Biofuels Present and Future Economics

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Keywords: Biofuels, Biodiesel, Ethanol, Biogas, Biomass, Economics

Abstract

The present and future economics of biofuels produced from agricultural commodities in Western Canada are presented. Biodiesel, ethanol, biogas and biomass burning are the main biofuels that are or will be produced from agricultural commodities or biomass. Although the biofuels are very different in the properties and use characteristics there are a number of aspects that are common to all biofuels. First, the delivered cost of the feedstock to the plant gate represents a high proportion of variable cost. Second, reliability of supply at the farm level as farmers are allocating their land resource to the highest return given production constraints. The biofuel crop or cropping system has to offer a competitive net return compared to competing land uses. Third, reliability of supply at the market level as biofuel manufacturers are competing with other uses for the feedstock. Fourth, high per unit capital cost of manufacturing the biofuel relative to the manufacture of competing products in markets where economies of scale exist. To date market entry in Canada has mainly been the result of regulation. However, the market for the product, by-products and co-products will determine the economic feasibility of producing a biofuel in the long run. The crude oil market, animal feed market and the carbon market will have major influences on the future profitability of biofuels.

Introduction

A general outline of the biofuels that the agriculture sector is or will be playing a role in now and the future prospects of the biofuel industry are presented. Biodiesel production will be focused on in some detail to highlight some of the issues associated with biofuel production. Technological improvements and markets important in the future profitability of biofuels will also be presented.

Overview

The biofuels are biodiesel as an additive or substitute for diesel made from any animal or vegetable fat. Ethanol as a substitute for gasoline made from starch or cellulose. Biogas produced from plant material and/or manure for the production of methane to produce electricity or fed directly into the natural gas grid. Biomass burning used as a heat source produced from grain or plant material.

The biofuels that can be derived from agriculture crop production have a number of similarities. The biofuels are competing against well-established products in the gasoline, diesel, natural gas and electricity markets. Infrastructure, institutions and businesses are already established that handle the products, set regulations and service the respective markets. Therefore, access to the market for new entrants can be an issue in some markets. Feedstock cost and the cost of getting it to the plant gate represents a large portion of the variable cost of production i.e. biodiesel 70%, ethanol grain 50%-60%. Therefore, small changes in the cost of the feedstock at the plant gate will have a large impact on the profitability of biofuel manufacture. Reliability of supply of the feedstock is a major concern (Maung 2006). At the farm level, farmers allocate land to the production of the most profitable crops given production constraints. Reliability of supply at the market level is also a problem as alternative uses of the agricultural commodity compete for the available supplies i.e. food, livestock. The use of grains in the production of biofuels is rather straightforward, as markets and market mechanisms such as futures markets exist. A competitive asking price for the grain by the biofuel manufacturer will result in the required amount of feedstock. The market and market mechanisms for other biomass feedstock have not been developed. Other types of relationships will have to evolve to suit the nature of the biofuel being produced. As an example, the producer of a cellulose crop will probably have only one firm within the economic hauling distance of the farm. Therefore, hold-up problems may occur, as neither player will commit to the necessary investments to produce the biofuel. Biofuels have high per unit capital and overhead cost of manufacturing relative to manufacturers of competing products i.e. integrated Petro-chemical firm producing billions of litres of product. Typically biofuel plants have a life expectancy of 15-20 years, compared to electrical power plants 40-60 years and hydro dams 100+ years (Maung 2006).

Ultimately, the net returns for the product, by-products and co-products produced in the manufacture of a biofuel will determine the economic feasibility of producing a biofuel.

Biodiesel Manufacture – Additive Market

Nagy and Furtan 2006 used a linear programming model (LP) for Saskatchewan consisting of conversion coefficients for crushing canola and for the manufacture of biodiesel. The LP model maximizes the returns from producing biodiesel and the associated co-products subject to a number of constraints. The supply of seed for each grade/transport category, the selling price of each product less cost, the size of biodiesel additive market and biodiesel priced at its value as an additive are the constraints.

A number of scenarios are used to assess the profitability of the biodiesel industry (Table 1). Oil extraction rates representing different technologies and costs of manufacture, low tech 92%, base case 95% and hexane extraction at 98% are used in the scenarios. Biodiesel price is based on $50/ bbl crude oil plus refining, transporting and marketing costs to the retailer (rack price). The Biodiesel priced as an additive includes the economic benefits of using the product. Seed cost in Scenario #1 is increased by $100/tonne.

Table 1: Assumptions Used in the Scenarios

	Oil Extraction	Biodiesel Price[b]	Seed Cost[c]
Scenarios[a]	**%**	**$ Litre^{-1}**	**$ tonne^{-1} difference**
Base Case	95%	0.5442	-
Scenario #1	95%	0.5442	+ $100
Scenario #2	92%	0.5442	-
Scenario #3	98%	0.5442	-
Scenario #4	95%	0.4722	-

Source: Nagy & Furtan 2006.

a. Scenarios are Base Case,
Scenario #1- cost of seed increased by $100 per tonne over the base case.
Scenario #2 – oil extraction rate decreased by 3% from the base case to 92%.
Scenario #3 – oil extraction rate increased by 3% from the base case to 98%.
Scenario #4 – biodiesel sold at wholesale for the rack price of diesel plus federal excise tax.

b. Biodiesel price is from table 8 for the $50 per barrel price of crude row.

c. Seed Cost – difference in the cost of seed from the base.

A biodiesel additive would be profitable however sample grade seed is the basis for much of the profitability with the problem of meal being sold at less than the cost of production as the amount crushed rises (Table 2). Supply of low quality seed is highly variable therefore the biodiesel industry will have to attract high quality seed from the food industry. The higher the extraction rate the less meal is produced resulting in higher profits. Higher profits can also result from sourcing higher oil content canola.

Canada currently exports 64%[1] of its canola meal to the U.S. while importing soybean meal. With the current quality of canola meal the feed market in Canada is maxed out. Therefore, meal has to be shipped farther incurring higher transportation and search costs.

Table 2: Model results Biodiesel Additive

	Model	Increased	Oil Extraction Rate[h]		Diesel
	Base Case	Seed Cost[g]	92%	98%	Rack Price[i]
Objective Function Value[a]	**$23,304,544**	**$12,870,485**	**$20,178,674**	**$26,239,230**	**$10,087,891**
Fixed Cost[b]	**$12,360,920**	**$3,945,025**	**$12,360,920**	**$12,360,920**	**$3,945,025**
Net Return[c]	**$10,943,624**	**$8,925,460**	**$7,817,754**	**$13,878,310**	**$6,142,866**
Seed Crushed (Tonnes)	**572,608**	**192,599**	**590,808**	**555,522**	**192,599**
Biodiesel Produced (Litres)	**237,710,000**	**75,865,864**	**237,710,000**	**237,710,000**	**75,865,864**
Meal Produced (Tonnes)	**343,482**	**119,473**	**361,681**	**326,395**	**119,473**
Meal Contribution ($)[d]	**-8,260,854**	**1,118,210**	**-9,057,168**	**-7,513,244**	**179,021**
LQS Sample Crushed (T)[e]	**192,599**	**192,599**	**192,599**	**192,599**	**192,599**
HQS Trans 1 Crushed (T)[f]	**380,009**	**-**	**398,209**	**362,923**	**-**

Source: Nagy & Furtan 2006.

a. Objective Function Value – the Selling price of the biodiesel, meal, glycerine, and FFA minus the respective variable costs times the quantities produced.

b. Fixed Cost – the costs of depreciation and interest on long-term debt for the integrated oilseed crushing and biodiesel manufacturing plants.

c. Net Return – the value for the objective function minus the fixed costs.

d. Meal Contribution – the dollar value of the meal sold in all markets.

[1] Statistics Canada 2006.

e. LQS Sample – amount of sample grade canola seed that is crushed.
f. HQS Trans 1 – amount of #1 grade of canola from the local market that is crushed.
g. Cost of Seed – increase the cost of seed by \$100 $tonne^{-1}$ over the base case, selling price of meal is also increased.
h. Oil Extraction Rate – 95% in the base case.
i. Rack Price – biodiesel priced at the rack price of diesel calculated as crude oil price + processing cost + marketing cost.

The returns to producing biodiesel as a substitute for diesel given the price of crude oil and canola are given in Table 3 assuming that all co-products are sold at their cost of production. Variable costs of producing Canola are between \$3.50- 4.50 per bushel, in the short run farmers may produce canola at that price (light green area). The light brown area is not feasible for a healthy canola market (sample grade canola may be sold in this range). A Canola industry that will meet the demands for the product from the food and biodiesel sector needs to be in the \$6.25 to \$8.50 per bushel range. A healthy biodiesel industry needs to have crude oil from \$60 to \$80 / bbl (bold area is the feasible range of operations).

Table 3: Net Return to Biodiesel Manufacture

		$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$	$
	$/bushel	1.70	2.27	2.83	3.40	3.97	4.54	5.10	5.67	**6.24**	**6.80**	**7.37**	**7.94**	**8.50**	9.07	9.64	10.21	10.77	11.34
	$/tonne	75	100	125	150	175	200	225	250	**275**	**300**	**325**	**350**	**375**	400	425	450	475	500
	Biodiesel	**0.264**	**0.287**	**0.311**	**0.334**	**0.357**	**0.380**	**0.403**	**0.427**	**0.450**	**0.473**	**0.496**	**0.520**	**0.543**	**0.566**	**0.589**	**0.612**	**0.636**	**0.659**
$/bbl	**Rack Price**	**Cost of Biodiesel $ per Litre (Seed Cost + Crushing Costs + Biodiesel Manufacture Costs)**																	
100	**0.787**	0.523	0.500	0.476	0.453	0.430	0.407	0.383	0.360	0.337	0.314	0.291	0.267	0.244	0.221	0.198	0.174	0.151	0.128
95	**0.755**	0.491	0.468	0.445	0.422	0.399	0.375	0.352	0.329	0.306	0.282	0.259	0.236	0.213	0.189	0.166	0.143	0.120	0.097
90	**0.724**	0.460	0.437	0.414	0.390	0.367	0.344	0.321	0.297	0.274	0.251	0.228	0.204	0.181	0.158	0.135	0.112	0.088	0.065
85	**0.693**	0.429	0.405	0.382	0.359	0.336	0.312	0.289	0.266	0.243	0.219	0.196	0.173	0.150	0.127	0.103	0.080	0.057	0.034
80	**0.661**	0.397	0.374	0.351	0.327	0.304	0.281	0.258	**0.234**	**0.211**	**0.188**	**0.165**	**0.142**	**0.118**	**0.095**	0.072	0.049	0.025	0.002
75	**0.630**	0.366	0.342	0.319	0.296	0.273	0.249	0.226	**0.203**	**0.180**	**0.157**	**0.133**	**0.110**	**0.087**	**0.064**	0.040	0.017		
70	**0.598**	0.334	0.311	0.288	0.264	0.241	0.218	0.195	**0.172**	**0.148**	**0.125**	**0.102**	**0.079**	**0.055**	**0.032**	0.009			
65	**0.567**	0.303	0.280	0.256	0.233	0.210	0.187	0.163	**0.140**	**0.117**	**0.094**	**0.070**	**0.047**	**0.024**	**0.001**				
60	**0.535**	0.271	0.248	0.225	0.202	0.178	0.155	0.132	**0.109**	**0.085**	**0.062**	**0.039**	**0.016**						
55	**0.504**	0.240	0.217	0.193	0.170	0.147	0.124	0.100	**0.077**	**0.054**	**0.031**	**0.008**							
50	**0.472**	0.208	0.185	0.162	0.139	0.115	0.092	0.069	**0.046**	**0.023**									
45	**0.441**	0.177	0.154	0.130	0.107	0.084	0.061	0.038	0.014										
40	**0.410**	0.145	0.122	0.099	0.076	0.053	0.029	0.006											
35	**0.378**	0.114	0.091	0.068	0.044	0.021													
30	**0.347**	0.083	0.059	0.036	0.013														
25	**0.315**	0.051	0.028	0.005															

Source: Nagy & Furtan 2006.

a. Canola seed price ($ $tonne^{-1}$) – plant gate price and co-products are sold at cost of production.

b. Diesel Rack Price ($ $Litre^{-1}$) = cost of crude oil + processing cost + marketing cost before federal excise tax, GST and Provincial Taxes.

c. The cost of seed as apportioned to the Canola oil is added to the cost of crushing Canola and biodiesel manufacture. Oilseed crushing variable costs $0.0377 per litre of biodiesel and fixed costs of $0.016 per litre. Biodiesel manufacture variable costs of $0.1047 plus fixed cost of $0.036 per litre. The price of Canola seed is converted using the standard coefficient of 2.3226 kilograms of seed to produce a litre of oil.

Ethanol
The cost of feedstock for grain based ethanol production represents 50% to 60% of the variable costs of production. Process energy, if natural gas or electricity is used, is the next largest variable cost. Transportation costs for the feedstock, ethanol, by-products and co-products are other major cost items. The market price of ethanol, co-products and by-products as ethanol production rises in North America will affect the long run profitability.

Biogas
The hauling cost of the manure feedstock, energy content of feedstock, and the capital cost to generate electricity or natural gas are the main factors affecting the profitability of biogas plants. Access to the grid and pricing of electricity or biogas are also important considerations in assessing the profitability of biogas production (Bradley 2006).

Biomass Fuels
Burning of grain or plant material directly to produce heat for buildings or as a process heat source are the main markets for biomass fuels. Electricity generation is also possible however the high per unit capital costs compared to coal or natural gas and operating efficiencies of 22% compared to 34%-60% of alternative fossil energy sources makes this option less likely (Maung 2006). A combined biomass – coal electricity generation plant can reduce the emissions of GHG by 19% relative to a coal only plant, maybe a profitable option for biomass fuels (Ledford 2006). The energy content of the feedstock given the cost of hauling affects the profitability of producing this biofuel as energy density of the feedstock is a key factor in the profitability of this biofuel (Maung 2006). Cost of converting from other energy sources to biomass is also another factor in determining the profitability of biomass fuels. Secure supply of dedicated energy crops or waste streams may require the use of market mechanisms that are mutually beneficial for the farmer and the manufacturer.

Industrial Biofuel Economy

At the farm level it is important that the energy in is less than the energy used to produce the feedstock. Commercial nitrogen use is the main factor in the energy balance of cropping systems (Zentner et al. 2006). Competitive net returns to competing land uses will be the incentive for farmers to produce biofuel feedstock crops.

Incentives are needed to have the right quality of product produced at the farm level; biodiesel-oil content, ethanol-starch or cellulose content, Biogas-energy/tonne, and biomass- energy density/tonne. An example of incentives changing the quality characteristics of a commodity is from Australian where the oil content of canola was consistently low. To solve the problem oil content based pricing of canola was introduced. The result was that farmers demanded better varieties and agronomic information. More research went into agronomic research by public and private institutions resulting in improved best management practices. Plant breeders used improved genetics to increase the oil content of varieties.

Future Profitability
The economics of biodiesel manufacture improves with increasing oil content of the seed and low cost high efficiency oil extraction techniques. Increasing the oil content of canola reduces

the amount of meal produced and as long as the varieties are not specific to the biodiesel industry the amount of meal produced across the industrial and food sector will be reduced. Higher valued meal and/or alternative uses for the meal would improve the economics of biodiesel manufacture. A use for glycerine apart from the traditional markets possibly as a process heat source would also improve the profitability of biodiesel manufacture.

Ethanol manufacture requires a high starch or cellulose content of the feedstock that is readily converted to sugar. If cellulose is the future of ethanol manufacture then many of the market institutional arrangements will have to be devised. Continued improvement in enzymes and yeast are needed to increase the efficiency of starch or cellulose conversion to sugars and in the conversion of sugars to ethanol (Bothast 2005).

Biogas manufacture requires high yield per hectare of a dense commodity and market access to the grid whether electricity or natural gas. Biomass burning requires high energy per tonne of feedstock delivered to the plant gate. Low transportation costs and market access to the grid for electricity at prices that reflect peak load or time of day pricing would improve the profitability of these biofuels.

Technological Improvements

Productivity gains in the production of biofuels will partly come from the improvements in the physical process equipment and the efficient operation thereof. However, improved yeast and/or microbes will be necessary to increase efficiency at the manufacturing level to any great extent in ethanol and biogas manufacture (Nature 2006).

New crop varieties or new platform crops with competitive net returns at the farm level need to be developed. In large part it will be genetics that will determine the extent of productivity gains as starch content in grains, oil content in oilseeds or energy content in biomass is improved. Ultimate goal is to increase the litres or energy produced per hectare (Sanderson 2006)

Markets Important to Biofuels

There are three markets that will have a major effect on the profitability of the biofuel sector being the crude oil market, animal protein market and carbon market. Western Canada will increasingly become dependent on oil from the tar sands, as conventional oil production has been declining at a rate of 4% per year since 2000[2]. The high cost of producing oil from tar sands could act as a floor price that biofuels will have to be competitive at supplying the market.

Increased biofuel production results in increased supply of high protein products and demand for commodities in North America. The effect on the animal protein market and number of livestock produced will be reflected in the profitability of biofuel production.

A viable carbon market from either the establishment of a revenue neutral carbon tax or a cap and trade system will benefit the production of biofuels to the extent that they replace fossil fuels (Nature 2006).

[2] National Energy Board of Canada.

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