



Assessing the Viability of an
Ethanol Industry in Saskatchewan

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1. INTRODUCTION

Ethanol has recently been heralded by governments in North America and around the world as an attractive renewable energy source that can reduce our dependence on non-renewable fossil fuels. The Saskatchewan provincial government has suggested that increasing ethanol use will not only reduce greenhouse gas (GHG) emissions that result from transportation, but also increase farm income for primary producers and create jobs in rural areas, thus contributing to a revitalization of the rural economy. Around the world, this kind of widespread enthusiasm has led to many governments mandating the use of ethanol-blended gasoline (EBG), while at the same time providing direct subsidies to ethanol producers. In light of the public resources being committed to the development of this industry, a clear understanding of the objective merits of developing an ethanol industry under these circumstances is required.

The presence of government supports for existing production and for potential expansion leads to the question of whether an ethanol industry is economically viable (without subsidies/mandates). Critics of the ethanol industry suggest that it cannot function without government support and is extremely vulnerable to changing oil and grain (feedstock) prices (Rilett, 2003). The collapse of the American ethanol industry in the mid-1980s when oil prices plummeted (Morris, 2003) gives credence to this concern. For Saskatchewan, given a small local market (even with mandated use), a major expansion means that access to export markets becomes essential. However, many jurisdictions to which Saskatchewan producers would hope to export have their own mandated/subsidized industries (Saskatchewan Eco Network Website, 2006) that they are likely to protect. Further, an expansion of the ethanol industry will have potential impacts on the closely linked livestock industry, which relies on the same feed inputs (Sopuck, 2002). If government support of an ethanol industry expansion cannot be justified in terms of the economic viability of the industry itself, perhaps the other widely touted benefits on the rural economy and/or the environment (e.g. GHG emission reductions) are sufficient to justify support at public expense. However, opponents have questioned the impact of ethanol development on the rural economy and also point to serious uncertainties about its environmental impacts (Sopuck, 2002; Pimentel, 2003; Niven, 2005).

This paper explores five key questions that require attention in the determination of the viability of an ethanol industry in Saskatchewan:

1. What are the major determinants of the economic viability of ethanol production in Saskatchewan, now and in the future?
2. Can Saskatchewan reasonably expect to export ethanol produced above locally mandated levels?
3. What is likely to be the impact of expanded ethanol production on the livestock industry in the province?
4. Will broader rural economic benefits justify government support of the ethanol industry?
5. Will environmental benefits resulting from mandated use of ethanol justify government support of the ethanol industry?

The Saskatchewan provincial government has suggested that increasing ethanol use will not only reduce greenhouse gas (GHG) emissions that result from transportation, but also increase farm income for primary producers and create jobs in rural areas, thus contributing to a revitalization of the rural economy.

It is recognized that the above list is not exhaustive, but it seems a reasonable approach to assessing the advisability and potential of this industry in Saskatchewan. This paper will not offer definitive answers to these questions. However, we provide some preliminary appraisal of findings to date, noting that there is much left to be discovered. It should be noted that ethanol production is occurring in a rapidly changing environment, and technological improvements have the capacity to reduce its cost of production. Major ethanol expansions in the U.S. directed at energy security could rapidly change the demand for feedstock, etc. The data and sources relied on in this paper are the most recently available from published sources as well as university and government working papers. Wherever possible, peer-reviewed articles are cited, though current articles are uncommon given the rapidly evolving and practical nature of the question.

The following section (Section 2) provides a background to the discussion including a description of the various ethanol technologies and the existing international ethanol industries including Saskatchewan and Canada. Section 3 presents a discussion around the five questions noted above, including the relevant literature. Section 4 contains a summary and conclusions, followed by a brief discussion of future research requirements in Section 5.

2. BACKGROUND

2.1 What is Ethanol?

Ethanol is a clean-burning, high-octane, water-free alcohol that can be produced from any biological feedstock that contains sugar or substances that can be converted into sugar. During ethanol production starch is converted to sugar, which is then fermented and distilled to produce alcohol. A dehydration process removes all water, leaving pure alcohol (or ethanol) that can be dissolved into gasoline and used as a fuel source for internal-combustion engines. The most common feedstocks used to produce ethanol are sugarcane, corn and wheat. In Canada, most ethanol is produced using corn (73%) and wheat (17%) (Olar et al., 2004).

Improved technologies are expanding the potential list of feedstocks to include cellulose materials like wood, crop residues, newspaper and solid wastes. The conversion of cellulose materials into ethanol is similar to conventional ethanol production but involves an additional step of initially converting cellulose materials into a usable starch form. The process of converting cellulose to starch is currently quite expensive and these technologies are not yet competitive with conventional ethanol production. For this reason, they have not yet been widely commercialized on a large scale. A primary advantage of cellulose feedstocks, however, is that they are not normally consumed as human food (and do not compete with the production of food), and therefore are typically much cheaper than feedstocks such as grain.¹

The types of feedstocks used in conventional ethanol production depend on several factors including their availability, the efficiency with which each can be converted to ethanol,² cost of production and the value of their co-products. In terms of efficiency, sugarcane is the most efficient feedstock followed by corn, wheat and barley (O'Conner, 2003; Pereira de Carvalho, 2006). From a cost of production standpoint, sugarcane is approximately 50% lower than most grains. The cost-of-production using corn, wheat and barley is similar, and choosing between them often depends on plant location (feedstock availability and transportation costs), plant size and co-products.

Ethanol produced from grains uses approximately two-thirds of each tonne of grain committed to its production. The remaining one-third of the grain is often used as a high-protein animal feed, which is ideal for ruminants like cattle (Canadian Renewable Fuels Association Website, 2006). Other by-products of ethanol production include wheat gluten, which can be used as ingredients in a variety of products, including packaging and coatings for food items, laundry detergent, cosmetics, cat litter and pharmaceuticals (Government of Saskatchewan, 2002).

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¹ For more information on cellulose ethanol production, please refer to the website of the Renewable Fuels Association (<http://www.ethanolrfa.org/resource/cellulosic/>).

² Efficiency can be defined as ethanol yield per tonne of feedstock used.

2.2. The International Ethanol Industry

World ethanol production was about 46 billion litres per year in 2005 (Renewable Fuels Association, 2005a) and is forecast to be as high as 76 billion litres by 2010 (Renewable Fuels Association, 2006). Production is dominated by Brazil and the U.S., each of which produced around 16 billion litres per year in 2005. China currently produces about 4 billion litres per year, while a host of other countries make up the remaining 10 billion litres of world production. Table 1 presents world ethanol production by country.

Table 1: World Ethanol Production by Country – 2005

Country	Production (millions of litres)	Country	Production (millions of litres)
United States	16,139	South Africa	390
Brazil	15,999	Spain	352
China	3,800	United Kingdom	348
India	1,699	Thailand	299
France	908	Ukraine	246
Russia	749	Canada	231
Germany	431	Others	1,707

Source: Renewable Fuels Association 2005a

2.2.1. Brazil

Large-scale ethanol production began in Brazil in the 1970s when the government decided to reduce the country's dependency on oil. Brazil's ethanol industry was developed with the aid of government support, although the industry has been deregulated since the early 1990s. Currently over three million vehicles in Brazil are powered by pure ethanol, which is sold at over 25,000 service stations. Ethanol production in Brazil is equal to 40% of domestic gasoline consumption, while all gasoline sold is required to contain 20%-25% pure ethanol (Chang, 2006). Ethanol that is not consumed domestically is exported. There are more than 300 commercial ethanol plants operating in Brazil, the majority of which use sugarcane as their primary feedstock (Olar et al., 2004).

Despite Brazil's impressive volume of ethanol production, it has been reported that the country's ethanol producers are having a difficult time keeping pace with consumption. Ethanol demand is expected to grow by 50% over the next five years, primarily as a result of mandated usage (Chang, 2006), and growth in production is being limited by

a diversion of sugarcane to the refined sugar market, which is also experiencing high world prices. Increased sugar prices are partly the result of sugar and ethanol competing for the same feedstock (sugarcane). Despite ethanol shortages, the Brazilian government currently imposes a 30% import tariff on foreign ethanol (Gallagher et al., 2006). Domestic producers are thus potentially able to realize a price for their product that is 30% higher than the world price.

2.2.2. United States

The United States began large-scale commercial ethanol production a decade later than Brazil, in the early 1980s. Between 1980 and 2004 the industry grew at approximately 13% annually, from 600 million litres to over 12.8 billion litres. Between 2000 and 2004, however, production has increased by approximately 20% annually (Dhuyvetter et al, 2005).

The primary reason the U.S. government promotes ethanol production has been to reduce dependence on foreign oil. In recent years, this goal has been fast-tracked by increased instability in the Middle East and rapidly increasing oil prices. In 2005, the U.S. government created the national Renewable Fuels Standard (RNS) as part of its Energy Policy Act (EPACT). Through mandates, the Standard seeks to further expand U.S. renewable fuel production (primarily ethanol) from its current level to around 30 billion litres by 2012. If this objective is achieved, renewable fuels will make up 4.7% of national fuel supply³ (Renewable Fuels Association, 2005a).

The U.S. ethanol industry is subsidized at both federal and state levels. The federal government offers incentives of 5.1 U.S. cents/gallon (1.34 U.S. cents/litre) for blends containing at least 10% pure ethanol and offers various income tax and excise tax credits. At the state level, approximately half of the 50 states provide incentives for ethanol production ranging from 5 U.S. cents/gallon (1.3 U.S. cents/litre) to 30 U.S. cents/gallon (7.9 U.S. cents/litre) (Olar et al., 2004), while at least three states (Minnesota, Montana and Hawaii) have mandated ethanol consumption. A variety of other incentives also encourage a conversion to ethanol usage. In total, subsidies for ethanol production in the U.S. are estimated to be \$2.5 billion (US\$) per year (Tyner, 2006).

There are 95 commercial ethanol plants in the U.S., with 33 more plants currently under construction. These plants are strongly concentrated in the corn-producing states of the Midwest, and are approximately 50% producer-owned. Almost all ethanol produced in the U.S. relies on corn as the primary feedstock, and it is estimated that 20% of all U.S. corn production will be devoted to producing ethanol by 2008 (Olar et al., 2004).

Ethanol demand in the U.S. is largely covered by domestic production. In 2004, U.S. domestic consumption of ethanol was 13.5 billion litres, while production was 12.9

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³ Includes all fuels and all uses.

billion litres. In that year, only 600 million litres of ethanol were imported, with most of it coming from Brazil, Jamaica and Costa Rica. The U.S. charges a 54 cents/gallon (14.27cents/litre) tariff on imported Brazilian ethanol in addition to a 2.5% *ad valorem* tariff imposed on all imported ethanol (Renewable Fuels Association, 2005b). Domestic production is thus highly protected from competition as would be expected in a highly subsidized industry.

2.2.3. Canadian Ethanol Industry

The Canadian ethanol industry is in its infancy relative to nations like Brazil and the United States. Although several small-scale industrial ethanol plants have been in existence since the late 1970s, the first fuel ethanol plant (Minnedosa, MB – Husky Energy Inc.) began operating in 1980. In 1992, the federal government began to encourage an expansion in production with an excise-tax exemption of 10 cents/litre for ethanol used in blended fuels. At this time, ethanol blending was seen as a way to reduce GHG emissions. More recently, ethanol production has also been seen as way to revitalize the struggling agriculture sector (Government of Saskatchewan, 2002).

Today, ethanol production in Canada is around 395 million litres annually, a substantial increase from the 231 million litres produced in 2005. Most of this capacity is concentrated in southeastern Ontario and Saskatchewan, where five plants account for approximately 335 million litres of production. Other plants are located in Red Deer, AB, Temiscaming, QC, and Minnedosa, MB. Production is set to expand by up to 740 million litres as a result of government funding and incentives, most notably the Ethanol Expansion Program (EEP) which was created by the federal government in August 2003. The EEP supports the expansion of Canada's ethanol industry in several ways including mandated usage, direct financial contributions to production facilities, guaranteed loans and a public-awareness campaign. Without factoring in the cost of mandated usage, total cost of the EEP is \$243 million. Many provincial governments have also begun supporting ethanol initiatives through fuel tax exemptions, mandated usage regulations and direct financial contributions for ethanol start-ups. The total value of these subsidies is difficult to discern.

The newly elected federal Conservative government has given no indication that it will back away from supporting ethanol expansion in Canada initiated by the former liberal government. In December 2005, Conservative leader (now Prime Minister) Stephen Harper made an election promise that if elected, his government would require an average of 5% renewable fuel content by 2010. In May 2006, the federal and provincial Ministers responsible for renewable fuels announced preliminary details for the Renewable Fuels Strategy (RFS) for Canada. Among other things, the RFS recommends mandated fuel usage, tax credits for ethanol production, further tax credits for small ethanol producers and start-up incentives for ethanol producers who did not benefit from the EEP. The RFS also recommends investing in the commercialization of cellulosic technologies, as well as research and development of new technologies (Canadian Renewable Fuels Association, 2006).

2.2.4. Ethanol Production in Saskatchewan

Ethanol production in Saskatchewan has been occurring since Poundmaker AgVentures completed its 10-million-litre facility in Lanigan in 1990. The provincial government directly subsidized the plant from 1991 to 1993 at approximately 40 cents per litre and also provided a tax exemption of 15 cents per litre through the early to mid-1990s. In 2000, the provincial government reinstated this exemption for all ethanol production in the province (Olar et al., 2004).

In the fall of 2006, two more plants opened in Weyburn (owned by NorAmera BioEnergy Corporation) and Lloydminster (owned by Husky Energy) with capacities of 25 million litres and 130 millions litres, respectively. Despite the fact that these plants were only recently completed, the provincial government had contemplated investing in, or facilitating the expansion of an ethanol industry for several years. In 2002, the provincial government unveiled its Greenprint for Ethanol Production in Saskatchewan, a plan that was designed to vastly expand the province's ethanol industry. The plan called for the industry to expand to 400 million litres per year of ethanol production in the next few years and suggested that 1 billion litres annually could be feasible (Government of Saskatchewan, 2002).

Since ethanol production is not currently cost-competitive with gasoline,⁴ the provincial government has suggested that it will facilitate industry expansion by providing tax exemptions on ethanol that is both locally produced and consumed. In addition, the government plans to create a local market by mandating that all gasoline sold in Saskatchewan contain 10% pure ethanol, to occur once provincial ethanol capacity is large enough to meet the demand thus created (around 130 million litres) (Government of Saskatchewan, 2002). It is anticipated that ethanol produced above this level will be exported to other jurisdictions in Canada and the U.S. A second component of the plan is to require that distributors buy 30% of their ethanol from "small" ethanol plants (25 million litres or less annually) in an effort to promote producer-owned facilities (Olar et al., 2004).

Producer-owned facilities are part of the province's plan to use ethanol as a vehicle to revitalize the rural economy, while at the same time benefiting the environment. The government's Greenprint suggests that ethanol plants will create up to 450 job opportunities both in terms of ethanol production and through feedlots that are often associated with ethanol production. In addition, the government has suggested that ethanol plants will create a new marketing alternative for producers (presumably at higher prices) who face low grain prices. In terms of the environment, the Greenprint suggests that ethanol offers numerous environmental benefits, most notably a reduction in GHG emissions and in compounds that contribute to smog (Government of Saskatchewan, 2002).

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⁴ Depending on the size and efficiency of the ethanol plant, as well as feedstock prices, ethanol is estimated to be between 35% and 42% more expensive to produce than gasoline (von Lampe, 2006).

Since the Greenprint was announced, expansion of the ethanol industry has been slow to occur. Initially, the government announced it would partner with an American company to build three 50-million-litre plants in the province. The provincial government was to provide 40% of the investment, while the partner company would provide the remaining 60%. These plants did not materialize because the American company in question was unable to secure financing (Olar et al., 2004). In total there have been (or currently are) upwards of 20 groups considering investing in ethanol plants in Saskatchewan, however, only the Weyburn and Lloydminster plants are completed. A 150-million-litre plant, located at Belle Plaine, is in the initial construction phase. The provincial government did not invest money in either the Weyburn or Lloydminster plants as both plants received start-up money (\$3.5 million for NorAmera and \$7.8 million for Husky) under the previous federal government's Ethanol Expansion Program (EEP). However, the provincial government recently committed \$23 million dollars to the Belle Plaine plant. The extent to which provincial start-up money will be required for future plants is uncertain.

3. ETHANOL INDUSTRY CHALLENGES / ISSUES

Despite the growth in ethanol production in Canada and around the world, it is evident from the discussion above that the industry faces some challenges. The heavy involvement of government in the development of this industry, including the use of public money for subsidies, demands a careful examination of whether the stated objectives can be met, whether the level of government support is sustainable, and whether there might be collateral damage to other sectors of the economy. Fundamentally, the alternative uses (opportunity cost) of taxpayers' money must be considered to ensure the best use of public resources relative to the stated objectives. In the case of Saskatchewan, the primary objectives of an expanded ethanol industry include reducing GHG emissions and revitalizing the rural economy. The following sections of the paper discuss the five questions raised above by way of highlighting the issues to be considered in making these assessments.

3.1. Determinants of the Returns on Investment in Ethanol Expansion

For private investors, the current and future profitability of ethanol production in the province is necessary for this to be an attractive option. The most important determinant of profitability is the cost-of-production of ethanol relative to gasoline, its primary substitute. Without subsidies, ethanol would have to compete directly with gasoline for market share and therefore would have to be priced equal to or less than gasoline. However, it has been estimated that in comparison to gasoline, production costs for ethanol from wheat are between 35% and 42% higher than for gasoline (von Lampe, 2006). At these relative costs, the only way that ethanol producers can compete with gasoline production is through access to tax incentives, direct subsidies, mandated usage, or some combination of the three. The overall subsidy must be at least equivalent to the difference in the cost-of-production or the ethanol will not have a market. At its current cost-of-production, it is unlikely that fuel ethanol production in Canada would occur at all without government supports. It is clear, however, that considerable investment is being made to find ways to reduce the costs of ethanol production.

The competitiveness of ethanol relative to gasoline depends on several factors, most notably the price of oil and the price of ethanol feedstocks (e.g. grain). Changes in the price of either input will directly impact the viability of ethanol production. For example, an increase in the price of oil will cause an increase in the price of gasoline, which in turn makes ethanol more competitive relative to gasoline.⁵ As ethanol feedstock prices increase, ethanol production costs increase, which decreases the viability of ethanol production. An optimal situation for ethanol producers is one in which oil prices are high and feedstock prices are low, a combination that has existed for much of the past two years.

Despite the currently favourable relative price conditions for ethanol production (which are, nevertheless, not sufficient to make ethanol competitive), contemplating

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⁵ This will be partially offset by increased prices for fuel used in ethanol production.

long-term viability requires that we also consider the situation where oil prices are low and feedstock prices are high. In this scenario, ethanol becomes even less competitive, and its continued production would require even higher levels of government support. Given that oil prices are presently near historic highs and feedstock prices are historically low (until recently), such a scenario is likely to occur. This is especially true when one considers that the U.S. government's plans for ethanol expansion call for a two-fold increase in production, and that increased North American ethanol production will undoubtedly put upward pressure on North American feedstock prices. To some extent this is already occurring today.

Given the history of the industry's dependence on government support, a primary consideration for investors is the uncertainty surrounding the long-term status of government support. Short-term government support of an industry is often rationalized by positing eventual economic viability, an argument often referred to as the "infant industry argument". However, offering early subsidization, support and protection often precludes maturation beyond the "infant" stage. In an era of free trade, it is not clear that this basis for support is sustainable. If ethanol production is feasible only as long as governments continue to offer tax exemptions and subsidies, and/or continue to mandate ethanol usage, assessment of the longevity of that commitment (not to mention advisability) is critical. Will the government be able to justify continued support for the industry once it has moved beyond its infancy? Are tax exemptions likely to continue indefinitely? Are governments willing to increase support if the economic conditions for ethanol production worsen? Manitoba, for example, has announced that it will be lowering its fuel tax exemption from 20 cents/litre to 15 cents/litre in 2007 and to 10 cents/litre in 2010 (Olar et al., 2004). Brazil initially supported its ethanol industry in the 1970s but had eliminated all direct subsidies by the early 1990s (Sandalow, 2005), though ethanol is still mandated and protected by very high tariffs (Gallagher et al., 2006). The willingness and ability of governments to support ethanol production in the long run is unknown, yet it must still be factored into any decision to invest in ethanol production.⁶ More importantly, the risks associated with investments predicated on the expectation of government subsidies must be carefully considered.

3.2. Accessing Export Markets

A second issue related to the advisability of expanding ethanol production in Saskatchewan has to do with acquiring access to other provincial, as well as international, markets. The increase in production being proposed by the provincial government far exceeds the level of local demand created through current proposed mandated usage. For example, the government proposes that an ethanol industry in Saskatchewan could feasibly produce as much as a billion litres of ethanol per year. If the government mandates that all gasoline contain 10% pure ethanol, the demand for ethanol in Saskatchewan would be satisfied at 130 million litres per year (Government of Saskatchewan, 2005). This would mean that close to 900 million litres per year would have to be exported to other provinces, to the U.S., or elsewhere.

⁶ The environmental justification for subsidies is considered in greater detail below.

The expansion of the ethanol industry thus appears to pre-suppose being able to export ethanol. The large-scale production increases currently being encouraged in potential destination jurisdictions, however, make access to these export markets questionable. For instance, Manitoba is attempting to expand its ethanol industry and will likely be looking to export ethanol that exceeds its mandated demand. Ontario is also pushing hard to increase ethanol production and is providing incentives to do so, while the Alberta government recently committed \$239 million over five years to expand its biofuels industry. Perhaps most importantly, the heavily subsidized U.S. ethanol industry is expanding rapidly, making that country's long-term demand for foreign ethanol uncertain at best. Of the 13.5 billion litres of ethanol consumed in the U.S. in 2004, only 600 million litres were imported. As of January 2006, there were 33 ethanol plants under construction in the U.S., so with this forecasted increase in ethanol capacity, it is likely that current consumption will be met through domestic production, if it has not already. Thus, it is not clear where Saskatchewan will find an export market for its production beyond provincially mandated demand.

In addition to uncertainty over export demand, there is also the potential for protectionist policies to prevent access of Saskatchewan ethanol into other jurisdictions. For example, to be eligible for tax exemptions in Saskatchewan and Manitoba, ethanol must be produced and consumed in those respective provinces. British Columbia and Quebec also require that ethanol be produced locally to be eligible for exemptions. Alberta and Ontario have no restriction on ethanol sources but this could change, depending on the extent to which local production can satisfy demand in those jurisdictions. Given that Saskatchewan protects its own ethanol production, it is likely that other provinces will follow suit as they seek to facilitate their own ethanol industries. If governments in other jurisdictions choose not to offer tax exemptions on imported ethanol, to access these markets the government of Saskatchewan would have to extend its own tax exemption to include all ethanol *produced* in Saskatchewan, as opposed to that which is both *produced and consumed* in Saskatchewan.

The potential for new protectionist policies to appear also needs to be considered in planning for exporting ethanol into U.S. markets. The U.S. ethanol industry relies heavily on government support and in cases where Canadian ethanol threatens the profitability of the American industry, it seems likely that the U.S. government will introduce tariffs that would preclude or seriously limit exporting to that country. Currently, the U.S. has only a general 2.5% *ad valorem* tariff on ethanol imports, but this seems likely to change once domestic supply is consistently able to keep up with demand. The much larger 54 cents/gallon (14.27 cents/litre) tariff directed at Brazilian ethanol illustrates the potential for much higher tariffs facing Canada in the future and according to WTO guidelines, the U.S. could levy a tariff if Saskatchewan is subsidizing ethanol.

The use of cellulosic technologies, though still in their infancy, could lower ethanol production costs sufficiently to offset tariffs that Canadian producers may face in international markets. However, there is still the potential for increased tariffs to offset potential increases in efficiency. Again, the 54 cent/gallon tariff charged by the U.S. on Brazilian ethanol is an example of this. In May 2006, American Congress voted down a proposal to reduce the tariff, indicating that the U.S. ethanol lobby carries

considerable weight in the U.S. Congress. Furthermore, even if Canadian ethanol entering the U.S. was not subject to tariffs, it is likely that new technologies will be accessible to producers elsewhere as well, thus mitigating any potential competitive advantage that these technologies can provide.

In addition to the influence of protectionist policies on ethanol export potential, distance to foreign markets could affect its ability to compete with other fuel sources. Unlike oil or natural gas, ethanol faces high transportation costs because it has to be transported by truck or rail. It cannot be transported by pipeline due to a high risk of water contamination that makes it difficult to blend with gasoline. There is also a risk of ethanol becoming contaminated with other petroleum products, including oils. This problem could be dealt with by the construction of pipelines exclusively for transporting ethanol, although this solution would be extremely expensive.

In summary, it would seem that relying on the export market is fraught with considerable risk and thus may not be a good basis for an expansion of the ethanol industry in Saskatchewan. A great many outstanding questions need to be addressed.

3.3. Competition for Feedstock

The rapid expansion of ethanol production in North America based on government support calls into question its potential impacts on other industries, most notably the livestock-feeding industry. Although one of the co-products of ethanol production is high-protein animal feed (e.g. dried distillers grains), this feed typically only makes up approximately 15% of an animal's diet (Government of Saskatchewan, 2005). Other components of animal feed must come directly from feed grains that are also used as an input for ethanol production, meaning that the ethanol industry competes directly with the livestock industry for feed. Feed prices in parts of the U.S. have increased with expanded ethanol production, and some economists predict that prices will continue to rise (Hart, 2006; Doering and Hurt, 2005). The hog and poultry industries are particularly vulnerable to competition from ethanol production because these industries are least able to utilize large quantities of dried distillers grains and therefore will not benefit from the increased availability of this product caused by expanded ethanol production (Elobeid et al., 2006). The net effect of this is that Canada will substitute ethanol production for livestock production because Canadian livestock will be less competitive on world markets. At the same time, consumers will end up paying more for livestock at the retail level, while taxpayers will absorb the cost of subsidies.

The rapid expansion of ethanol production in North America based on government support calls into question its potential impacts on other industries, most notably the livestock-feeding industry.

From the perspective of the Western Canadian livestock industry, the potential feed price increase problem is multiplied, as livestock producers are affected by ethanol production on both sides of the border. In recent years Western Canada has been experiencing a feed deficit, despite a relatively small ethanol industry. Traditionally this deficit has been made up by importing corn from the U.S. With the American ethanol industry experiencing a massive expansion of its own, the cost of such imports will likely increase. A further expansion of the Canadian ethanol industry will likely contribute to increased North American feed prices thus further increasing the cost of livestock production.

The effect of ethanol production on other industries is not unique to North America. In Brazil, for example, ethanol competes directly with the refined sugar market for sugarcane, the primary feedstock for both industries. The government of Brazil mandates the use of ethanol at rates that are determined on an annual basis. Changes in this rate affect the price received at the farm gate for sugarcane, as well as prices that manufacturers and consumers pay for refined sugar and ethanol. Because Brazil is such a large player in the refined sugar market, this also affects the world price of sugar (Schmitz et al, 2002). This Brazilian example illustrates why an expansion of the ethanol industry cannot be considered in isolation and why the impact on other industries that do not receive equivalent subsidies must be considered.

3.4. Rural Revitalization / Farm Income

One of the primary stated justifications for government involvement in ethanol production in Saskatchewan is its potential impact on the rural economy. The provincial government's ethanol plan suggests that an expanded ethanol industry will create permanent jobs in ethanol production as well as spin-off jobs in the livestock industry, and will increase farm income by providing new marketing opportunities for grain producers, thereby adding value to the struggling agriculture sector. The plan further suggests that the government will establish an environment necessary for expanded ethanol production through providing tax exemptions (15 cents/litre) on locally produced and consumed ethanol, through mandated ethanol usage, and through working with other governments to create new ethanol markets (Government of Saskatchewan, 2002).

The impact of an expanded ethanol industry (including indirect effects) on the rural economy must be carefully considered. To accurately assess the benefits to Saskatchewan's economy, one must also consider what such an investment could end up costing taxpayers and what the alternative uses of this subsidy might be. For example, consider a hypothetical scenario where the provincial government invests 25% of construction costs for a 400-million-litre/year ethanol industry (an investment 15% less than what it was prepared to do with three proposed plants discussed earlier), provides a tax exemption of 15 cents/litre on all production that is consumed in the province (130,000 million litres/year⁷), and mandates ethanol use at 10% of all gasoline sold in the province. The government estimates that the construction cost for new ethanol plants is between \$0.65/litre and \$1.00/litre per litre of capacity (Government of Saskatchewan, 2005). Assuming that the cost of construction is in the middle of this range (\$0.83/litre per litre of capacity), the total cost of construction for a 400-million-litre industry would be \$332 million. If the provincial government provided 25% of this, the investment would cost taxpayers \$83 million in capital costs. A 15 cent/litre tax exemption on 130 million litres would cost taxpayers an additional \$19.5 million annually. Mandated usage would not directly affect consumers, since

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⁷ The government currently subsidizes ethanol that is both produced and consumed within Saskatchewan. If ethanol usage is mandated at 10%, this will amount to 130 million litres of ethanol.

ethanol prices would be based on the price of gasoline.⁸ However, it would affect the profitability of refiners, who would be forced to substitute ethanol for gasoline and must purchase ethanol from an outside source. The cost to refiners is not included in this estimate.

According to Husky Energy's Website (2006), the construction of its 130-million-litre ethanol plant in Lloydminster will create up to 200 person-years of engineering and construction employment and will create 26 full-time permanent positions. If these numbers are extrapolated over a 400-million-litre industry, the result is 615 person-years of engineering and construction employment, and 80 full-time permanent jobs being created. In terms of the return on investment, an \$83 million capital investment by the government for building the plants would cost taxpayers \$135,000 for each engineering and construction person-year.⁹ For the \$19.5 million annual subsidy and the 80 permanent jobs created, the annual cost to taxpayers would be approximately \$244,000 per job. If the government elected to offer tax exemptions on all ethanol produced in Saskatchewan¹⁰ (at 400 million litres), this number would be closer to \$750,000 per year for each job. Given these numbers, it is imperative to consider whether an expanded ethanol industry is the most cost-effective way to create jobs in rural Saskatchewan. Even if the government elects not to provide money for ethanol start-ups, its tax exemption alone results in enormous cost for taxpayers, while providing very few permanent jobs. Moreover, this assessment does not take into account the potential loss of livestock jobs due to higher feed costs. While there is the potential for feedlots to be developed in conjunction with ethanol plants, thus creating spin-off jobs, neither of the two recently constructed plants (in Lloydminster and Weyburn) includes adjacent feedlots. It should also be noted that the opportunity costs of subsidizing this industry also includes roads, schools, health care facilities, recreation and cultural venues, all of which could improve the quality of life in rural Saskatchewan.

As noted above, the provincial government suggests that additional ethanol production in Saskatchewan would benefit grain producers by increasing the demand for feed grain. This assertion is questionable given that feed prices in Saskatchewan are established in the world market and ethanol plants in the province will source local feed grains only if they are cost competitive with potential (imported) substitutes. While there is evidence that North American ethanol production is putting upwards pressure on feed prices, the impact of Saskatchewan's ethanol industry on feed prices would likely be negligible. If feed prices received by grain farmers increase, this will occur with or without a Saskatchewan ethanol industry.

⁸ This does not include the potential costs to consumers associated with reduced fuel efficiency of ethanol relative to gasoline.

⁹ The construction phase is estimated to be approximately two years in duration.

¹⁰ As discussed earlier, this is conceivable if governments in other jurisdictions choose not to offer tax exemptions on imported ethanol and Saskatchewan expands its ethanol industry beyond levels that are required for provincial consumption (i.e. beyond 130 million litres per year).

3.5. Environmental / GHG Issues

In addition to rural revitalization, the Government of Saskatchewan cites environmental benefits as its other primary justification for facilitating the expansion of the province's ethanol industry. Ethanol-blended gasoline is purported to reduce net CO₂ emissions by as much as 10%, CO emissions by as much as 20% and smog-creating compounds by as much as 15% over pure gasoline (Government of Saskatchewan, 2002). For the blending levels being considered in Saskatchewan (E10 or 10% pure ethanol), current scientific evidence does not support this claim. For example, Niven (2004) conducted a review of current peer-reviewed literature on the environmental impact of ethanol and found that ethanol blended at 10% (E10) offers a GHG emission reduction ranging between 1% and 5%. He suggests that although E10 is more emission friendly than pure gasoline, its reduced energy content results in increased fuel consumption leading to a slight overall increase in GHG emissions. The emission reductions noted above occur only when the complete fuel life-cycle is examined, including ethanol production, transportation, and combustion. When ethanol is blended at 20% (E20), GHG emission reductions increase to between 2% and 11%, while E85 offers substantial GHG emission reductions (between 19% and 70%). Niven (2004) notes that the choice of feedstock does not have a large impact on emission reductions. He further notes that discrepancies between the various studies are largely the result of differing assumptions and input parameters and that these areas need to be improved in future studies. This view is endorsed by other recent studies on the environmental impacts of ethanol production (Farrell et al., 2006; Hammerschlag, 2006).

These emission reduction findings are consistent with the results of several recent government studies. Natural Resources Canada (2003a) found that ethanol-blended gasoline (made from wheat) containing 10% pure ethanol (E10) reduces GHG emissions by approximately 4.3% over pure gasoline. A similar study by the Government of Manitoba (2002) found the reduction in GHG emissions resulting from E10 to be 4.1%. A study commissioned by Climate Change Central (Rilett, 2003) estimates that emissions for E10 are reduced by between 1% and 5% over pure gasoline. Ethanol produced using cellulosic technologies (which are currently uneconomical) was estimated to reduce GHGs by as much as 8% (Natural Resources Canada, 2003b). All of these estimates are based on a full GHG emission life cycle that accounts for emissions resulting from the production of feedstocks and their related inputs, ethanol production, transportation, storage, and combustion, as well as emissions resulting from co-product production.

In terms of other environmental impacts, the literature suggests that ethanol production may actually do more harm than good. For example, Niven's review (2004) found that ethanol production may actually increase the production of smog, increases the risk of soil and groundwater contamination, and offers little advantage in terms of overall environmental sustainability. A study by Pimentel (2003) suggests that corn ethanol production is particularly harmful for the environment because it causes soil erosion at a greater rate than other crops and also uses more herbicides and pesticides. Pimentel further suggests that corn production requires more nitrogen than most crops, thus contributing to ground-water contamination. A final major criticism by Pimentel of corn ethanol production relates to the quantity of waste-water produced

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by ethanol plants. He suggests that each gallon of ethanol produced results in 12 gallons of waste water.¹¹ He notes that the cost of treating this water is not included in most cost-of-production studies. An increase in corn acreage as a result of ethanol expansion would exacerbate the negative impacts described here. Nevertheless, the negative environmental impacts of corn ethanol production are relevant for Saskatchewan only if ethanol producers are forced to import corn, a possibility if feed shortages worsen. To the extent that Saskatchewan ethanol producers would rely on imported corn, our ethanol production will contribute to the adverse environmental impacts described here.

¹¹ It should be noted that these technologies are rapidly developing and have the potential for significant improvements.

4. SUMMARY AND CONCLUSIONS

Based on the evidence presented here, it is apparent that there are numerous issues associated with ethanol production that need to be considered by private industry and governments prior to making investments. The single largest issue affecting the long-term viability of ethanol production is whether it can compete with gasoline in an open market. It is not uncommon for industries to require tax exemptions or other forms of subsidization to initially establish themselves. But this is normally justified by the expectation that the special concessions are short term and that there are great benefits to the broader public. In addition, the likelihood that ethanol will require mandated usage in addition to these supports should give some cause for concern. At present, without mandated usage there simply isn't a market for fuel ethanol and it is not clear that this will change in the future, despite the fact that conditions are as favourable for ethanol production now as they have ever been. The assertion that these conditions will continue in the long run is optimistic at best. Oil prices are already showing signs of leveling off, and feed prices will certainly rise as ethanol production expands. If either or both of these occur, it is likely that an ethanol industry will require additional government support to remain viable.

Related to the issue of long-term public support of the sector is the risk associated with depending on an export (outside the province) market. Rapid expansion of the industry elsewhere in North America, coupled with protectionist policies in most jurisdictions make the prospect of an export market tenuous. Governments elsewhere have a lot of money invested in ethanol, and it is unlikely that they will offer incentives for Saskatchewan ethanol unless they are unable to fulfill their own demand. It is quite possible that the 15 cents/litre subsidy offered by our provincial government would have to be extended to all ethanol produced in Saskatchewan (as opposed to the 130 million litres that will be consumed here), a prospect that would require an annual subsidy of \$60 million for a 400-million-litre industry. In the case of the U.S., even if they cannot meet their own demand, it is quite possible that Canadian ethanol will face additional tariffs, as the Brazilian example clearly illustrates. Saskatchewan cannot cry foul because it is also unwilling to subsidize ethanol produced in other jurisdictions and has openly stated that it does not want to rely on ethanol imports from elsewhere to satisfy local demand.

In terms of rural revitalization, it is conceivable that an expanded ethanol industry could create 80 full-time permanent jobs in rural Saskatchewan and may offer grain farmers a new market alternative. The real question, however, is what the opportunity costs are for creating this growth. Even if the government does not invest directly in ethanol plants, the cost of a relatively minor rural revitalization initiative could result in significant long-term costs to taxpayers (between \$20 million and \$60 million annually). The question has to be asked whether there is a better use for this money to stimulate the rural economy.

A concern with ethanol's effect on the rural economy has to do with its impact on the livestock sector. While it is unclear what the long-term effect of ethanol will be on that sector, it is evident that livestock producers will face increased feed prices and consumers will encounter increased prices at the retail level. If livestock producers are able to pass on these costs to consumers, the net result of the policy is essentially a tax

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on consumption. Producer-owned ethanol plants with feedlots are perhaps one way of mitigating this risk, as they would allow for hedging on grain prices. However, producer-owned facilities are typically smaller, which could decrease efficiency and prevent the capture of economies of scale typically associated with large plants. It should also be emphasized that because feed grain prices in Saskatchewan are set in the world market-place, any price increase (and potential benefit to grain producers) is likely to occur regardless of whether Saskatchewan expands its own ethanol production.

A final issue affecting the viability of an expanded ethanol industry is its questionable impact on the environment. Consumers are led to believe that ethanol is undeniably “green”, yet there is evidence that refutes this or at least suggests that the positive effects are less than is often professed. If ethanol was economical, consumers would probably be willing to overlook this. However, problems will surely arise if neither economic nor environmental benefits accrue. On the plus side, there is some evidence that cellulosic technology may someday allow the fuel to live up to its environmentally friendly billing.

Despite governments’ willingness to heavily subsidize the ethanol industry in the short run, the real risk for private industry occurs in determining whether the government will maintain or increase these supports (when required) in the long run. As for governments themselves, they must clearly identify what they hope to accomplish by investing in ethanol plants, subsidizing production and mandating consumption. Once this is done, they should be able to clearly state the risks and quantify both the costs and benefits of their investment, and in doing so justify the investment itself. Given the issues identified in this paper, it is clear that this has yet to be done.

Although additional research is required to answer the five questions we address in this paper, our findings suggest that in the foreseeable future the ethanol industry in Saskatchewan will not be viable in the absence of government subsidies and mandated use. Further, access to export markets seems a high risk basis for industry expansion, while impacts on the livestock industry require careful consideration. Positive impacts on the rural economy appear limited and occur at very high cost, while environmental benefits are uncertain. Good information and an objective assessment of the facts are necessary for informed decisions around private and public investment in an ethanol industry in Saskatchewan.

5. FUTURE RESEARCH

The unknowns implicit in the above discussion suggest the need for current, objective research based on a number of scenarios for the industry, especially a “no subsidy” option to truly assess the advisability of the development of an ethanol industry in the province. In addition, the claimed positive ‘externalities’, or side effects, such as rural development and environmental benefits require systematic investigation with a careful consideration of alternative uses of public money to achieve these ends.

More specifically, potentially useful government investment in research may be:

1. *Cellulosic technologies.* These technologies have been shown to be more environmentally friendly and have the ability to make ethanol more competitive with gasoline.
2. *Ethanol transportation.* Currently, the only way to move ethanol is by truck or rail. Given that Saskatchewan is located a long way from major fuel markets, a mechanism for reducing these costs is essential if the province is ever to compete internationally in ethanol production.
3. *Rural economy solutions.* While the rural economy is struggling in many areas, there are bright spots where rural manufacturing or tourism has provided new industry and new jobs that assist in retaining population. Likewise, there are cases where rural-urban interdependencies have allowed rural communities to benefit from urban-based growth. Research to determine the bases for existing successes and the means of providing an environment that may permit replication of these successes may yield a higher return and more employment than subsidizing an ethanol industry.
4. *Ethanol expansion and the livestock industry.* A final area of research has to do with the relationship between ethanol expansion and the livestock industry. A system-wide approach considering the full range of linkages would be useful.

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