Climate Change Central

Ethanol Vehicle Fuel:
Energy Balance, GHG Reductions, Supply and Economic Overview

DISCUSSION PAPER C3 – 014

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Date: April 15, 2003

EXECUTIVE SUMMARY

This discussion paper focuses on four aspects of ethanol vehicle fuel. Specifically these are the energy balance of ethanol, potential for Greenhouse Gas reductions, Canadian production capacity based on available ethanol feedstock and an overview of the economic issues in the Canadian ethanol industry. The major findings of are as follows:

Energy Balance

- Consensus exists in essentially all recent research that ethanol has a positive energy balance. This research consists of many different studies carried out by private consulting firms, government researchers in Canada and the U.S., and academic institutions.
- The one recent work that suggests ethanol has a negative energy balance is well critiqued by several independent researchers. The reason for finding a negative energy balance was largely due to outdated data and improper assumptions about energy inputs for the production of ethanol.

Greenhouse Gas Reductions

- Again consensus exists among researchers that using ethanol as a vehicle fuel, either in high or low percentage blends, does result in a reduction of GHG emissions.
- For E10 blends (10% ethanol & 90% gasoline) the GHG reductions are estimated to be between 1% and 5% over pure gasoline.
- Based on the estimated reductions, if all gasoline sold in Alberta was an E10 blend the minimum reduction in GHG emissions would be 103,220 tonnes C02e. If the maximum estimated reduction was achieved it would result in a reduction of 516,100 tonnes CO2e.

Available Ethanol Feedstock

- This paper focused on wheat as a feed stock, as the majority of growth in the Canadian ethanol industry is expected to be wheat based production
- Based on 1997-2001 yearly average wheat production in Canada, 4.6 million tonnes of wheat would be suitable for ethanol feedstock. This surpasses the amount required to meet the federal government's goal of having 35% of all gasoline be an E10 blend.
- Eastern Canadian corn increases the available feedstock even further.
- Achieving an E10 blend for all Canadian gasoline would not be possible, unless cellulosic ethanol production technology becomes commercially viable.

Economical Viability

- Ethanol cannot compete on a cost basis with gasoline.
- For a large ethanol industry to develop in Canada, ethanol producers would require ongoing fuel tax exemptions and mandatory blending percentages for fuel refiners to ensure a Canadian market of sufficient size.

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1. INTRODUCTION

The use of ethanol as a vehicle fuel has received much attention of late, largely due to increased awareness of greenhouse gas (GHG) emissions from transportation. Because ethanol is derived from a renewable resource, typically corn or wheat, an opportunity exists to reduce GHG emissions by displacing gasoline with ethanol in the fuel market. Proponents have argued that ethanol is a viable and sensible way to reduce GHG emissions, reduce the consumption of fossil fuels and create a more diverse market for farmers. Opponents have argued that more energy is required to produce ethanol than is returned from the fuel, that GHG reductions are not achieved, that feedstock material is not in abundant enough supply to support a large ethanol industry and that ethanol cannot be cost competitive with gasoline. The goal of this paper is to review current research on ethanol explore the issues of energy balance, potential GHG reductions, feedstock availability and the cost differential between ethanol and gasoline in the Canadian market.

2. ETHANOL'S ENERGY BALANCE

Any investigation of ethanol as a transportation fuel source should begin at ethanol's value as a fuel, or stated differently, what is the energy balance of ethanol? The amount of energy required to extract, refine, produce or transform a resource into a useable fuel and the amount of energy returned by the fuel is vitally important in determining whether a fuel is viable or not. For example, if more energy is required in fuel production than is returned in fuel consumption, this negative energy balance deems the fuel non-viable. Conversely, if a positive energy balance exists, the fuel could be deemed viable for use in transportation.

The debate as to whether ethanol has a positive or negative energy balance has been waged for several decades. Proponents of ethanol have claimed ethanol to have a positive energy balance and the added benefit of being derived from a renewable resource (typically corn or wheat in North America). At the same time, the detractors of ethanol claim a negative energy balance when all the energy inputs (including fertilizers for crops, farm machinery and production processes) are included in the analysis. Much controversy over the energy balance of ethanol was created by David Pimentel,[1] who claimed that ethanol production from corn had a negative energy balance of 56,300 British Thermal Units (BTU) per gallon of ethanol produced. This corresponds to an input/output ratio of .58.[2] Most striking about Pimentel's finding is that it is in direct opposition to the majority, if not all, recent research focused on the energy balance of ethanol.

The following chart summarizes the energy inputs and outputs of ethanol as described in recent large-scale studies of ethanol production in the U.S. and Canada.

[1] Pimental, D. - 1998

[2] Input/output ratios refer to the units of energy returned for each unit of energy input into the production of a fuel. A value of less than 1 represents a negative energy balance, while a value greater than 1 represents a positive energy balance.

Table 1 – Comparison of Energy Balances from Recent Ethanol Studies (BTU/US Gallon)[3]

Study	Inputs – Corn Growing	Inputs – Ethanol Manufacture	Co-Product Credits	Total Inputs	Net Energy Balance
Pimentel (1998)	55,300	74,300	Nill	129,600	(53,600)
Wang (2001)	21,896	41,400 (dry mill) 40,300 (wet mill)	14,076 12,493	49,220 49,703	26,780 26,297
Graboski (2002)	21,268	48,539 (dry mill) 60,658 (wet mill)	14,829	54,978 67,097	21,022 8,903
Levelton (2000)	17,775	50415	14,055	54,135	21,865
S&T consultants Inc. (2003)	18,475 (wheat)	43,434	9530	52,379	23,621

The question of why Pimentel's ethanol energy balance is so different from other research in the field is well explained and rebutted in Graboski's 2002 paper prepared for the National Corn Growers Association in the U.S. It is important to note that the National Corn Growers Association has a vested interest in finding a positive energy balance for ethanol, as 95% of ethanol in the U.S. is produced from corn. However, representatives of the Argonne National Transportation Laboratory, the U.S. Department of Energy, the National Renewable Energy Laboratory and the U.S. Department of Agriculture have reviewed Graboski's paper and evaluation of Pimentel's methods. None of these reviewers disputes Graboski's findings in any significant manner in term of the energy balance calculations.

The key points in the evaluation of Pimentel's paper are as follows:[4]

- The energy utilized to manufacture corn seed is over estimated.
- The energy inputs for the manufacture of nitrogen fertilizer are representative of a world wide average and do not take into account the significantly lower inputs in the U.S. fertilizer industry.
- Pimentel correctly assumes 30% of the energy consumed in growing corn can be attributed to irrigation; however, he then attributes this energy consumption to 100% of the corn crop. In reality only 10% of the corn grown for the production of ethanol is irrigated.
- The energy consumption values used by Pimentel date from the late 1970's. Ethanol plants have become significantly more efficient in the last decade, with the average BTU/gallon of ethanol produced dropping from nearly 70,000 to 47,637 BTU/gallon.
- The average corn yield per acre used by Pimentel reflects typical yields in the early 1990's, which are 9% lower than average yields of the late 1990's and early years of the current decade. The increase in yield per acre is attributed to improvements in farming technique and is expected to increase marginally until the end of the current decade.
- Pimentel makes no allowances for co-products of ethanol production. It is generally assumed that the high protein animal feed that is produced in conjunction with ethanol will displace other types of feed for livestock. Thus, an energy credit is attributed to the production of ethanol for this displacement.

In light of the justified criticisms of Pimentel's work, and the consensus among other ethanol researchers, it seems clear that ethanol does have a positive energy balance. In essence, more energy is returned from a gallon of ethanol than is required to produce it.

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[3] For a more complete overview of previous studies dealing with the energy inputs of ethanol production see Wang et al. 1997, page 16.
[4] See Graboski (2002) for the full evaluation and reviewers comments.

It should be noted that the above discussion of the energy balance of ethanol focuses on ethanol produced from either corn or wheat as a feedstock. Under this process, the starch component of the grain is fermented to produce alcohol. A new process of producing ethanol known as hydrolysis of lignocelullosic biomass (e.g. woody or herbaceous biomass) appears to be close to commercially viable. Iogen Corporation has constructed a test facility to showcase this technology in Ottawa, Ontario and is currently processing 25 tonnes of straw per week to total 320,000 litres of ethanol per year.[5] It is hoped that a full-scale cellulosic ethanol plant (200 million litres per year) will be operational by 2004. The advantages to cellulosic ethanol production over the traditional fermentation process are:

- Less valuable feedstock materials, typically straw, corn stover, or grass reduces production costs
- Cellulose is more widely available than starch or sucrose products
- Cellulose can be grown in a wider variety of climates and soils than starch or sucrose feedstock (e.g. corn, wheat, sugarcane)
- The component of the cellulose feedstock not utilized in ethanol production is used for power generation in the ethanol plant. Typically the plant can generate a surplus of power and thus offers the opportunity to displace power generated from other sources in the power grid.[6]

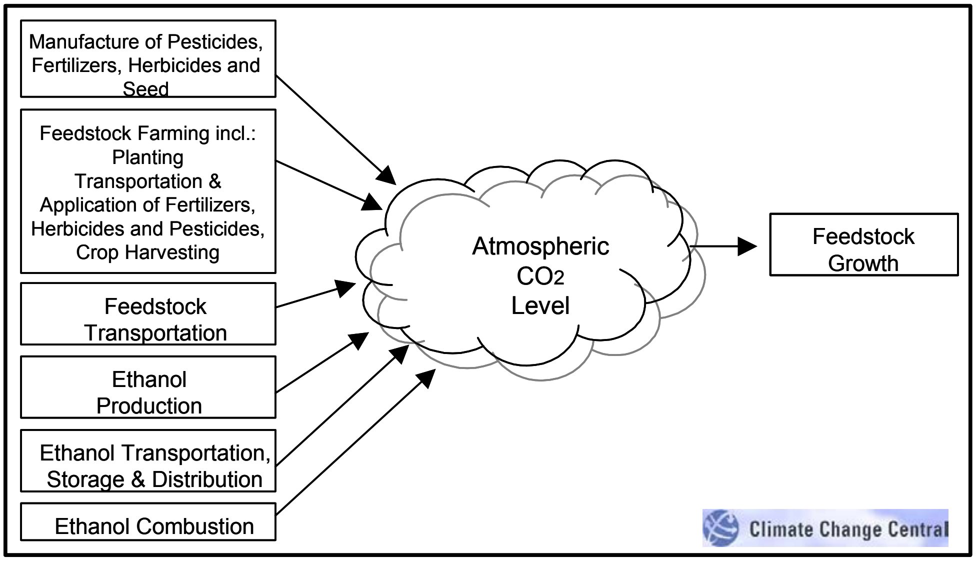
Considering that the energy balance of cellulosic ethanol is even more positive than its fermentation process counterpart, this technology may offer an interesting opportunity in the future assuming it can be made viable on a commercial scale.

3. REVIEW OF ETHANOL LIFECYCLE GHG EMISSIONS

The recent interest in ethanol as a vehicle fuel is largely a result of an increased awareness of GHG emissions from transportation and the potential for ethanol to reduce these emissions. This seems a straightforward concept, as the carbon released during the combustion of ethanol in a vehicle engine (CO2 being the most significant GHG gas) has already been draw out of the atmosphere when the feed stock crop was grown. When compared to fossil fuels (e.g. gasoline and diesel) ethanol would appear to provide a significant advantage, as none of the carbon released from fossil fuels is recaptured. However, the actual consumption of fuel in a vehicle is only one part of the fuel lifecycle and in order to truly understand the potential for reductions in GHGs the other parts of the cycle must be included.

[5] See Iogen website at :www.iogen.ca
[6] Tolan, 2002.

Figure 1 – Lifecycle GHG Pathway of Ethanol Fuel



The above diagram depicts the full cycle GHG emission and absorption processes involved in the production of ethanol. Notice that many more GHG emission processes exist than do GHG absorption processes. Therefore, in order for a GHG reduction to occur in comparison to fossil fuels, the total emissions from the emitter processes, less the absorbed emissions, must be lower than the total emissions from fossil fuels.

The volume of GHGs released by the emitter processes in the ethanol production cycle can vary significantly, depending on farming practices, transportation distances, the energy efficiency of the ethanol plant and the energy source for the production phase.[7] For example, ethanol produced in a plant that receives electricity from a coal fired power generation facility will have higher GHG emissions than a plant powered by hydro electricity.

Another issue that must be addressed is in what form will the ethanol be consumed in a vehicle. In order for a vehicle to operate on high percentage ethanol fuels (e.g. E100 or E85),[8] it requires that the engine be tuned specifically to operate on ethanol fuel. The engine must operate with a higher combustion ratio than a gasoline engine. Currently, no production vehicle can operate on pure ethanol and only a handful of E85 vehicles are available from manufactures. The more common application for ethanol is the E10 blend, which may be used in any gasoline vehicle without engine modification. In light of this, E10 fuel has the most potential to become widespread in availability.

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[7] While the focus of this paper is on GHG emissions it should be noted that ethanol in generally considered a cleaner burning fuel than gasoline and therefore could help reduce criteria pollutant emissions from vehicles. The exception to this rule is increased acetaldehyde emissions, although it is unclear if this has any negative effect on ambient air quality. Greater concern may be targeted at ethanol plants, as proper emission control must be in place to avoid violating air quality regulations for criteria pollutants. In 2002 the U.S. EPA brought charges against many mid-west ethanol producers for failing to control emissions (www.epa.gov).

[8] Ethanol fuels are typically denoted by the percentage of total volume comprised of ethanol. Therefore, E100 refers to 100% ethanol, or neat ethanol. More commonly ethanol is blended with gasoline to make up 10% or 85% of the total volume, respectively known as E10 or E85.

Of late, several full lifecycle studies have been carried out to attempt and determine whether ethanol does have a GHG benefit over gasoline. The following table summarizes the results from several of the most recent studies.

Table 2 - % Reduction in GHG emissions per unit of distance traveled

Study	E10	E85	E100	Notes
Wang et al. (1999)	1%	14-19%	NA	U.S. Corn (Current Technology)
	2%	24-26%	NA	U.S. Corn (Future Technology)
	6-9%	68-102%		Cellulose Ethanol (2005)
(S&T) Consultants Inc. (2003)	4.8%	NA	NA	Ontario Corn
	4.3%	NA	NA	Saskatchewan Wheat
	5%	NA	NA	Manitoba Wheat
Sagar (1995)	NA	NA	37-52%	Corn
	NA	NA	85%	Cellulose (future estimate)
ChemInfo (2000)	3.6-4%	NA	45-62.5%	Alberta Wheat
Levelton Engineering Ltd. (2000)	3.9%	NA	NA	Ontario Corn (2000)
	4.6%	NA	NA	Ontario Corn (2010)

At this juncture, it is an opportune time to discuss the implications of evaluating ethanol on a distance traveled versus volume basis. The numbers in the chart above are based on units of distance traveled. For example, according to Wang (1999) for every mile a vehicle travels on E10 fuel a net GHG reduction of 1% is achieved when compared to gasoline. This value is calculated based on the average fuel efficiency rating of a light duty vehicle operating on E10 fuel and subsequently the amount of gasoline and ethanol combusted to travel that mile. A very little amount of ethanol is actually consumed to travel that mile and so the GHG reductions are relatively minor. However, using the same statistical model, Wang estimates the GHG reductions on a volume basis as a much larger 12-19% depending on the ethanol production method. This comparison is based on the GHG emissions observed from combusting one gallon of ethanol in an E10 blended gasoline. Thus the comparison is really between combusting 10 gallons of pure gasoline versus 9 gallons of gasoline and one gallon of ethanol. It is important that the method used to estimate GHG reductions is clear to avoid comparing apples to oranges in a manner of speaking.

The fuel economy assumptions made when calculating GHG reductions also have an effect on the outcome. In Table 2 the results displayed show a range of GHG reductions, the lowest being 1% and the highest being 5%. While differences in ethanol production processes account for some of this variation, the estimated fuel economy of vehicles accounts for some variability as well. Wang (1999) did not estimate any improvement in fuel economy in vehicles using E10 fuel, while all the other studies assume a 1% improvement in fuel economy. The larger GHG reductions from E85 vehicles is attributed to the larger displacement of gasoline by volume, as well as a fuel economy improvement of 5%.

In summary, it appears that ethanol does offer a GHG reduction benefit over pure gasoline, weather blended in low or high percentage volumes. The question to ask at this point is how significant this reduction is in the grand scheme of reducing GHG emissions. For example, is a 1% reduction per unit of distance traveled worthwhile in comparison to other options for reducing

GHG emissions from transportation? Using Alberta as an example, if E10 gasoline was used in all light duty vehicles and GHG emissions were reduce by 1% per kilometre traveled this would amount to a reduction of 103,220 tonnes of CO2e per annum. If the 5% reduction could be achieved, it would result in 516,100 fewer tonnes of CO2e being emitted into the atmosphere.[9] These are sizable reductions, particularly when compared to other transportation initiatives. Consider that Natural Resources Canada estimates that a national anti-idling program would result in GHG reductions in the 4,500 tonne range.[10] This equates to just 4% of what could be achieved in Alberta through the use of E10 gasoline.

4. CANADIAN ETHANOL PRODUCTION CAPACITY

The previous two sections have dealt with the energy balance of ethanol and the potential GHG reductions possible through ethanol blended gasoline versus pure gasoline. In both cases it would appear that ethanol is in a positive position, as consensus agrees that ethanol offers both a positive energy balance and GHG reductions. However, the issue of ethanol supply must be addressed before a wholehearted endorsement of ethanol-blended fuel is made. Ethanol supply is determined by two factors, one being the production capacity of ethanol producers, the second being the availability of ethanol feed stocks. The second of these two concerns is likely the more important of the two, as ethanol production capacity can be increased with relative ease while feedstock availability may be more problematic. These two issues will be discussed in turn, but it is first necessary to establish the quantity of ethanol required to achieve significant market penetration in Canada in order to make a meaningful assessment of potential supply.

In determining the quantity of ethanol required in for the Canadian market, two scenarios are considered. The first is a target of 35% of all gasoline in to be an E10 blend, while the second is 100% of gasoline being an E10 blend.[11] Based on the net gasoline sales for Canada in 2001, it would require 1,279 million litres of ethanol to achieve the 35% target and 3,655 million litres to achieve the 100% E10 gasoline target. Estimates for E85 blends will not be made, as the availability of vehicles capable of operating with this fuel is so limited that it is really not feasible to expect this form of ethanol fuel to gain significant market share anytime in the near future.

Table 3 summarizes the current ethanol production capacity in Canada. Of note is the fact that only one plant, the Commercial Alcohols Inc. plant in Chatham, Ontario, would be considered a large facility and is the only one that is achieving the economy of scale deemed necessary to be viable in the long term.[12]

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[9] Calculations of CO2e reductions are based on vehicle kilometres traveled in Alberta in conjunction with the average fuel economy rating of light duty vehicles. Data provided by Statistics Canada – Canadian Vehicle Survey and Transport Canada – Annual Report 2001.

[10] NRCan Idle-Free website: http://oee.rncan.gc.ca/idling/issues_idling/contribute.cfm

[11] The Federal Government Climate Change Plan has set the goal of having 35% of gasoline be an E10 blend by the year 2010. The 100% target was included simply to test the feasibility of all gasoline being E10.

[12] Ethanol made in Manitoba

Table 3 – Canadian Ethanol Production Capacity

Producer	Location	Capacity	Feed Stock
Mohawk Oil, Canada, Ltd.	Minnedosa, Man.	10 M. Litres	Wheat-based
Pound-Maker Agventures, Ltd.	Lanigan, Sask.	12 M. Litres	Wheat-based Partnered with a cattle feedlot
Commercial Alcohols, Inc.	Tiverton, Ont.	23 M. Litres	Corn-based
Commercial Alcohols, Inc.	Chatham, Ont.	150 M. Litres	Corn-based
Tembec	Temiscaming, Qué.	17 M. Litres	Forestry product-based
	Total	212 M. Litres	

Source: Canadian Renewable Fuels Association

It is plainly evident that current ethanol production capacity in Canada is woefully distant from meeting the 35% E10 gasoline target and even further from a 100% E10 market. Production capacity would be required to increase by some 600% to 1700% in order to meet the 35% and 100% targets respectively. In real terms this would require the construction of between seven and 23 additional plants the size of the Commercial Alcohols facility in Chatham, Ontario. While it is difficult to accurately assess how quickly capacity could be added to Canadian ethanol production, to meet the 35% E10 blended gasoline target would require the construction of 1-1.5 large ethanol plants each year between now and 2010. Given the appropriate market conditions this goal should be attainable. For example, eight new ethanol plants have already been proposed for the province of Saskatchewan.[13] While it is too early to determine how many of these will actually be constructed and what the total output would be, it would appear that ethanol production capacity could be increased substantially in a relatively short period of time.

More important than the ability to construct new ethanol plants is the question of whether the feedstock is available to support the added capacity. It is assumed that the most likely feedstock for increased ethanol capacity in Canada will be wheat. Two reasons for this are that Canada grows a large quantity of wheat making it an abundant feedstock, and that Manitoba and Saskatchewan, the two largest wheat producing provinces, are motivated to reduce fuel imports and encourage a diversified market for farm products.[14] [15]

In order to meet the prospective targets of 35% and 100% of gasoline on the Canadian market to be an E10 blend it will require 1,279 million and 3,655 million litres of ethanol respectively. At an average yield of 370 litres per tonne of wheat processed, 3.5 million tonnes of wheat would be required for the lower target and nearly 10 million tonnes for the higher target. Table 4 displays the average Canadian wheat production by wheat variety from 1997-2001.[16]

[13] Major project inventory 2003
[14] Ethanol made in Manitoba
[15] GreenPrint for ethanol production in Saskatchewan
[16] Agriculture and Food Canada – Bi-weekly bulletin.

Table 4 – Average Annual Wheat Production By Variety

Wheat Variety	Average Annual Tonnes (millions)
Canadian Western Red Spring (CWRS)	15.4
Canadian Western Extra Strong (CWES)	0.6
Canadian Prairie Spring Red (CPSR)	1.8
Canadian Western Red Winter (CWRW)	0.3
Canadian Prairie Spring White (CPSW)	0.4
Canadian Western Soft White (CWSW)	0.15
Canadian Western Amber Durum (CWAD)	4.7
Eastern Canadian	1.4
Total	24.75

The wheat varieties of greatest interest to ethanol producers are the low protein wheat varieties, specifically Canadian Prairie Spring Red, Canadian Western Red Winter, Canadian Prairie Spring White, and Canadian Western Soft White. Due to the lower protein content of these varieties they have less value as milling products for human consumption. The higher protein wheat varieties may be used in ethanol production, although this typically occurs when the quality has been diminished due to poor growing conditions (e.g. No. 3, 4 and 5 grade CWRS). When these varieties are of higher grade, (e.g. No. 1 or 2) market price is typically too high to warrant using them as ethanol feedstock. It is simply not cost effective to produce ethanol with high-value wheat that would typically be destined for human consumption.

On average, during the period from 1992-1996 some 2.9 million tonnes per year of all wheat classes were designated as feed quality. Added to this total would be the remainder of the CPSR and CPSW that is most suited to ethanol production. This would bring the total feedstock available to 4.6 million tonnes per year, surpassing the 3.5 million tonnes required to meet the 35% E10 fuel target.[17] This is achieved even before Eastern Canadian corn, the largest feedstock for current ethanol production, is included in the total.

It is also likely that wheat production would be increased if a large ethanol market existed. The number of acres of land used in wheat production has declined steadily for the past decade or more. If more land were to be used for wheat production, reaching the volume required for a 10% ethanol blend in 35% of all gasoline would be even more easily attained. It is estimated that Saskatchewan alone could increase production of ethanol grade wheat by some 1.3 million tonnes per year by using half of the current summerfallow land. This could represent an additional 480 million litres of ethanol per year.[18]

Reaching the 100% E10 ethanol blend across Canada would prove much more difficult. While technically feasible based on the total production of wheat in Canada, achieving this goal using current ethanol technology would require a significant change in the Canadian wheat market. Specifically, the production of wheat varieties suitable for ethanol would have to be increased fourfold and Canadian exports of milling quality wheat would be significantly reduced. Because the high protein milling wheat is also the most valuable, it is unlikely that production would be altered so significantly, or that ethanol could be produced economically with this feedstock. The one option that may allow the ethanol production to achieve the 3,655 million-litre mark would be the large-scale adoption of cellulosic production technology. Iogen Corporation estimates that the Prairie Provinces produce 40 million tonnes of straw per year.[19] If all of this material was used a further 12 billion litres could be added to Canada's ethanol production capacity, essentially three times the volume required to meet a 100% E10 target. Unfortunately, many uncertainties exist in this plan, ranging from environmental concerns over removing so much material from the natural cycle, to the fact that a full-scale cellulose ethanol plant has yet to be constructed.

[17] Manitoba Rural Adaptation Council and Canadian Wheat Board – 1999.
[18] S&T Squared Consultants Inc., and Meyers Norris Penny, October 2001.
[19] http://www.iogen.ca/2600.html

5. ETHANOL ECONOMICS - OVERVIEW

The typical laws of a free market economy do not govern the market price of ethanol. In an unregulated market, such as in Canada currently, ethanol must compete directly with gasoline for vehicle fuel market share. This results in the need for ethanol to be priced competitively with gasoline to encourage fuel refiners to blend ethanol into gasoline. The way this competitiveness is achieved is for ethanol producers to sell ethanol at the current rack price of gasoline. Thus the profit margin for anyone selling ethanol-blended fuel is not adversely affected. The issue with this system is that the factors that determine the rack price of gasoline and ethanol are very different. Gasoline rack price is essentially determined by the price of crude oil, refining costs and somewhat by market demand and current inventories. The cost of feedstock materials and the production costs, less the value of co-products, determine the cost of ethanol. Needless to say, the price of crude oil and the price of ethanol feedstock and ethanol co-products are not related. If the price of crude oil drops, the price of ethanol drops along with it, whether the price of ethanol feedstock has dropped, increased or remained the same. The overwhelming question then, given that the market value of ethanol is unrelated to the production cost, is can ethanol be economically viable in this type of Market?

The short answer to the above question is no, in the current fuel market ethanol is not competitive with gasoline. The average cost of production for a litre of ethanol in Canada's most efficient plants, net of the co-product value, hovers around the \$0.45 mark. The production costs in smaller plants, which are the majority of Canadian ethanol producers, are estimated to be in the \$0.60 to \$0.70+ range.[20] By comparison, the average rack price of gasoline in 2002 was \$0.35 per litre.[21] Clearly, gasoline has a significant economic advantage over ethanol in a cost comparison. However, comparing ethanol to gasoline is not so straightforward, owing to fuel tax exemptions that apply to ethanol.

The federal government currently has an excise tax exemption of \$0.10 per litre of ethanol that is sold in ethanol-blended gasoline. In the exemption process, the consumer still pays the full amount of tax at the pump, but the portion of the tax attributed to the volume of ethanol in the fuel is returned to the ethanol producer. Under this scenario, if the current wholesale price for ethanol is \$0.35 based on the rack price of gasoline, the actual selling price of the ethanol is \$0.45 (\$0.35L wholesale price + \$0.10L tax exemption). Ethanol producers' also benefit from provincial fuel tax exemptions in six provinces.[22] For example, Manitoba has an exemption of \$0.25 per litre, while Saskatchewan offers a \$0.15 per litre exemption. Under these conditions the selling price of ethanol, given an assumed wholesale price of \$0.35, is effectively \$0.70 and \$0.60 per litre. At this point the economics of ethanol begin to look viable in an open market system for large plants (80 million litres per year) that can meet the \$0.45 cost target and take advantage of the tax exemptions.

Unfortunately for ethanol proponents, too many unknown variables exist in the market place to support the development of a large ethanol industry in Canada. The first of these is the rack price of gasoline. In the above scenario the 2002 average rack price of gasoline was used to estimate whether ethanol could be competitive. It is important to realize that the \$0.45 per litre of ethanol is at the lower cost limit of current technology in Canada[23], while the \$0.35 per litre of gasoline is very near the record high average. As recently as 1999 the average rack price of gasoline was

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[20] Bliss Baker – Canadian Renewable Fuels Association, personal communication.

[21] Fuel Facts – December 17, 2002.

[22] The six provinces offering fuel tax exemptions to ethanol are: British Columbia (11-15cents), Alberta (9 cents), Saskatchewan (15 cents), Manitoba (25 cents), Ontario (14.7 cents), and Quebec (20.4 cents).

[23] S&T Consultants (2001) estimate that the cost of wheat based ethanol could decline to \$0.36/L in the future. To date this level of efficiency has not been achieved.

nearly 50% lower than the 2002 average.[24] If the price of crude oil, and subsequently the rack price of gasoline were to return to 1999 levels, even the most efficient ethanol plant supported with the current tax exemptions would be a money losing proposition. This uncertainty is compounded by the variable nature of wheat prices as well. If the price of wheat on the world market were to increase, driving ethanol production costs up, the gap between revenues and costs would become larger still. Finally, some uncertainty exists around whether the tax exemptions for ethanol are going to continue, or at what level. Manitoba is considering lowering its tax exemption from $0.25 to $0.15 per litre.[25] The net effect of these uncertainties is that financial investment in ethanol plants is not an attractive proposition.

Yet another hurdle for ethanol to overcome is the lack of a market in Canada. Consider that ethanol is, in essence, a displacer of gasoline. For every litre of ethanol blended into gasoline, one litre less of gasoline is sent to market. This has several implications to fuel refiners, as blending ethanol essentially reduces the volume of gasoline they sell and that they must purchase ethanol from an outside producer.[26] This system has the net effect of reducing the profit of the fuel refiner, as the profit on 10% of the total volume is flowing to the ethanol producer not the refiner. Naturally, in this scenario the incentive for fuel refiners to blend ethanol into gasoline is low. Fuel companies that choose to blend ethanol into their gasoline are usually motivated by the environmentally friendly image of ethanol and/or using ethanol to increase the octane rating of the fuel. In the Canadian market only a few fuel companies are choosing to blend ethanol and there seems to be little interest on the part of the remaining fuel companies to do so. Ultimately this means that even if a large-scale ethanol plant was financially viable based on the market price of ethanol and tax exemptions, it is likely that such a plant would not have a customer in the Canadian market to sell ethanol to. Two options then exist for ethanol producers. The first is to export ethanol to other markets, while the second is to create a market in Canada through the mandatory blending of ethanol in gasoline. In the provinces of Manitoba and Saskatchewan, where the strongest push for an expanded ethanol industry is occurring, both these options are being pursued. As the U.S. phases out the use of MTBE as a gasoline oxygenate, due to environmental concerns, it is likely that ethanol will become the primary replacement.[27] Therefore Manitoba and Saskatchewan are advocating the development of the ethanol industry, largely for export to the U.S. market. In addition, both provinces are planning to mandate blending ethanol into gasoline sold in the province as a means of guaranteeing a local market.[28] [29]

In summary it is apparent that the economic viability of ethanol relies on several factors being in place. These include a relatively high market price for crude oil, stable wheat prices, ongoing fuel tax exemptions and a mandated market for ethanol-blended fuels. Without these ethanol will not be economically viable, as it cannot compete on a cost basis with gasoline and subsequently the incentive for fuel refiners to purchase ethanol is virtually non-existent.

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[24] Fuel Facts – December 27th, 2000.
[25] Bliss Baker – Canadian Renewable Fuels Association, personal communication.
[26] At present the Mohawk ethanol plant in Minnedosa, Manitoba is the only Canadian ethanol plant to be directly linked to an oil refiner.
[27] It is estimated that the State of California will require 2 – 3 billion litres of ethanol each year. Currently the U.S. does not have the capacity to supply this demand, nor the increased demand from other jurisdictions (S&T Squared – 2001).
[28] Ethanol made in Manitoba
[29] GreenPrint for ethanol production in Saskatchewan

6. SUMMARY AND CONCLUSIONS

This paper has provided an overview of ethanol fuel and attempted to address some of the issues that commonly arise when discussing the benefits or drawbacks of ethanol. In terms of energy balance and the potential to reduce GHG emissions, ethanol receives passes grades on both accounts. Consensus among recent research points to a positive energy balance for ethanol, meaning that it has value and is viable as a vehicle fuel. Consensus also exists that using ethanol blended gasoline will reduce GHG emissions when compared to straight gasoline. Although the reduction may be a small percentage of the total emissions, typically thought to be between 1 and 5% in an E10 blend, in absolute terms this represents a significant reduction in GHG emissions because of the high volume emitted from transportation fuels. A rough calculation suggests that Alberta alone could reduce GHG emissions by over 100,000 tonnes if all gasoline sold in the province was an E10 blend.

Concern over the necessary volume of feedstock for ethanol production has always been in the forefront of ethanol discussions. It would appear that concern over feedstock can be justified, or not, depending on the amount of market penetration desired. It is clear that ethanol cannot be produced in large enough quantities to replace gasoline as the primary vehicle fuel, essentially ruling out the possibility of a Canadian vehicle fleet operating on ethanol. With current ethanol production technology, even reaching a point where all gasoline in Canada is an E10 blend would be difficult and a very unlikely scenario. The one caveat to this statement is the potential that cellulosic ethanol technology could provide the volume required to meet a 100% E10 goal. However, at present this technology is largely untested and it remains to be seen if it will live up to its potential. It is also clear that the federal government goal of 35% of all gasoline be an E10 blend is achievable with current traditional feedstock supplies. In fact it is likely this goal could be surpassed if more land was put into production, which could be done relatively easily and without affecting other crops. The message to take from this is that while ethanol will never replace gasoline, it could be used in a large enough quantity to make a significant impact in the fuel industry.

The largest hurdle for the Canadian ethanol industry to overcome is the need to be competitive on a cost basis with gasoline. On a production cost basis this is unlikely to happen, barring a significant increase (i.e. 50%) in the price of gasoline or a major technological leap in ethanol production methods. In order to be a viable business, ethanol will require government support in the form of fuel tax exemptions and mandated blending requirements for fuel refiners. In the current fuel market, the demand for ethanol is too low and the cost of production too high. If government, either provincial or federal, wishes to see an expanded ethanol market it will require a long term commitment to ensure that the necessary incentives are in place to attract investment into the ethanol industry.

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