MARKET OPPORTUNITIES ANALYSIS FOR CANADIAN SOYBEANS

Section 2

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Bio-diesel

Introduction:

Bio-diesel is manufactured from degummed soybean oil through the addition of methanol and an appropriate catalyst. Soybean oil is composed of triglycerides, a glycerin molecule with three long chain fatty acids attached. The catalyst facilitates the transfer of each fatty acid from its attachment to the glyceride to an attachment to the methanol molecule, thus forming three methylesters from each triglyceride. This process also liberates the glycerin molecule from the fatty acids thus resulting in glycerin as a co-product of methylester synthesis. Vegetable oils produced by different plant species have different relative distributions of fatty acid chain lengths. These fatty acids also differ among species in relation to their level of saturation, the number of double bonds they have between carbon molecules along the chain. These differences result in functional differences in the properties of the bio-diesel generated.

Table 2: Functional properties of various bio-diesel formulations

	Diesel	Rapeseed	Canola	Tallow	Soybean
Cloud point C^0	-12	0	1	16	3
Iodine value		91.9	102.8	49.1	103.6

The cloud point of a bio-diesel fuel is an indication of its flowability at low temperature. The iodine value is a measure of the degree of fatty acid oxidation, and as such is an indicator of the potential stability of the fuel. Higher iodine values reflect lower fuel stability. Thus bio-diesel made from rendered animal fats (tallow) has poorer cold temperature flow-ability compared to bio-diesel made from vegetable oils, but can be stored for much longer periods of time without a loss of functionality. The values provided above were derived from 100% bio-diesel formulations. In practice, due in part to the difficulties discussed above, and in part to economic reasons, bio-diesel is generally commercially used in blends of 5 to 20% bio-diesel/diesel.

The key technical advantage to bio-diesel blends is a reduction in the level of pollutants emitted after burning.

Table 3: Bio-diesel emissions:

Emission	B100	B20
Total unburned hydrocarbons	-67%	-20%
Carbon monoxide	-48%	-12%
Particulate matter	-47%	-12%
NOx	10%	2%
Sulfates	-100%	nd
Polycyclic aromatic hydrocarbons (PAH)	-80%	-13%
nitrated PAH	-90%	-50%
Ozone potential	-50%	-10%

Currently sulphur is added to diesel fuel to obtain a necessary level of lubricity. The addition of 1 to 2% bio-diesel provides an equivalent amount of lubricity thus enabling the removal of sulphur. The U.S. government has mandated lower levels of sulphur in diesel fuel by 2006, and the Canadian government has indicated that it will as well.

In addition, bio-diesel fuel has a higher cetane level than diesel fuel.

Table 4: Cetane levels of various bio-diesel formulations

	Diesel	Rapeseed	Canola	Tallow	Soybean
Cetane	49.2	61.8	57.9	72.7	54.8

This allows diesel fuel refiners to reduce the use of costly additives when formulating premium fuels through the use of bio-diesel blends.

Economic Analysis of Bio-diesel Manufactured From Soybeans

The following tables present current cost point analysis for a bio-diesel manufacturing process starting with whole soybeans and using current prices.

Table 5: Current soybean prices

Prices		
Grain price	$8.72	$/bu
Soymeal price	$0.13	$/lb
Soy protein concentrate price	$0.20	$/lb
Soy oil price	$0.32	$/lb
Soy oil price	$0.64	$/L
Diesel price	$0.38	$/L
Glycerin price	$0.50	$/lb
Ethanol price	$0.35	$/L

Prices for both soybean grain and soy oil are currently substantially higher than five year averages. The difference in value per lb between soy protein concentrate and soymeal is strictly a translation of the increase in protein content in soy protein concentrate. Our cost point analysis is based on an analysis of a bushel of soybean. This allows us to be sensitive to changes in soybean prices directly and facilitates clear estimates of the relative amounts of various components that are extracted from a bushel of soybean in practice, rather than in theory.

Table 6: Relative amounts yielded by various soybean subcomponents

Yields		
Soy meal protein content	48%	fresh weight
Soy protein concentrate protein content	70%	fresh weight
Protein difference between SPC and soymeal	146%	
Soy meal yield	47.50	lbs/bu
Soy protein concentrate yield	30.10	lbs/bu
Oil yield	11.35	lbs/bu
Soy oil yield	5.66	L/bu
Soy carbohydrate yield	17.40	lbs/bu
Glycerin yield	1.135	$/lb

Soy protein concentrate is extracted from soymeal by washing the soymeal with a 60 to 70% aqueous ethanol solution.

The costs of extracting the components listed above are provided below. These costs represent operating costs/bushel, and do not include depreciation for capital investment.

Table 7: Operating costs for soybean component extraction and bio-diesel manufacture

Costs		
Crushing cost	$0.07	$/bu
Cost of bio-diesel production	$0.11	$/L
Incremental cost of SPC extraction	$0.10	$/bu

The cost estimated for bio-diesel production listed above is based on the Biox process and represents operating cost per litre of bio-diesel produced. This cost does not include depreciation for capital investment. The Biox process has a lower operating cost than other traditional processes. Other processes have an operating cost of at least $0.15/L of bio-diesel produced.

The province of Ontario has exempted bio-diesel from their $0.143/L diesel tax. In addition, the federal government has exempted bio-diesel from their $0.04/L diesel tax.

Table 8: Relative value of bio-diesel with diesel after tax exemptions

Tax calculation		
Biodiesel tax exemption	$0.183	$/litre
Oil price necessary for competition with diesel	$0.38	$/L
Bio-diesel price justified by tax exemption	$0.56	$/L

We assume that the value of these tax exemptions would be captured by the bio-diesel manufacturer, such that the retail price for bio-diesel fuel would be the same as diesel fuel after taxes. In the model above, diesel fuel is currently selling at $0.38/L. A retailer would need to add $0.183/L in taxes to the retail pump price, or at least $0.56/L. This means that a bio-diesel manufacturer could sell bio-diesel fuel to the same retailer for $0.56/L because the retailer does not need to add taxes to the bio-diesel fuel. Both products would retail at $0.56/L. This calculation does not include retail profit margin, but this is irrelevant to the exercise at hand because this profit margin would presumably be the same regardless of the fuel being sold. Bio-diesel fuel would be sold as discussed above, as a 5 to 20% blend with diesel fuel, and the tax exemption would only apply to that portion of the fuel that contains bio-diesel. However, given that bio-diesel will replace diesel fuel 1:1 on a volume basis the above calculation and argument still apply.

Table 9: Estimation of operating margin for bio-diesel production from a bushel of soybean

Output proportions	Volumes	Value
Bushels of soybean	1.0	$8.72
Litres of bio-diesel	5.7	$2.73
Litres of ethanol	1.2	$0.41
Kg of soy protein concentrate	13.7	$6.11
Kg of glycerin	0.5	$0.57
Operating cost		$0.79
Gross revenue		$9.82
Net operating revenue		$0.31

Thus bio-diesel can be produced from soybeans at an operating profit. This model requires value generation from four co-products. The key difference between this model and more traditional analyses of bio-diesel value is that we have extracted soluble sugars (in particular sucrose) from the soy meal and converted it into ethanol. This results in two co-products ethanol, and soy protein concentrate. The incremental operating cost of performing this extraction is negligible compared to the added value provided to the model. In addition, the co-product values that we have estimated for ethanol production and soy protein concentrate are conservative.

Soybean contains on average 7.3% sucrose, 4.1% stachyose and 0.6% raffinose. It is possible that a portion of the stachyose and raffinose extracted in the soluble carbohydrate fraction would be fermentable but we are confining our analysis to the sucrose portion. Sucrose is directly fermentable by yeast, at an operating cost of less $0.01 per litre of ethanol produced. Ethanol production from corn starch requires the use of desachrifying enzymes that add an additional operating cost $0.04/litre of ethanol produced.

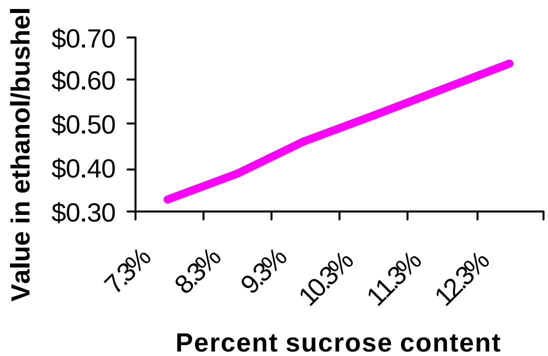
Table 10: Soybean sugar value calculations

Value of soybean sugars		
Sucrose %	7.3%	% of seed fresh weight
Sucrose mass (lbs)	4.38	lbs/bu
Sucrose mass (kg)	1.99	kg/bu
Practical efficiency of ethanol production	0.514	g ethanol/g glucose
Amount of ethanol produced per bushel of soy	1.02	kg/bu
Volume of ethanol produced per bushel		
Conversion mass to volume	1.15	L/Kg
Soy ethanol yield	1.18	Litres/bu
Cost of soy carbohydrate extraction/bushel	$0.10	$/bu
Cost of soy carbohydrate extraction/Litre ethanol	$0.08	$/Litre
Value of sucrose content/bushel	$0.33	

The value of the soy protein concentrate has been estimated as a soy meal feed replacement (after adjusting for the higher protein content). Soy protein concentrate (SPC) is currently used as a food ingredient for much higher prices. The oligosaccharides, stachyose and raffinose are not digested in non-ruminant stomachs thus leading to flatulence. The removal of these components from soymeal should thus increase the value of the protein.

The level of sucrose present within soybean is known to vary considerably. Higher levels of sucrose will not have an effect on the cost of extracting them, thus there is a more than linear positive value in the selection of soybean varieties with higher levels of sucrose for bio-diesel production.

Chart 20: Increase in ethanol value as a result of increases in sucrose content in soybean

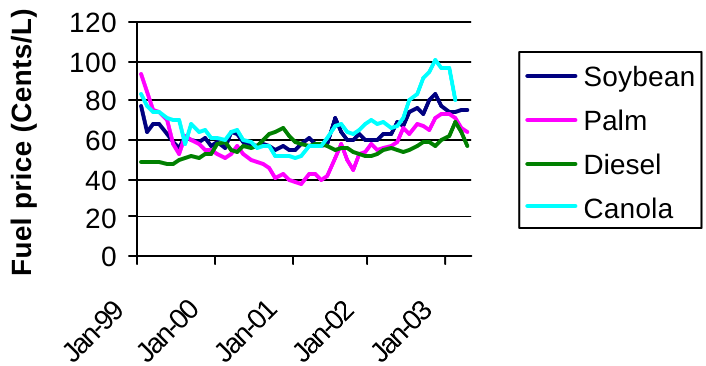


Comparative Value of Various Bio-diesel Formulations

The cost of the feedstock is the primary variable in determining the economic feasibility of bio-diesel manufactureing. In our calculations above we have based the price for bio-diesel on the wholesale diesel price. This is independent of the market price for soybean oil. If, as currently is the case, the market price for soybean oil is higher than the potential value in bio-diesel there is an implicit opportunity cost. This opportunity cost is offset by the co-product value of an integrated bio-diesel/ethanol manufacturing process. In the following analysis we will consider a bio-diesel manufacturing plant that simply purchases vegetable oil as a substrate. In this instance, how competitive is soybean oil versus other vegetable oils?

Bio-diesel can be manufactured from any vegetable oil source, and at low percentage blends the difference in functionality will be minor (Tables 2 and 4). We analyzed comparative bio-diesel prices versus wholesale diesel prices over the last four years.

Chart 21: Comparison of bio-diesel prices from various vegetable oil sources with wholesale diesel prices over the last four years



Bio-diesel prices were calculated based on monthly vegetable oil market prices translated into Canadian dollars for each month's respective currency rate. A cost of $0.11 per litre was added to each respective vegetable oil price to estimate a wholesale bio-diesel price. The diesel prices are based on a translation of spot wholesale diesel prices quoted for New York harbour converted to wholesale Canadian prices through the appropriate monthly currency rate calculation coupled with a translation upwards through the use of the following formula;

$S + (1/S) \times 100$

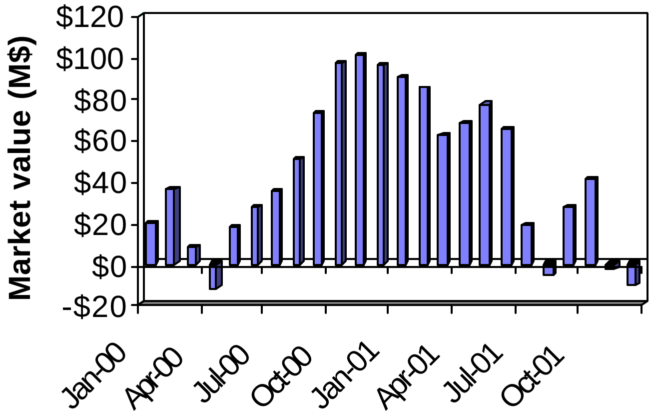
Where S = the New York harbour spot price.

This formula was developed by Soy 20/20 as a best fit to available data.

It is clear that a bio-diesel manufacturing plant that relied on direct purchase of soybean oil at market prices would not have been cost competitive with wholesale diesel prices except for a brief period late in the year 2000 and early in 2001. The market price for canola oil generally tracks higher than soybean oil. We consider rapeseed oil at the same price as canola oil, as any farmer growing rapeseed would not be realizing the potential price for canola oil. The market price for palm oil is interesting in that it exhibits two types of variation. On the one hand it exhibits a strong, slightly delayed response to soybean oil prices. On the other hand it is more volatile with a four to five year oscillation period. One potential reason for this oscillation in palm oil prices is the implicit five year delay between tree planting and oil harvesting. When the market price for palm oil is increasing additional trees are planted, but this incremental capacity does not become available for five years, at which point over supply depresses prices. The average palm tree remains productive for an average of 25 years. A cyclical stimulus is also provoked when orchards are taken out of production.

If bio-diesel made from palm oil was available in the market period analyzed above it would have been competitive with diesel prices for at least half the time. In a market where bio-diesel sold for a lower price than diesel, demand for bio-diesel would exceed supply. We assume that the maximum market penetration in regard to maintaining engine warranties and maintaining acceptable cold flow properties would be a 20% bio-diesel/diesel blend. In this scenario, the total market opportunity for bio-diesel based on palm oil for the Canadian trucking industry would have exceeded one billion dollars from January 1st, 2000 to December 31st, 2001.

Chart 22: Monthly value difference of a 20% palm based bio-diesel blend versus diesel fuel for the Canadian trucking industry for the years 2000 and 2001



It is clear that feedstocks other than vegetable oil, such as rendered animal fat and yellow grease, will be the primary drivers of bio-diesel production for economic reasons.

Table 11: Comparison of feedstock prices for bio-diesel manufacture

Feedstock prices	$/lb
Tallow	$0.07
Yellow grease	$0.11
Soybean oil	$0.32

Tallow is a form of rendered animal fat, and as we saw in Table 2, the functional performance of bio-diesel made from tallow is significantly different than the performance of vegetable oil based bio-diesel. Tallow based bio-diesel has a much higher cold point (16^{o}C as opposed to 3^{o}C for soybean based bio-diesel). In blends up to 10% bio-diesel, this difference will only amount to a lowering of the cold point by one degree. Bio-diesel blends of 20% made from rendered animal fat, will, however, have a three degree higher cold point than blends from vegetable oil.

Bio-diesel Market Potential

Primary market opportunities for bio-diesel will be at low percentage blends (2 to 5%). These blends achieve some reduction in pollutant emissions, enable significant sulphur reductions, and minimize engine warranty concerns, while still enabling the marketing of a premium quality fuel. We have limited our market analysis to the Canadian trucking industry. The marine and rail use of diesel represents a significant portion of the diesel market, however, these markets are currently allowed to use cruder diesel blends at a lower cost than the diesel fuel required for the trucking industry. Thus, we consider rail and marine markets as secondary markets that will only be penetrated as a result of government regulations reducing the level of pollutants these industries are allowed to emit.

Chart 23: Total diesel fuel sales in Canada

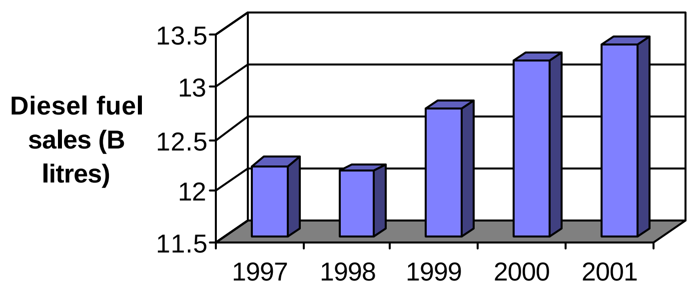
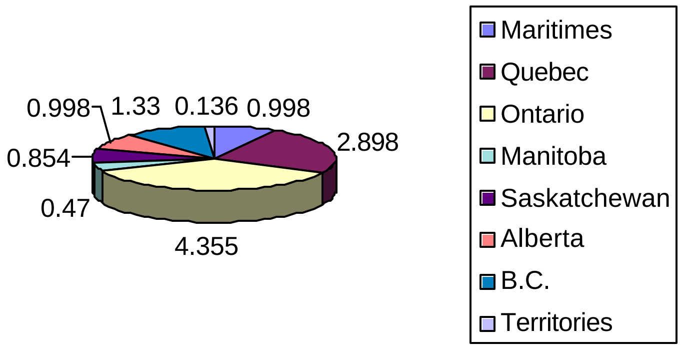
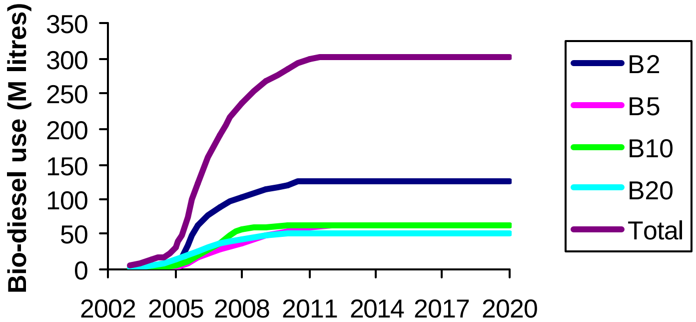


Chart 24: Distribution of diesel fuel sales in Canada by province (2001)



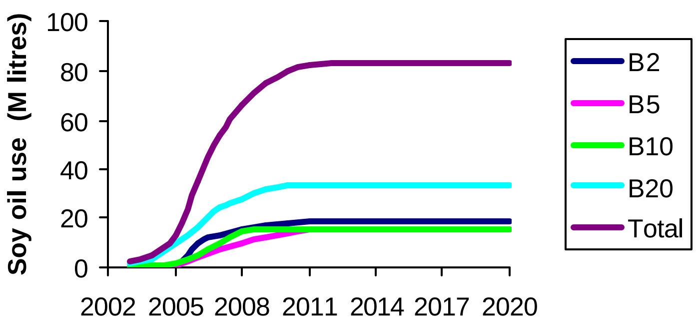
Values are in billions of litres.

Chart 25: Estimated market penetration for bio-diesel blends



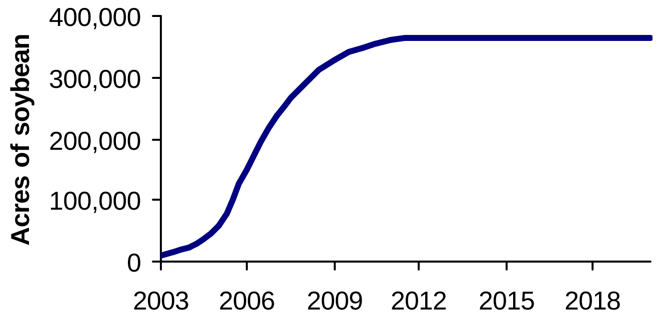
Given the above discussion of economic and technical considerations of bio-diesel feedstock blends, the opportunity for soybean based bio-diesel is obviously higher in higher percent blends.

Chart 26: Soybean oil use in various bio-diesel blends



The estimates derived in Chart 26 can be used to determine the impact of soybean oil use in bio-diesel on demand for soybeans in Canada. Translations to soybean usage were calculated on the basis of 18% oil, and yields of 40 bushels per acre.

Chart 27: Impact of bio-diesel use on demand for Canadian soybeans



This represents a peak demand for 364,000 acres of soybean. We have not allowed for market growth in this model. It is reasonable to assume that the trucking industry will continue to grow, it is unclear how much impact increased fuel efficient motors will have on the growth in diesel demand.

We have analyzed the potential value that the production of this amount of bio-diesel from soybean would have for a bio-diesel manufacturing plant.

Table 12: Balance sheet for projected soybased bio-diesel production

Output proportions	Volumes	Value
Bushels of soybean	14,558,631.5	$126,660,094.23
Litres of biodiesel	82,364,730.2	$48,018,637.74
Litres of ethanol	17,136,798.6	$6,031,309.92
Kg of soy protein concentrate	198,771,130.1	$87,714,519.36
Kg of glycerin	7,495,190.5	$4,957,214.03
Operating cost		$11,535,087.69
Gross revenue		$146,721,681.05
Net operating revenue		$8,526,499.14
% net revenue of operating costs		6%

The estimated 14 million bushels of soybean used to produce bio-diesel would require 363,966 acres to produce. We assume that the purchase of these soybeans would create increased demand for domestically produced soybeans. This increased demand would translate into a premium amounting to at least the cost of transporting U.S. grown soybeans into Canada. We are currently estimating this cost as $0.20/bushel. Therefore, we estimate a potential combined value of a soybean based bio-diesel plant operating in Canada equaling $8.5 M from bio-diesel operations per year, and $23.1 M in on farm value per year. This latter value is calculated by multiplying the bushels used (14.5 M) by the sum of the current operating profit per bushel of soybean ($1.39/bu) and the transportation premium ($0.20).

Bio-diesel Summary

The production of bio-diesel from soybean has not occurred to date in Canada because of a previous lack of bio-diesel tax exemptions and a reluctance on the part of petro-chemical companies to enter into the market. The introduction of both federal and provincial tax exemptions coupled with government intentions of mandating ultra-low sulphur diesel fuel regulations have made bio-diesel manufacturing more attractive. The capital investment in manufacturing capability is offset by the ability to hedge diesel prices through the use of different feedstocks. This flexibility has been greatly enhanced by the Biox patented bio-diesel manufacturing technology. The use of soybean oil to produce bio-diesel becomes attractive when potential co-products are considered, especially in conjunction with ethanol production. This is a significant market opportunity, and Soy 20/20 will continue to exert considerable effort in working with companies interested in developing Canadian based manufacturing plants.