republic	France	Germany	Italy	Sweden	USA
Standard/ Specification		ON C1191	CSN 65 6507	Journal Officiel	DIN E 51606	UNI 10635	SS 155436	ASTM PS121-99
Date		1-Jul-97	Sep-98	14-Sep-97	Sep-97	21-Apr-97	27-Nov-96	Jul-99
Application*		FAME	RME	VOME	FAME	VOME	VOME	FAMAE
Density 15°C	g/cm3	0.85-0.89	0.87-0.89	0.87-0.90	0.875-0.90	0.86-0.90	0.87-0.90	-
Viscosity 40°C	mm2/s	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	3.5-5.0	1.9-6.0
Distillation 95%	C	-	-	< 360	-	< 360	-	-
Flashpoint	C	> 100	> 110	> 100	> 110	> 100	> 100	> 100
CFPP	C	0/-15	-5	-	0/-10/-20	-	-5	-
Pourpoint	C	-	-	< -10	-	< 0/< -15	-	-
Sulphur	% mass	< 0.02	< 0.02	-	< 0.01	< 0.01	< 0.001	< 0.05
CCR 100%	% mass	< 0.05	< 0.05		< 0.05			< 0.05
10% dist.resid.	% mass			< 0.3		< 0.5	-	
Sulphated ash	% mass	< 0.02	< 0.02	-	< 0.03	-	-	< 0.02
(Oxid) Ash	% mass	-	-	-	-	< 0.01	< 0.01	-
Water	mg/kg	-	< 500	< 200	< 300	< 700	< 300	< 0.05%
Total contam.	mg/kg	-	< 24	-	< 20	-	< 20	-
Cu-Corros. 3h/50°C		-	1	-	1	-	-	< No.3
Cetane No.	-	> 49	> 48	> 49	> 49	-	>48	>40
Neutral. No.	mgKOH/g	< 0.8	< 0.5	< 0.5	< 0.5	< 0.5	< 0.6	< 0.8
Methanol	% mass	< 0.20	-	< 0.1	< 0.3	< 0.2	< 0.2	-
Ester content	% mass	-	-	> 96.5	-	> 98	> 98	-
Monoglycerides	% mass	-	-	< 0.8	< 0.8	< 0.8	< 0.8	-
Diglyceride	% mass	-	-	< 0.2	< 0.4	< 0.2	< 0.1	-
Triglyceride	% mass	-	-	< 0.2	< 0.4	< 0.1	< 0.1	-
Free glycerol	% mass	< 0.02	< 0.02	< 0.02	< 0.02	< 0.05	< 0.02	< 0.02
Total glycerol	% mass	< 0.24	< 0.24	< 0.25	< 0.25	-	-	< 0.24
Iodine No.		< 120	-	< 115	< 115	-	< 125	-
C18:3 and high. unsat. acids	% mass	< 15	-	-	-	-	-	-
Phosphor	mg/kg	< 20	< 20	< 10	< 10	< 10	< 10	-
Alkaline met. (Na, K)	mg/kg	-	< 10	< 5	< 5	-	< 10	-

* RME.........Rapeseed oil Methyl Ester
FAME.......Fatty Acid Methyl Ester
VOME......Vegetable Oil Methyl Ester
FAMAE…….Fatty Acid Mono Alkyl Ester

>.........Greater than
<.........Less than

The best standard in Europe has been the German E-Din 51606 standard. A great deal of joint research has been done by the institutions, associations and the vehicle/engine manufacturers. The standards in Europe are usually feedstock (the types of oil/alcohol used) specific. [135]

The US has taken a slightly different route to obtain their standard. They decided that since the only difference between the feed-stocks is the length of the carbon/hydrogen chain (effects the cloud point) a generic standard was more applicable (biodiesel is defined as the mono alkyl esters of long chain fatty acids derived from vegetable oils or animal fats, for use in compression-ignition (diesel) engines). Their specification is for pure (100%) biodiesel prior to use, or blending with diesel fuel. [136]

For the past several years there have been efforts undertaken in Canada to develop a Canadian General Standards Board specification for biodiesel fuels for Canada. These efforts have not yet produced a published specification. [137]

4.10 Glycerine Market

The glycerine market is greatly affected by the oleochemical and biodiesel markets. If the agricultural sector in a specific region has a bad year for oil crops such as canola or soybeans, glycerine supplies will decrease and prices will increase. In fact, in Germany, where biodiesel production is rapidly growing, the glycerine market has been flooded and biodiesel producers can all but give it away. As more biodiesel plants are built due to favourable market conditions, the price of glycerine is expected to drop for the foreseeable future. Speaking on the effect biodiesel production will have on the glycerine market, Mike Hemming a glycerine specialist at HB International, a Paris-based oleochemicals broker, stated in the Sept. 30, 2002 Chemical Market Reporter:

"We are seeing the end of glycerine as a high-priced commodity. There may be price spikes now and again linked to changes in the cost of mineral oil, but the trend now is one of long-term decline."

A purchasing.com article from Nov. 24, 2003 entitled, ‘Supply growth will keep glycerine prices in check’ states:

*“One of the key factors affecting global markets today is the increased crude glycerine supply from the European biodiesel industry. According to Stevens, (*Jon Stevens of Cognis Corp.), *demand for glycerine should remain strong especially as it becomes more favorably priced versus other polyols. “Supplies of glycerine should be ample at the beginning of 2004, and pricing will be at or near the bottom of the cycle,” says Stevens. “Beyond the first or second quarter, pricing will be highly dependent on the supply of glycerine in the market. A disruption in glycerine supply due to unfavorable biodiesel economics could send prices higher. However, if global supply remains strong, prices will remain low well into 2004.”*

Pricing for natural refined 99.5% glycerine at the end of 2003 was at US 77¢/lb., down from 90¢/lb. at the beginning of the year.[138]

March 1, 2004 spot pricing[139]:

Glycerine kosher 99.7% tank truck, bulk, dlvd.	US$0.67-0.80 / lb.
Glycerine non-kosher 99.5% vegetable grade, FCC grade tanks dlvd.	US$0.53-0.77 / lb.

Since a small number of refineries represent the entire potential customer base, selling crude glycerine in large shipments to glycerine refining plants would be the simplest solution. The amount of money paid for the "crude" glycerine will vary based on fluctuating market rates, quality and purity, but may be as low as U.S. 5-7¢/lb not including shipping costs[140]. Again, depending on the growth in supply, this amount could reduce further to the point that "give-away" is considered. At this stage, use of the material as a burner fuel should be considered.

From an overall glycerine market perspective, it is apparent that the industry must intensify its focus on new applications for glycerine products (especially refined). This is a subject under consideration by the major producers and distributors, and efforts in this arena are expected to intensify.

Table 39: US Glycerine Refining Capacity (2001)

PRODUCER	CAPACITY*	PRODUCER	CAPACITY*
Cognis, Cincinnati, Ohio	65	Lever, Hammond, Ind.	25
Colgate-Palmolive, Jeffersonville, Ind.	20	Lonza, Painesville, Ohio	20
Crompton, Mapleton, Ill.	20	Marietta American, Olive Branch, Miss.	2
Crompton, Memphis, Tenn.	30	Procter & Gamble, Ivorydale, Ohio	150
Dial, Montgomery, Ill.	30	Starchem, Fostoria, Tex.	20
Dow, Freeport, Tex.	140	Uniqema, Chicago, Ill.	35
Total	**557**		

Source: www.the-innovation-group.com/ChemProfiles/Glycerine.htm

*Millions of pounds per year of refined glycerine.

4.10.1 The Canadian Glycerine Market [141]

The Canadian glycerine market is mainly conducted by a relatively few chemical industry companies (see Tables 40 and 41).

Table 40: Canadian Glycerine Production Capacity

Company	Plant Location	Capacity (Kilotonnes/year)
Akzo Nobel	Saskatoon	0.6
Cognis Canada	Toronto	5.0
Perth Soap	Perth, ON	2.0

Akzo Nobel Chemicals and Perth Soap produce crude glycerine as a byproduct and ship to the U.S. for refining.

Table 41: Canadian Glycerine Market

(Kilotonnes/year)	2001	2002	2005
Canadian Production	4.4	4.5	5.0
Canadian Imports	13.8	18.8	19.4
Canadian Exports	1.6	2.1	2.0
Apparent Domestic Consumption	16.6	21.2	22.4

Canadian refined glycerine is mainly used in food (30%), personal care such as toiletries, cosmetics, soap (25%), pharmaceuticals (20%), and candles and other (25%).

4.10.2 Biodiesel Crude Glycerine Co-Product Market

Small-scale glycerine purification is not seen as economically viable. An attempt to determine the approximate cost for a small-scale glycerine purification unit was made. Recycling Sciences Ltd., who specialize in small to mid scale solvent recovery units, quoted a price of U.S.$300,000 with a $100,000 non-refundable deposit for engineering, on site studies and approved drawings. They recommended finding local buyers for the crude glycerine. Local markets for the crude glycerine could be developed. One such market is the construction industry.[142] When building with concrete, wooden forms are used as a mold to pour the concrete into. In order to pull the forms off the concrete with ease, once it has set, form oil is applied to the forms before pouring the concrete. Form oil also ensures the forms do not get damaged in the removal process, so they can be reused, saving significant money and trees.

Typically form oil is a petroleum - hydrocarbon base marketed by petroleum companies. Some construction companies have been known to apply #2 diesel, as it is similar, cheaper and more convenient to get than form oil. A vegetable oil based form oil is currently competing in the form oil market and gaining market share, as environmental consciousness and the safety of workers become core values of the industry.

The crude glycerine from biodiesel production has been identified as a possible alternative to petroleum based form oil. This would create a market in just about any location where concrete construction is being performed. Testing needs to be performed to evaluate the long term effects on forms and the concrete itself. Glycerine is soluble in water and biodegradable, and so, could easily be washed off.

For a complete listing of Concrete Construction Forms and Accessories suppliers in B.C. search local yellow pages, or for a provincial listing see:

http://bc.finditincanada.ca/app/search/cat-101161/Concrete+Construction+Forms+Accessories.html

A random survey of 6 listings from the above website resulted in the following prices: For non-discounted petroleum based form oil the average price was $1.30 / litre when purchasing by the 55 gallon drum and $2.53 / litre when purchasing by the 5 gallon pail. One supplier had a Canola based form oil that was being sold at a premium price of more than one and a half times that of the petroleum based product while another in the Kelowna area, sold a winter grade form oil at a $0.05 / litre premium.

A random phone survey of five building contractors was performed. All of the contractors indicated that they use form oil. Three of the companies surveyed build large concrete buildings and all apply the oil with a low pressure sprayer, while the two smaller residential scale contractors apply the oil with a brush or roller. All of the contractors surveyed indicated they would use a natural alternative if it performed well and the price was competitive.

These initial results are encouraging and indicate that some testing needs to be performed to determine the suitability of the glycerine co-product as a form release substitute. The market appears to be there, and if priced competitively, should provide a profitable use for the co-product.

Once the methanol has been recovered, the glycerine co-product forms a relatively solid mass. When KOH is used as the catalyst, the glycerine is less dense compared to when NaOH is used. Testing will need to be performed to determine the best way to thin the glycerine in order to make it thin enough to spray or brush on. Methyl esters may be the most suitable medium for this. In fact neat methyl esters are a suitable form release substitute in and of itself, as #2 diesel is what is often used currently.

4.11 Mandatory Requirements and Critical Success Factors

The critical success factors for Sales and Distribution are:

- To investigate and to survey both fleet operators and fuel distributors to:

  Understand the vehicle/engine configurations, fuel consumption volumes, contractual obligations, seasonal patterns, pricing and refueling logistics of potential fleet users.

  Understand the strategies, market shares, customer segments and pricing/margin requirements of regional fuel distributors.

- To Segment fleet operators by strategic profile:

  Large fleets with in-house refueling infrastructure and potential blending capability.

  Fleets with Triple Bottom Line performance measurement systems. These fleets measure contribution to society and the environment as well as strict financial / operational performance.

  Private sector fleets that monitor only financial and operating performance measurements.

- To investigate the tax structures and exemptions applicable to each segment of the fuel market and to prioritize those segments where tax exemptions significantly increase margin and market penetration opportunities.
- To focus upon end user fleets that have a Triple Bottom Line orientation and/or a desire to promote a "green" image:

  Prioritize and target those distributors that service these fleets where the fleet operator does not have in-house refueling facilities. Fleet examples include dairy, food & grocery fleets.

  Prioritize and target those fleets that do have in-house refueling and potential fuel blending facilities for direct sale and delivery. Fleet examples include transit fleets, large municipal fleets and crown corporation fleets).

- To investigate biodiesel performance & warranty issues for key engine configurations within priority target fleets to build credibility and to overcome objections.
- To make face-to-face contact with targeted end users and distributors and to understand their decision processes in making commitments to biodiesel.
- To research existing fuel supply relationships. To consider potential competitive reactions from distributors that will be displaced by biodiesel and to develop contingency plans.
- To perform sensitivity analysis re: fluctuations in competitive diesel prices due to crude fluctuations.
- To develop a comprehensive sales and marketing strategy, incorporating marketing, sales, blending, storage and distribution. This strategy will strike a strategic balance between direct sales of B100 to selected fleets with in-house refueling and sales to distributors who service other high profile fleets.
- To develop appropriate supply contracts with distributors and fuel consumers incorporating minimum product off-takes and minimum price ranges that exceed the lowest price at which production would still be viable.

4.12 Conclusions

This section has shown:

- That the size of the diesel market in B.C., for transportation, freight and marine fleets, offers biodiesel many opportunities.

- The numbers and types of clients will be driven by a number of factors. These include the volume of biodiesel a client requires, their location, their business type (end user or fuel supplier, commercial resellers or private), supplier cost (some businesses may be willing to pay a /litre premium due to environmental goals).
- The distribution strategy will also depend on specific clients capabilities including their storage/blending requirements/capacity.
- Biodiesel can be used as 100% fine or blended in any percent volume with petro-diesel. The extent of benefits realized, however, will depend on the biodiesel percentage of the final blend.
- The available local by-product market i.e. glycerin, will drive whether additional equipment for refinement is warranted. It is likely best to re-evaluate the refined glycerine market once the biodiesel is being manufactured.

5 FINANCIAL EVALUATION, PROJECT FINANCING & THE TRIPLE BOTTOM LINE FOR A COMMUNITY SCALE PLANT

5.1 Purpose of This Section

The purpose of this section is to provide an assessment of the feasibility of building a community scale plant for producing biodiesel at a hypothetical location in British Columbia. The assessment will examine the following components: production technology, biodiesel production costs, and overhead expenses.

Since the ability to finance a project is of vital importance to successful implementation, this topic is reviewed in 5.3. A more comprehensive overview of project financing and potential funding is presented in the appendices. Finally, the "success" of a biodiesel project cannot be defined in financial terms alone. Section 5.4 introduces the concept of the "Triple Bottom Line" and reviews the non-financial elements of a biodiesel project that are key components of overall success.

5.2 Financial Evaluation

In assessing the feasibility of producing biodiesel in your region, the following components need to be assessed: production technology, biodiesel production costs, and office and administration expenses.

The following assumptions are based on a plant capable of producing approximately two million litres of biodiesel (meeting ASTM PS 121 standards) per year.

The figures used for the assumptions are based on a combination of various processing technology offerings that were assessed, and are meant for theoretical discussion purposes only. They are not meant to be used directly. A complete financial evaluation will need to be performed based on regional costs and the processing technology chosen.

5.2.1 Production technology

Cost of Equipment

Generally, the total installed cost for a plant capable of producing two million litres per year ranges in price from $800,000 to $1,200,000. Included in these amounts are costs to cover buildings (if constructed), equipment, utility connections, module preparations, module assembly, engineering / permits, consulting assistance and a process support package.

For the purposes of this study, we assumed the cost of the equipment to be $1,000,000. This includes a 10% contingency expense.

Note: As plants become smaller, the engineering, consulting and the process support package costs will not change much, but the costs for the building, equipment and module preparation will decrease.

Plant Configuration

Table 42: Community Scale Plant Configuration Costs

Plant Configuration	
Plant Capacity (litres/year)	2,000,000
Process Configuration (Acid – Base)	batch - batch
Estimated Total Installed Cost *	~$1,000,000
Days of Operation per Year (at capacity)	~260
Hours of Operation per Day	8-16
Building (sq ft)	4,000
Outside Tank Storage Space (sq ft)	1,750
Depreciation Period	10 years

*** Note:** the cost for land or for a lease is not included in this estimate. Estimate accuracy +/- 25%.

A production facility of this scale would require approximately 8 - 10,000 sq ft for the building, outside tank farm and transportation areas. Note: A buffer zone around the building and tank farm may also be a necessity depending upon the surrounding level of development.

To house the plant, a 4,000 sq ft building with a maximum height of 35'ft would be required Approximately 3,000 sq ft of the building would be required to contain all the processing equipment. Of the 4,000 sq ft, approximately 1,000 square feet needs to be set aside for a quality control laboratory and offices.

5.2.2 Biodiesel Production Costs

Feedstock and Reagents Assumptions

Table 43: Feedstock and Reagent Costs (February/2004 market rates)

Raw Materials Costs	
Feedstock	
Feedstock FFA content (average)	10%
Feedstock Cost	Extremely variable
Reagents	
Methanol Cost ($/litre)	$0.26
93% Sulfuric Acid Cost ($/kg)	$0.32
96-99% Sodium Hydroxide Cost ($/kg)	$1.85

Feedstock assumptions assume an annual production of ~1,940,000 litres of biodiesel per year or an average of 7,500 per day. This is based on the availability and suitability of ~2,000,000 litres of yellow grease. Generally the assumption for yellow grease with 8% to 10% FFA, is that the typical yield will be in the range of 0.96 to 0.98 gallons biodiesel / gallon oil input.

The above pricing for reagents is based on pricing from 2.9.

Direct Costs

Direct costs include heat, energy and water, plant labour and repairs and maintenance costs.

Energy & Water Cost Assumptions

Table 44: Energy and Water Costs (February/2004 rates)

Energy & Water Costs	
Natural Gas Cost ($/GJ)	$9.5
Electricity Costs ($/kWh)	$0.065
Water Costs (per 1,000 Imp. Gal.)	$3.00

Note: Energy consumption use will be based on the process design of the production plant. The typical energy consumption for natural gas appears to be approximately 650 BTU per litre of biodiesel produced. Water usage will vary depending on plant configuration. The source for the above information is based on information supplied by BC Hydro, Terasen Gas and Saanich Water. These are estimated costs for utilities and they may vary according to region.

For the purpose of the model it is assumed that gas heat will be used for the process heat requirements, and that the energy consumption rate is 650 btu / per litre. Biodiesel can also be used for process heat.

Plant Labour Cost

Table 45: Plant Labour Cost Estimates

Plant Labour	
Plant Manager ($65,000 /year + benefits)	$77,000
Shift Manager ($45,000 /year + benefits)	$53,000
Production Assistant ($30,000/year + benefits)	$35,000

Most production plants specify a minimum of two operators per shift. Depending on the hours of operation, and the configuration batch or continuous, this may range from one to three shifts per day.

The estimated salaries provided above, include an allowance for employee benefits including workers compensation.

Depending on the location of the plant; salaries may vary according to region, cost of living and local market conditions.

Repairs and Maintenance Costs

Generally the cost for repairs and maintenance can be estimated at 4% of the total installed costs on the equipment but this should be confirmed with the equipment manufacturer.

Overhead Costs

Overhead costs include office and administrative, insurance and professional fees.

Table 46: Office and Administrative Expenses

Office and Administration Expenses	
Office and Administration ($/year)	$24,000
Sales and marketing (depends on distribution method)	$10,000
Insurance	2% of capital costs
Professional Fees	$15,000

Office and Administration

A budget of $2,000 per month for office and administration expenses for telephone, internet, basic marketing materials, office supplies and other administration expenses should be enough to cover basic overhead costs. These costs may decrease with a smaller plant, but not significantly.

Sales and Marketing

This figure assumes that a fuel distribution company will distribute more than 50% of the biodiesel, and their sales representatives will take care of their % of the market. Plant management could cover the sales and marketing to the fleets with in-house blending capabilities as they will likely use a large portion of the fuel and be limited in number.

Insurance

Generally, it is assumed that insurance costs for general liability and directors and officers insurance will be less 2% of capital costs. This should be confirmed with an Insurance Broker as rates have increased substantially in the last few years.

Professional Fees

Legal and accounting fees for a year are estimated to be less than $15,000. This assumes no budget for compliance work that might be necessary for some types of investor offerings.

5.2.3 Profitability Analysis

The three largest factors that contribute to the costs of the production of biodiesel from used oils are the costs of the feedstock, labour and the capital costs for the processing equipment. Based on the assumptions above, Table 47 presents a profitability analysis of a 2 million litre/year community scale biodiesel production facility at **full capacity**.

Table 47: Profitability Analysis

Profitability Analysis Items	Total	Per Litre
Revenue *	$1,143,000	$0.52
Expenses		
Feedstock & Reagents **	893,000	$0.405
Direct costs	258,000	$0.12
Overhead costs ***	158,000	$0.07
Capitalization	100,000	$0.045
Total Costs	1,409,000	$0.64
Profit (Loss)	$ (266,000)	-0.12
Income Taxes	0	
Net profit for the year	$ (266,000)	

* Revenue assumes biodiesel is sold for $0.52 per litre, and glycerine for $0.20 per litre.

** Assumes $0.35 cents per litre (March 2004 commodities price) for yellow grease purchased from a rendering company.

*** Assumes property lease of $11.50 per square foot.

5.2.4 Feedstock Costs

As noted from the table above, the feedstock & reagents expense represent the greatest costs in manufacturing biodiesel. The reagents represent approximately 11%of the costs. It is the cost for the feedstock that is the key component of the production costs.

Figure 8 shows how the feedstock cost affects the breakeven biodiesel price point of a 2MM litre/year plant. Figure 9 shows the profitability of the plant based on feedstock cost. These charts have been based on the same assumptions as Table 47 above.

Figure 8: Breakeven Biodiesel Selling Price based on Feedstock Costs

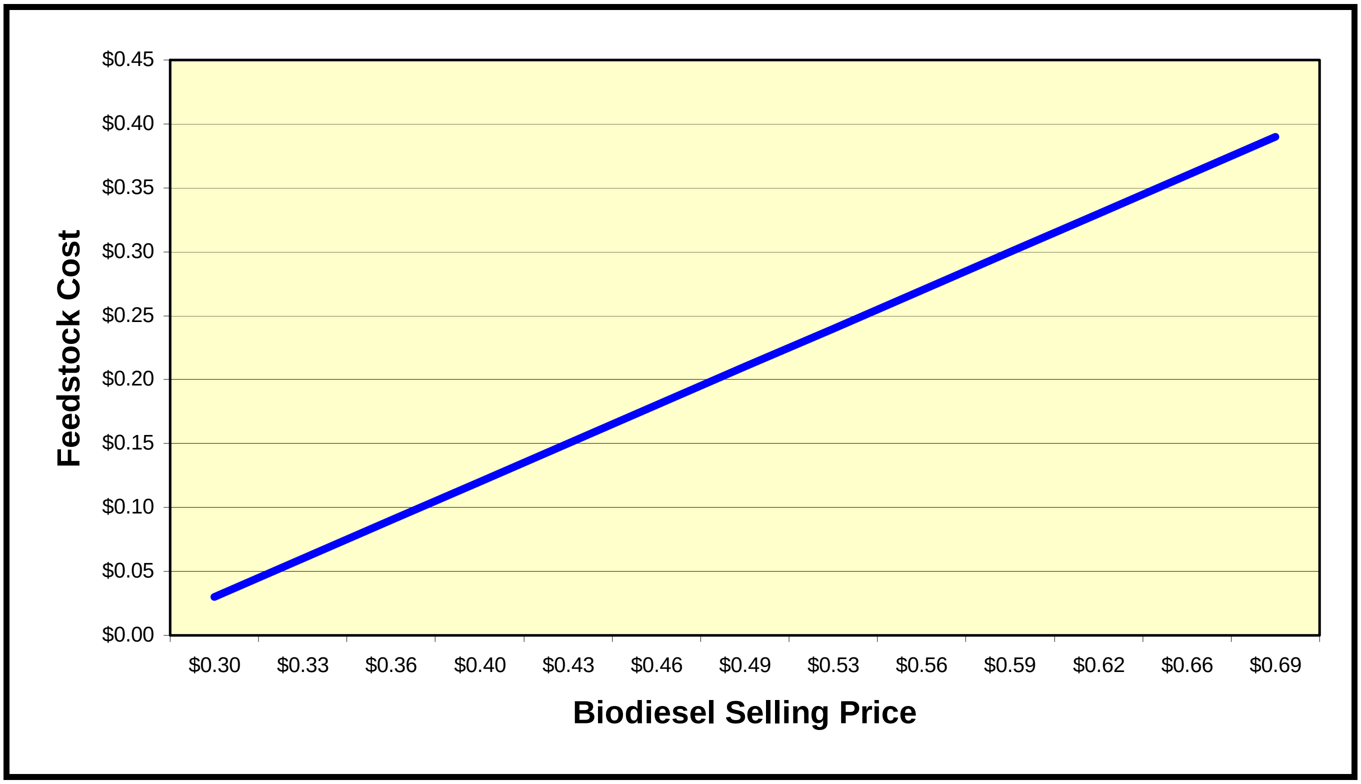
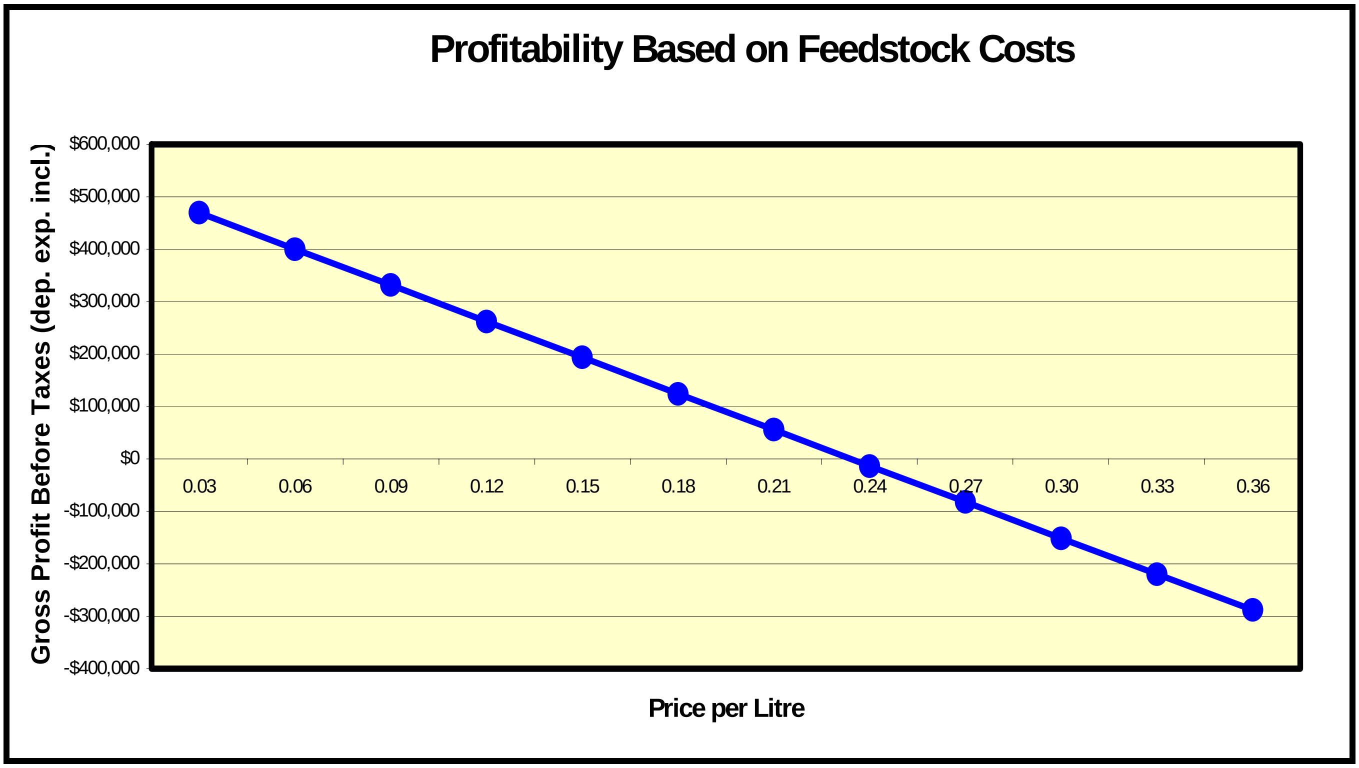


Figure 9: Plant Profitability Based on Feedstock Costs



Conclusions from Figures 8 and 9

The breakeven feedstock price appears to be ~ $0.22-23/litre for a 2MM litre plant that wishes to sell biodiesel at $0.52/litre.

A reasonable business case could be made for a 2MM litre plant if a low-cost feedstock can be secured at less than the ~$0.18/litre range. Additionally, a rise in diesel prices will create more viable business opportunities for smaller scale biodiesel plants throughout the province.

A cautionary note: These figures are based on the 2MM litre/year plant configuration running at full capacity, which depending on the source of the feedstock, may take a number of years to reach. It is these first few years that will be a major deciding factor on plant viability, as the profitability will decrease significantly with a drop in actual yearly operating capacity. Full financial projections for the first 5 years will need to be considered before moving into the next business development stage.

5.2.5 Financial Evaluation Conclusions

As mentioned, the three main factors that contribute to the costs of the production of biodiesel are the costs of the production technology, feedstock and labour.

To help ensure that the proposed plant will suite the region, careful analysis of the availability and the suitability of feedstocks will need to be determined to ensure that the size of the production facility will support the operation.

As shown, the cost of the feedstock could be reduced by using used cooking oils instead of purchasing yellow grease from a rendering company. This grease would require additional pretreatment and give slightly lower yields, but it would substantially help to reduce the feedstock costs. Agreements would need to be made to purchase the used cooking oils directly from local restaurants.

To help offset the labour costs, consider finding a facility where operational, maintenance, and support personnel can be shared with other companies. There are also a number of federal job incentive programs that help employers hire workers. This would help to reduce labour costs.

Given the current price for diesel, biodiesel priced at $0.52 per litre could be competitive enough to enter the market if a low priced feedstock can be secured.

Please note, the assumptions used in this model are strictly to provide guidelines. A complete detailed feasibility study of your region needs to be conducted.

5.3 Project Financing & Funding Support

Successful project financing may entail securing equity and debt financing, and obtaining funding support from government and NGO sources to assist in meeting required risk and return on investment criteria.

5.3.1 Finding Growth Capital

Securing financing is a critical step in the development of a successful biodiesel project. The process of preparing for and implementing a financing strategy is complex, and is best implemented with the assistance of a qualified advisor. Fortunately, there are many resources available to small business people that describe the process and guide potential project developers through the early stages of research and preparation. In general, local economic development organizations, federal and provincial agencies, chambers of commerce, legal/accounting/consulting firms can help to provide information and guidance.

Industry Canada, through its “Strategis” web site, provides an excellent resource base for project proponents seeking access to capital. The critical path flow chart (see Table 49) provides an overview of the process. Additional information and links to sources of financing from this site are presented in **Appendix L: Steps in Financing.**

Table 48: Finding Growth Capital: A Critical Path

Source: Industry Canada Strategis Web Site:
http://strategis.ic.gc.ca/sc_mangb/stepstogrowth/engdoc/homepage.php

Determine your financial needs	Develop your business plan. Determine how much money you need to pursue the plan.
Consider alternate sources of financing	Review the types of financing available. Build a financing package to suit your needs.
Show your investment potential	Find ways to convey to investors your potential for growth and profit.
Demonstrate management capabilities	Show that your management team can successfully manage the firm and pursue the opportunity. Prove that your team is well balanced and that it can make the investment a real success.
Build an investment proposal	Write and structure an investment proposal that attracts investors. Communicate your vision, your passion and your potential for growth.
Identify potential investors	Find investors you might approach.
Meet likely investors	Develop a strategy for approaching investors. Contact, follow up and meet with potential investors.
Negotiate the deal	Develop your negotiating strategy. Find a solution that satisfies both parties.
Close the deal	Bring the agreement to a successful completion. Undertake and pass due diligence process.

5.3.2 Funding Assistance and Support

If estimated project economics fall short of the requirements for normal private sector financing, it may be possible to obtain funding support from a range of government and NGO sources that will assist in closing the gap. **Appendix M: Sources of Funding Assistance**, provides a listing of sources to investigate for funding that is targeted towards socially beneficial projects.

5.4 Triple bottom line

Renewable energy project analysis needs to include the social and environmental benefits beyond economic, or bottom-line, viability. Many downstream costs that result from our current activities, and ultimately have to be paid for, are not accounted for in the daily cost of doing business.

Increasingly, mass media coverage includes the impacts of global warming. Climate change scientists worldwide have become convinced that we are adding to this rapid growth in unusual weather events through our collective emissions of GHGs.

The research indicates that any actions today will not be fully reflected in the atmosphere for at least a couple of decades. Therefore, even if a world ban on the use of fossil fuels was enacted today, we would still continue to experience escalating, costly weather swings for at least another generation.

Although it is difficult to quantify these social and environmental aspects they are important factors that must receive greater recognition. They should not be overlooked by communities, businesses, and governments trying to access a project's true worth.

Table 50 introduces cost examples of recent weather-related events, and descriptions, where direct costs could not be determined. It also includes other quality of life impacts that a biodiesel renewable energy project will likely influence.

Table 49: Value Added Benefits of a Biodiesel Project.

Topic	Description	Sample Impacts
Renewable Energy (RE) Awareness	Community-based RE projects will provide associations and individuals with a working example of the benefits and an opportunity to participate.	Direct worth is not known, however, based on the negative impacts of current practices below, this positive impact should be considered highly valuable.
Climate Change	Throughout the world there have been recent weather events that have broken all records. Examples are heat waves, cold snaps, floods, fires, ice storms, and dollar record breaking hurricanes. Although these weather activities have always been present the severity and occurrence has been escalating in recent years.	The 2003 BC Fire Storm direct fire fighting costs surpassed $500+ million. (http://vancouver.cbc.ca/regional/servlet/PrintStory?filename=bc_collins20031024&region=Vancouver). Indirect business losses have now surpassed $600 million. B.C.'s warmer winters have led to a Pine Beetle infestation. Lost revenue estimates topped $20B in 2004. (www.mountainpinebeetle.com/epidemic_impact.html). Record rainfall in B.C. in October, 2003. The B.C. Government's Solicitor General Rich Coleman says it's likely to run $20 – 25M (other parts of BC not included in this estimate). (www.cbc.ca/cgi-bin/templates/print.cgi?/2003/10/22/bcfloods031022). Damage estimates for the California wildfires in October/November 2003 range from US$2 - 12B (www.cbc.ca/cgi-bin/templates/print.cgi?/2003/11/03/california_fires031103). In the United States, there were 562 tornadoes during May, 2003, a record number for any recorded month. In Europe the past 10 years have been the hottest in 500 years. The heat records across Europe in August, 2003 directly resulted in 35,000 deaths. (Times Colonist, March 5th, 2004). These were followed by record floods in France in December. (www.cbc.ca/cgi-bin/templates/print.cgi?/2003/12/02/floods031203). The 1998 Quebec Ice Storm was estimated to cost $2.8B

Topic	Description	Sample Impacts
		in direct loss costs, and $1.6B in indirect lost wages/productivity costs, by the Conference Board of Canada. (www.colorado.edu/hazards/workshop/1999/ss33.html) The world's second-largest reinsurer Swiss Re recently warned: economic costs of global warming threatened to double to US$150 billion a year in 10 years. Scientists expect global warming to trigger increasingly frequent and violent storms, heat waves, flooding, tornadoes, and cyclones while other areas slip into cold or drought. Losses to insurers from environmental events have risen exponentially over the past 30 years, and are expected to rise even more rapidly still, said Swiss Re climate expert Pamela Heck. A growing number of policy experts warn that the environment is emerging as the security threat of the 21st century. (Atkins, Thomas, "Insurer warns of global warming catastrophe", © Reuters News Service, 4/3/2004, www.commondreams.org/headlines04/0303-07.htm).
Effect of Climate Change on Eco-systems	Changing weather patterns affects terra and marine ecosystems. This can have a direct cost in loss of income from agriculture, fisheries industries, etc., but will also have the affect of permanent species losses.	Direct industry costs not known. Paul Brown, The Guardian (UK) Environment Correspondent, wrote (January 8, 2004) climate change over the next 50 years is expected to drive a quarter of land animals and plants into extinction, (1 million species), according to the first comprehensive study into the effect of higher temperatures on the natural world. (www.guardian.co.uk/climatechange/story/0,12374,1118281,00.html).
Health	Findings have shown that diesel fume particulate matter cause cancer. They also cause many respiratory diseases. Most school buses run diesel fuel.	Findings released from a 2003 study indicate as many as 13,600 Canadians will develop cancer over their lifetimes due to exposure to diesel particulate matter. (Sierra Club, July, 2003, www.planetark.com/dailynewsstory.cfm/newsid/21427/story.htm). A 1995 B.C. Environment study estimated that health care costs of air pollution in the Lower Fraser Valley alone was estimated to be $830 million in 1990 and is projected to rise to $1.5 billion by 2005.
Environmental	There are many, many oil spills annually around the world.	The entire costs associated with the environmental impacts from fossil fuel recovery and transportation mishaps cannot be measured. The Exxon Valdes spill cleanup costs, however, were estimated at US$93,569.00/tonne (Etkin, Dagmar Schmidt, "Worldwide Analysis of Marine Oil Spill Cleanup Cost Factors", "Presented at: Arctic and Marine Oilspill Program Technical Seminar (June 2000)", www.environmental-research.com/publications/pdf/spill_costs/paper7.pdf). This means a total cleanup cost in excess of US$2B.

Topic	Description	Sample Impacts
Government Fossil Fuel Investment	Federal and provincial governments spend billions/year in direct and indirect costs associated with petroleum discovery and research.	In 2001, the Pembina Institute determined the Canadian federal government spent $40.4B in direct spending on fossil fuel recovery projects between 1970 and 1999. An additional $2.8B in federal loans to the fossil fuel industry has been written off since 1970, over and above the direct spending. In 2000, an additional $55M was spent on fossil fuel R&D expenditures by the federal and provincial governments. ("Give Green Power a Chance", Pembina Institute, March 01, 2001, http://eco-ie.com/ecovie/n_greenpower.html).
Waste FOG Management	As we have seen biodiesel can be made from waste agri-oils and greases (FOGs). Municipalities must budget annually for scheduled and non-scheduled event cleanups of the FOGs that reach public sewer systems.	Some of this waste causes sewer system blockages, which has resulted in costly effluent backflows into marine ecosystems. Municipalities do not separate out the management costs specifically associated with FOGs however must budget thousands to millions of dollars annually for sewer system cleaning. As an example, North Saanich, with a population base of ~105,000, budgeted $107K in 2003.
Energy/Fuel Market Control	Electrical utilities are recognizing that centralized transmission systems are too costly. The move now is toward distributed energy nodes to reduce production and maintenance related costs. This will permit communities, and countries, to become more energy independent while maximizing local energy potentials. Distributing fuel sources would benefit fuel users in the same way. First there would be reduced dependence on foreign fuel and on fossil fuel projects that had considerable risk. Second there would be more price competition i.e. where currently none exists in communities like Victoria.	This move by the electric industry will also help guard against massive, cascading blackouts that occurred in Ontario, the northern U.S., and Europe in 2003. August's power blackout that hit Ontario and the northeastern United States led to the biggest drop (0.7%) in Canada's wholesale trade since the ice storm of January 1998, according to Statistics Canada said Tuesday. (www.cbc.ca/cgi-bin/templates/print.cgi?/2003/10/21/wholesale_031021, Oct 21, 2003).
Bovine Spongiform Encephalopathy	The cause of the BSE infected cows in Canada, the U.S., and Japan this year were traced many years ago to the practice of intra-species feed stocks, animal feed produced from same species waste products. Although this practice has been discontinued in Canada, as we have seen, our cattle industry is still susceptible to this disease. This is an opportunity to use rendered fats to produce a	The Canadian economy has lost $3 billion due to two cases of bovine spongiform encephalopathy, says Alberta trade policy analyst, Nithi Govindasamy of Alberta Agriculture's policy secretariat (January 22, 2004)(One in Canada, the second in the U.S.). This includes losses to the feedlot sector estimated at about $700 million since trade stopped after the May 20, 2003 case was announced. (www.producer.com/articles/20040122/news/20040122news10.html). Also, this feedstock that can no longer be sold in Canada, is being sold by Canadian companies into Asia. Does this leave Canada susceptible to an international court

Topic	Description	Sample Impacts
	beneficial fuel rather than animal feed.	case?
Fossil Fuel Recovery Emissions	Elsewhere in this document we have noted that it takes more units of energy to recover, transport and refine petroleum than is returned in fuel energy units, in other words returning a negative energy balance from most petroleum recovery sources. In addition, there are the additional emissions associated with recovering and transporting this fuel, which are not accounted for when tail pipe emissions are measured.	The Canadian Energy Research Institute recently stated that the oil sands could consume as much as 3.7 billion cf/d (cubic feet> per day) of natural gas if oil sands production rises to 3.5 million b/d(barrels per day) by 2017 as predicted. Once recovered the oil must be processed and transported. This use of natural gas to recover the oil and the energy to process and transport the oil translates to additional emissions attributable to the life-cycle of the recovered oil.

5.4.1 Greenhouse Gas Emissions Reduction Trading

In a number of countries, due to increasing regulations, or on a voluntary basis, firms and individuals are starting to take steps to reduce greenhouse gas (GHG) emissions. Main GHGs are the naturally occurring Carbon Dioxide (CO_2), Methane (CH_4), Nitrous Oxide (N_2O), and the manufactured hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6).

Since GHGs mix uniformly in the atmosphere, it is equivalent, from an environmental standpoint, to reduce emissions either domestically or abroad. Many countries and companies take advantage of some form of outside purchase of emission credits, thereby laying the groundwork for the “carbon market.” Recent efforts have been made to formalize this market.

To learn more about the background and current status of this “Carbon Market”, detailed information can be found in **Appendix H – Greenhouse Gas Emissions Trading**.

5.5 Conclusions

This section indicates:

- That producing biodiesel at a community level can be economically viable, however there are many critical success factors that must be accounted for.
- Although most biodiesel clients will make a purchasing decision based on the final cost of the fuel, there are many additional reasons to support the growth of this industry.
- That the greenhouse gas emission reduction industry growth in Canada, and in B.C., could be driven by the growth of the global emission reduction trading market.
- A hope that overall renewable energy growth, including the biodiesel industry, in B.C., will be assisted by a combination of personal and collective awareness building, and government and corporate initiatives, to find improved business models/methods.

6 COMMUNITY SCALE BIODIESEL PRODUCTION: MANDATORY REQUIREMENTS AND CRITICAL SUCCESS FACTORS

6.1 Purpose of this Section

The purpose of this section of this document is to provide a summary of key issues and considerations that impact significantly upon the potential success or failure of a proposed biodiesel project. Critical Success Factors identified in preceding sections are integrated within this segment. Section 5.6 provides a discussion of the potential requirement for a small-scale demonstration in advance of full-scale processing.

6.2 Strategic Factors

The four critical strategic factors that will impact the success or failure of a potential biodiesel project are:

1. The ability to balance feedstock supplies, processing technology and market demand/penetration for products produced within an integrated system that that is both reliable and efficient;
2. The ability to form key and stable strategic alliances with feedstock sources/suppliers, distributors, end users and other stakeholders;
3. The ability to anticipate and to deal effectively with competitive pressures;
4. The ability to accomplish the above while providing a risk/return profile that will allow the project to be financed and to maintain financial health.

Biodiesel is becoming an increasingly attractive economic and environmental opportunity. As a key component of project planning and due diligence, it is important to investigate whether others in your area are planning similar projects. These might be competitive in nature, or may offer opportunities for partnering and cooperation.

Subcategories of mandatory requirements and critical success factors for a biodiesel project naturally fall into three areas: Feedstock Factors; Market, Sales & Distribution Factors; and Technology/Production Factors. It is important to assess the Feedstock and Market/Sales/Distribution elements thoroughly before making key decisions about Technology and Production.

Given the relative lack of market experience and penetration of biodiesel in BC, potential biodiesel end users and distributors may require a small-scale demonstration of the process and resulting biodiesel product before committing to large-scale use.

6.2.1 Feedstock Factors

The mandatory requirements and critical success factors for feedstock are to ensure:

- ❖ That a thorough and realistic assessment of feedstock volumes is conducted using several methodologies to estimate each potential feedstock as a crosscheck for accuracy. This should include sampling surveys.
- ❖ That initial feedstocks targeted can be processed readily, with no in-house requirement for complex pre-processing or requirement for yet-to-be-developed technology. Future growth plans may incorporate more problematic feedstock opportunities.

- That source-related, seasonal or other fluctuations in the supply of each feedstock are examined and considered in production planning and overall strategy.
- That potential changes in the quality or consistency of targeted feedstocks are thoroughly investigated and that the ramifications on process technology selected and on end product characteristics are carefully considered.
- That the costs and related logistics of acquiring targeted feedstocks are examined strategically, including: market trends, forecasts and fluctuations in commodity feedstock prices; potential market shifts or legislative impacts; current disposition of targeted feedstocks and the strategic importance of these materials to existing processors; contractual arrangements or inherent loyalties that may apply within existing channels; anticipated competitive reactions and contingency strategies.
- That strategies both for cooperation with key players in the current channels of feedstock disposition and for competition with these companies are developed and explored using SWOT analysis before the best option is selected.
- That strategies such as contractual arrangements or incentives are developed to stabilize feedstock volumes and costs in order to reduce the overall risk profile of the biodiesel project.
- That reagent costs and supply options are thoroughly investigated and that strategies are developed to stabilize costs and to ensure consistent supply as needed.

6.2.2 Manufacturing & Production Technology Factors

The mandatory requirements and critical success factors for Manufacturing and Production Technology are to ensure:

- That the "pros" and "cons" of a variety of process options are investigated and evaluated with respect to the volumes and characteristics of feedstocks, end products and by-products capital and operating costs, production flexibility, and the ability to meet required finished product specifications on a consistent and reliable basis. This includes an analysis of batch vs. continuous processing and an assessment of quality control systems and methodologies. In general, simplicity and flexibility are desirable.
- That the "pros" and "cons" of acquiring a modular "turn-key" system vs. a custom designed and fabricated facility are investigated and evaluated.
- That the selected plant is capable of processing low-high FFA feedstocks efficiently and without a loss in yield.
- That the selected plant will provide cost-effective expandability to handle projected growth in feedstocks, new sources of feedstocks and growth in market demand.
- That the selected technology will present no unusual siting problems, and that all necessary permits can be obtained.
- That all waste products can be handled to meet the requirements of the license and local legislation.
- That an appropriate plant location is selected, taking into consideration feedstock supply sources, manufacturing (zoning, access, space for process equipment and feedstock/finished product storage, collection equipment storage), product distribution and customer locations.
- That the production process be supported by developing internal testing, record keeping and sample storage capability for quality assurance for both feedstocks and finished product (it may also be prudent to develop a back-up relationship with a third party laboratory for verification and potential dispute resolution).
- That a cost analysis is undertaken to determine the best payment method for plant technology – capital vs. licensing.

- That the adequate training, technical support and warranty/performance guarantees are offered by the manufacturer or designer of the selected plant.

6.2.3 Potential demonstration

The lack of local fuel user familiarity with biodiesel will mean that both target fleets and related fuel distributors may need to be convinced as to its value (price, quality and incremental costs/risks). The capital cost of fleet equipment (e.g. transit buses >$300,000 each), the operating cost of disrupted service due to breakdowns. Also, risk to corporate reputations due to real or perceived problems with fuel quality will mean that both fuel distributors and larger fleets will be unlikely to take a chance on an unknown company producing an unknown product without a successful local demonstration.

Considering the potential variability of feedstocks, it will be especially important to convince core fuel users that minimum quality fuel can be produced from the full range of waste feedstocks over a reasonable length of time.

In addition to the capital and operating cost risks implied in any commitment to produce large volumes of biodiesel, the fuel-using marketplace and plant financiers will likely demand a demonstration that suitable product can be made reliably. If no other recourse is acceptable, it may be necessary to build and operate a demonstration plant that encompasses on a small scale all of the elements necessary in a full-scale commercial venture. Since the small-scale operation is unlikely to be economically viable, it will be important to secure government funding assistance to defray the capital and operating costs involved. To avoid the costs and delays associated with constructing and operating a demonstration-scale plant, every effort should be made to utilize outside sources of biodiesel that have been produced from similar feedstocks, using similar technology, for use in fuel testing programs by potential end users and distributors.

7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Purpose of this Section

In this section the project findings are summarized and a number of recommendations are provided on how best to initiate a community-based biodiesel project in B.C.

7.2 Summary of Findings

This biodiesel industry is poised for significant growth in many countries, making the construction of multiple new biodiesel plants in Canada in the short term highly possible. This rapid growth should drive the effort to mandate national biodiesel standards in Canada which will enable Canada to participate in global reductions trading markets and set minimum biodiesel blend requirements. These developments will help the industry mature and become more stable in British Columbia.

There is upwards of 123 million litres/year of biodiesel, based on common feedstocks, across British Columbia. This is sufficient to support a considerable number of 2-4 million litre/year community-based plants. Except for grease trap grease, however, which has its own inherent manufacturing barriers, the feedstocks in this study were already in production streams for other products.

This means further analysis is required in each region to first determine potential feedstocks, and assess the volume available at a price that will allow biodiesel to be manufactured economically. In addition to the feedstock costs, the reagents, catalysts, labor, electrical power, process energy, and service and supplies must be considered.

It is advisable to use historical prices trends as a guideline for potential future costs. Many of these costs fluctuate over time and are subject to continued changes depending on market, political and regulatory developments.

The rapid growth of this industry in other countries should result in intense competition among engineering and construction firms to establish their reputation for building plants. Although there are many biodiesel plant manufacturers there are no plant manufacturing standards to follow. It is therefore important to determine your exact requirements first and then gather quotes from manufacturers based on your specifications. As this area of the industry is developing quickly it will be very important to stay aware of new technology and service offerings, and cost reductions.

In addition to manufacturing costs, the logistical costs of collecting the feedstock and distributing the biodiesel product have to be accounted for. There is no best way to do this other than to create partnerships as early as possible in order to take advantage of existing expertise and to potentially reduce long term operational costs.

Perhaps most important is to remain aware of both changes in the petroleum industry and in Canadian renewable energy and fuel policies. These two areas will have a direct impact on biodiesel competitiveness.

7.3 Conclusions

This study has shown:

- ❖ Biodiesel is a proven, highly beneficial, replacement or additive fuel for the petro-diesel industry.

- Although not an established industry in Canada, it is manufactured and used extensively in many other countries in the world.
- A number of potential biodiesel feedstocks exist in B.C., however, they all currently feed into other manufacturing streams, therefore a region must determine the most promising feedstock within that region.
- To help turn potential into actual feedstocks for the biodiesel market in B.C., the biodiesel manufacturing industry has to fully establish itself through a number of community-based plants, and provide a ready alternative market for these feedstocks.
- The biodiesel manufacturing plant industry is well established in other countries. B.C. plant developers need to determine their requirements and then match those to available technology and price structures.
- Plant siting will depend on a number of region-specific parameters.
- Distribution strategies will depend mainly on client requirements versus cost implications.

And potentially the most important conclusion of all,

- It is critical for a new biodiesel project to develop relationships with potential stakeholders, partners, suppliers, clients, potential funders, and government agencies, as early as possible, to make a project of this nature feasible.

Finally, a project's success depends on many parameters. Continued lobbying and awareness building among government agencies, industry and individuals is important to develop a renewable energy mindset, and industry, capable of competing with other countries.

To fully establish the biodiesel industry in Canada, there needs to be a better level of recognition of the impacts of "business as usual". Canadian governments, businesses, organizations, and individuals must work together to evaluate and promote the measure of a business beyond their economic return. Europe has become very successful with this approach so an example does exist.

7.4 Recommendations

For organizations and/or individuals interested in conducting biodiesel projects in their community to get started, we recommend the following actions:

1. Make full use of this study.
2. Update the time sensitive information in this "**Biodiesel in British Columbia - Feasibility Study Report**" document, including commodity pricing and the status of the provincial Transportation Fuel Tax, to ensure quality decisions during the analysis process.
3. Perform an initial analysis to determine the potential biodiesel client market for your region.
4. Perform an initial analysis to determine the best potential biodiesel feedstocks in your region. Note that each region may have additional, promising feedstocks that are not covered here, therefore you will need to perform their own potential feedstock analysis.
5. Concentrate on defining key potential partners, participants, stakeholders, suppliers, distributors, and clients for your project and establish early strategic relationships.
6. Use the checklist, the critical success factors, and the statistics included in the Report to start defining the start-up, and long term project potential in your region.
7. Perform a detailed analysis of the business potential findings making sure to account for seasonal impacts, fuel price fluctuations, client base, etc.

8. Complete your detailed feasibility study. If it appears to indicate a viable business, then
9. Prepare a complete business plan to report your findings, along with a go forward plan, and the economic and value added potentials.
10. If necessary, determine any potential project development financial assistance that is available in your region (see **Appendix M** to get started).
11. Establish long term contracts with suppliers as early as possible.
12. Advocate that local, provincial and federal representatives address items 1-6 listed below.

To Government:

1. Remove Transportation Fuel Tax for Biodiesel (Provincial).
2. Where abundant biodiesel feedstocks fall short, consider economic support for developing alternative fuel community-based programs.
3. Provide leadership by mandating a minimum biodiesel % blend in diesel fuel.
4. Provide leadership by running biodiesel in government fleets.
5. Assist greenhouse gas emission reduction efforts by jointly developing a cohesive, widespread, awareness building campaign with the renewable energy industry.
6. Continue to assist conservation and energy efficiency growth through reduced consumption incentives.

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