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ETHANOL

The fuel ethanol industry is an important market for North American grains, particularly corn which is the primary feedstock used in ethanol production. The economics of ethanol production improved significantly during the latter part of 2000 due to a combination of relatively low commodity prices, record high crude oil prices, and advances in production technologies. In both the United States (U.S.) and Canada, concerns about environmental issues and the need for sustainable energy sources continue to be primary considerations in the long-term prospects for the ethanol industry. This issue of the *Bi-weekly Bulletin* examines developments in the ethanol industry and the implications for the agricultural sector.

Background

The origins of ethanol as fuel for automobiles go back to the early days of the Ford Model-T car, however, ethanol production virtually stopped during the prohibition years. It was during the early 1970s that ethanol re-emerged and began to gain favour in the U.S., which, at the time, was heavily reliant on crude oil imports and experiencing fuel shortages. In response, the U.S. Congress, under the first U.S. *Clean Air Act* established a federal ethanol program in 1979 to encourage the production of fuel from domestic, renewable energy sources such as corn. The program allows gasoline marketers who blend their fuel with ethanol to claim a gasoline tax exemption of 54 cents for each gallon of ethanol that is blended into qualifying gasohol.

In Canada, the first commercial venture into renewable fuels was the 1980 renovation of an idled distillery in Minnedosa, Manitoba by Mohawk Oil Company Ltd. for the production of wheat-based ethanol. The Minnedosa plant currently uses about 27,000 tonnes (t) of grain annually, most of which is wheat in the following proportions: Canada Prairie Spring wheat, 50%; durum and extra strong wheat, 30%; and winter wheat, 10%. Less than 10% of the total grain used at this plant is non-wheat, most of which is corn. Small amounts of rye and triticale are used for ethanol production.

Since 1980, Canada's ethanol industry has expanded from 1 plant producing 10 million litres (ML) of ethanol, to 4 plants capable of producing 238 ML of various grades of ethanol annually. This equates to about 600,000 t of corn, or about 8% of Canada's annual corn production. Canada's ethanol industry is currently concentrated in Ontario, its major corn growing province. Commercial Alcohols Inc.'s Chatham plant, which started operations in late 1997, is the largest in Canada and employs 65 people, producing about 150 ML of ethanol annually. This highly automated and energy efficient plant also produces 125,000 t of dried distillers grains and 100,000 t of compressed, food-grade carbon dioxide annually.

As global corn prices declined during the 1980s, U.S. legislators saw ethanol production as a means of increasing domestic corn use and helping to stabilize farm incomes. From an environmental standpoint, ethanol use in automobiles has helped to reduce carbon monoxide emissions, as mandated by the U.S. *Clean Air Act of 1990*.

In Canada, fuel ethanol is an important market for Canadian grains, and any increases in ethanol production are seen as beneficial to the agricultural sector and rural communities, as well as the environment.

Did you know?

- corn grown in Illinois is used to produce 40% of the ethanol consumed in the U.S.;
- more than 95% of the gasoline sold in the Chicago area contains 10% ethanol;
- it is virtually impossible for ethanol to contaminate drinking water because it biodegrades easily and quickly;
- the use of ethanol fuels reduces particulate matter emissions (when blended with diesel fuel), carbon monoxide, and greenhouse gases that cause global warming;
- ethanol use enhances engine performance by increasing octane and raising oxygen levels, cleaning and preventing engine deposits, and acting as a gas-line antifreeze.

Canada

The Government of Canada has granted an excise tax exemption of 10 cents per litre (¢/L) on ethanol that is blended with gasoline as a means of encouraging its production and use. In addition, "Fleetwise" is a federal initiative aimed at reducing automobile pollution, and it involves a phased-in approach for increasing the use of alternative fuels such as ethanol. This includes integrating environmental considerations and sound management practices in the operation of the government's fleet of motor vehicles, including the acquisition of alternative fuel vehicles. In addition to the federal initiatives, several Canadian provinces provide varying levels of road tax exemptions which help ethanol-blended fuels compete with regular gasoline. Ontario, for example, waives its 14.7¢/L provincial fuel tax for the ethanol portion of ethanol-blended fuels.

CANADA: ETHANOL PRODUCTION PLANTS

OPERATING

Producer	Location	Capacity (million litres)	Commodity Base
API Grain Processors	Red Deer, Alberta	26	wheat
Commercial Alcohols Inc.	Tiverton, Ontario	23	corn
Commercial Alcohols Inc.	Chatham, Ontario	150	corn
Mohawk Oil, Canada, Ltd.	Minnedosa, Manitoba	10	wheat
Pound-Maker Agventures, Ltd.	Lanigan, Saskatchewan	12	wheat
Tembec Inc.	Temiscaming, Quebec	17	forestry product

PLANNED OR UNDER CONSTRUCTION

Producer	Location	Capacity (million litres)	Commodity Base
Commercial Alcohols Inc.	Varennes, Quebec	150	corn
Commercial Alcohols Inc.	Chatham, Ontario	150 *	corn
Seaway Grain Processors, Inc.	Cornwall, Ontario	66	corn

* expected from expansion

Source: Canadian Renewable Fuels Association

Globally, the demand for alcohol-based fuels is estimated at 27 billion litres (GL) per year, which is equivalent to about 4% of world grain production. Brazil, for example, is a world leader in the use of fuel ethanol and the majority of its cars operate on either a 95% or a 24% ethanol-blended gasoline. Responding to the oil crisis of the 1970s, the Brazilian government, in cooperation with private industry, created a national program to produce alcohol from sugar cane and to build engines designed to run on nearly pure ethanol. More recently, the largest growth has been in the use of lower ethanol-blended gasolines, due largely to higher sugar cane prices.

The Economics of Ethanol Production

The feasibility of ethanol production depends on several factors. A major consideration with any new construction or expansion is the huge capital investment in plant and equipment. However, as with most capital-intensive industries, there are economies of scale to be exploited which, combined with technological advances, have helped reduce the cost of ethanol production at some plants by as much as 50% during the past decade. As well, the cost of feed stock and the price of ethanol relative to other, non-renewable sources of energy are critical to determining the feasibility of ethanol production.

In terms of benefits to the economy, the ethanol industry provides jobs for the residents of smaller, rural communities where the plants are often located. The United States Department of Agriculture (USDA) estimates that a 100 million gallons (Mgal.) plant creates about 2,500 direct and indirect jobs.

Ethanol is an important value-added market for **U.S.** farmers. As the third largest use of corn behind feed and exports, the ethanol industry uses about 7% of the U.S. annual corn crop, which was 10 billion bushels in 2000-2001. A 1997 study commissioned for the Midwestern Governors' Council concluded that ethanol use increased net farm income by US$4.5 billion, improved the U.S. trade balance by US$2 billion, and resulted in net savings of US$3.6 billion in the federal budget. In addition, for every 100 million bushels (Mbu) of corn that are used in ethanol production, the price of all corn (including Canadian) is estimated to increase about US$0.15 per bushel (/bu).

Ethanol competes directly with fossil fuels. In the past, critics of ethanol have cited high production costs relative to gasoline as its major drawback, without taking into account large government subsidies to the oil and gas industry. In a recent U.S. General Accounting Office (GAO) report, the Joint Committee on Taxation (JCT) estimated subsidies to the oil and gas industry at about US$54 billion over the past 20 years. For the same period, subsidies to the ethanol industry have been estimated by the JCT at US$8 billion.

In **Canada**, the estimated cost of ethanol production from grain ranges between CAN$0.35 and CAN$0.45/L, which is significantly higher than the refinery-gate price of gasoline. However, with larger and more efficient plants either being planned or recently having come into operation, ethanol is becoming closer to being price-competitive with gasoline. Similar to the situation in the U.S., the refinery-gate price of gasoline in Canada reflects the subsidies government provides in the form of tax write-offs for exploration expenses, and the government's contribution to mega-projects such as Hibernia and the Alberta Tar Sands.

There are other considerations when assessing the relative value of ethanol. These include the environmental and societal costs of burning regular gasoline. Currently, the highest economic value of ethanol is as a replacement for some of the octane enhancers which are considered a serious health risk. Benzene is one of those enhancers used in gasoline and it is a known carcinogenic.

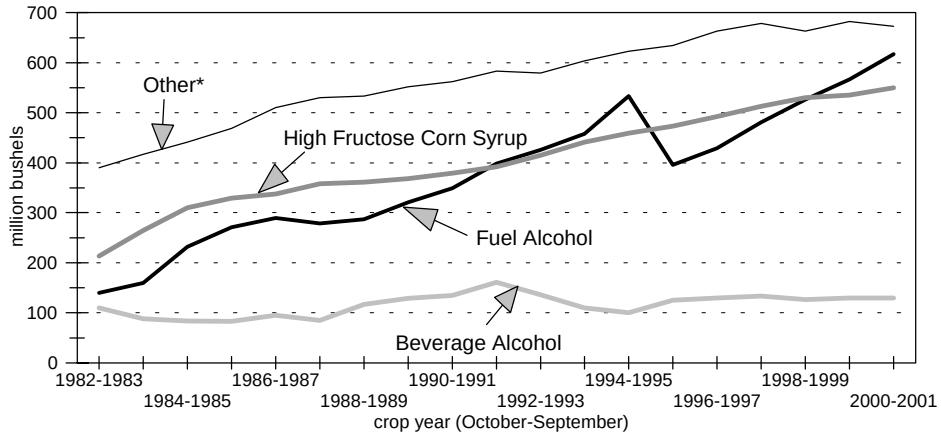
Another consideration is that there are virtually no waste products in the production of ethanol, especially from feedstocks such as corn. One bushel of

corn yields between 10 to 11L of ethanol and several valuable co-products, depending on the milling process. Dried distillers grains, a high-energy animal food ingredient, and carbon dioxide, which is used by the food and beverage industry, are two co-products of the dry milling process. The dry milling process has lower production costs and higher ethanol yields, although the co-products tend to be of lower value. The wet milling process compensates for a slightly lower ethanol yield with higher-valued co-products such as sweeteners, corn oil, gluten feed and gluten meal. The choice between the two technologies is dependent on many factors, but the main consideration is the size of the plant. For very large plants, the economics of production favour wet milling. In Canada, due to market conditions, plants tend to be smaller, and dry milling technology predominates in this country.

In terms of an energy balance, or on a "comprehensive life cycle basis", ethanol contains about twice the amount of energy required to produce it. This includes the energy used to produce the various inputs of production such as fertilizer and pesticides, the fuel costs associated with grain production, and the cost of transporting grain from the farm to the ethanol plant, and from the ethanol plant to the retailer. Ethanol yields an estimated 26,575 British thermal units (BTU) of energy per litre (BTU/L), and there are about 3,720 BTU of energy in the co-products of ethanol production, which brings the total energy value to 30,290 BTU. There are about 4,700 BTU of energy required to produce the amount of corn required for 1 litre of ethanol, and 13,300 BTU to process the corn into ethanol, which leaves a net gain of 16,990 BTU/L of ethanol.

The use of petroleum-derived energy in the production and transportation of inputs for ethanol production is more than offset by the solar energy captured through the process of photosynthesis. This positive energy balance is expected to improve as crop and ethanol production processes become more efficient. In the U.S., the ratio of energy content to energy required to produce ethanol is slightly lower than in Canada due to a heavier reliance on irrigation which itself consumes energy and increases the costs of production.

U.S. CORN: FOOD, SEED, AND INDUSTRIAL USE



* Other includes: glucose and dextrose, starch, seed, and cereals and other products.

Source: USDA

Historical data show that global and domestic prices for corn and other grains, adjusted for inflation, have trended downward since 1950. If real grain prices continue to trend downward, and if developed countries increase their dependence on crude oil from remote and/or expensive sources, fuel ethanol will become more price-competitive with gasoline.

Canada is more self-sufficient in energy sources than the U.S., but it has become more dependent on imported crude oil in recent years, importing up to 82 ML of light crude per day. These imports represent billions of dollars flowing out of the Canadian economy annually that might be invested domestically, creating more job opportunities for Canadians. Additional benefits to be derived from increased ethanol production are the valuable co-products such as distillers grain that can be substituted for the imports of high-protein livestock feed ingredients valued at about CAN$200M annually.

Ethanol as an Oxygenate

The Energy Policy Act of 1992 legislated oil companies to add an oxygenate to their fuels as a further means of reducing exhaust emissions. Oxygenates have been used to boost octane levels since leaded gasoline was phased out due to the health risks associated with lead in automobile fuel. Now, ethanol is increasingly being used in place of other oxygenates, some of which have less-than-desirable effects on the environment. They are: methanol, which is a derivative of natural gas; Methyl Tertiary Butyl Ether (MTBE), which is made by combining methanol and isobutylene; Ethyl Tertiary Butyl Ether (ETBE), which is a combination of ethanol and isobutylene; and Tertiary Amyl Methyl Ether (TAME) and Tertiary Amyl Ether Ether (TAEE), which are complex methyl and ethyl ethers, both with similar characteristics to MTBE and ETBE. The U.S. Environmental Protection Agency has supported major reductions in the use of MTBE in order to protect drinking water supplies.

Ethanol Production

In the **U.S.**, there are about 60 ethanol plants with a total productive capacity of about 1.8 billion gallons (Ggal.). During the 1980s, Archer Daniels Midland (ADM) dominated the ethanol industry, accounting for about 75% of the nation's ethanol output. By 1997, ADM's share dropped to about half, but it is by far the largest producer with an annual capacity of about 0.75 Ggal., followed by Minnesota Corn Processors, Midwest Grain, Cargill, and Williams Energy Services, each with about 0.1 Ggal. capacity. ADM's ethanol plants are located in Iowa and Illinois which, together with Nebraska and Minnesota, account for more than half of U.S. corn production and 95% of total domestic ethanol production. For 2000, U.S. ethanol production is estimated at 1.6-1.7 Ggal., up from 1.47 Ggal. in 1999, but still slightly below capacity.

At the state level, **Illinois** leads in the production and use of ethanol-blended gasoline. With annual production at more than 730 Mgal., nearly half of the gasoline sold in Illinois contains 10% ethanol. Illinois is also taking the lead with the introduction and operation of one of the largest fleets of flexible fuel vehicles

(FFV), which are designed to run on E85, regular unleaded gasoline, or any combination thereof. E85 is a blend of 85% ethanol and 15% gasoline, and has been touted as an effective way to increase the use of ethanol in automobiles and to eliminate harmful emissions. **Iowa** is the second largest ethanol producing state with 430 Mgal. produced annually but it only uses about 15% of that production, exporting the rest to other states. **Minnesota** legislators are looking to secure $30 million worth of state funding over the next five years to install E85 pumps at many of the state's gasoline stations. The plan would offer gas station owners matching grants of up to $20,000 to install the E85 stations. Stations that have already installed E85 pumps would receive a tax exemption for the equipment they have purchased. The plan would also require Minnesota officials to purchase FFVs for their fleets whenever that option becomes available.

In **Canada**, annual production of ethanol is currently about 238 ML (62.9 USMgal.) and this total includes fuel, industrial and beverage grades of alcohol. More than half of that total is produced at the Commercial Alcohols Inc. plant in Chatham. The company plans to double capacity at the Chatham plant to 300 ML and, in addition, plans to build a $100 million ethanol plant in Varennes, Quebec. When fully operational, the Varennes plant is expected to employ 50 full-time employees and produce 120ML of fuel grade ethanol. The ethanol produced at the Varennes plant will be blended with gasoline and, for the first time, it will be sold at Petro-Canada stations throughout Quebec. Petro-Canada joins retailers Sunoco Inc. in Ontario, and Husky Energy Inc. in western Canada, as a major marketer of ethanol blends of gasoline in Canada. Once all proposed Canadian plants are fully operational, which would be sometime in 2002, Canada's ethanol production is expected to be about 675 ML annually.

On the basis of population, Canada's current ethanol production lags that of the U.S. However, with the proposed expansion in plant ethanol capacity, Canada's ethanol production-to-population ratio is expected to fall more in line with that of the U.S. Canada currently has one station dispensing E85 and it is located in Ottawa. This station is operated by Natural Resources Canada and provides E85 fuel for a fleet of government vehicles.

Looking to the Future

A study commissioned by the Governors' Ethanol Coalition for the Renewable Fuels Association concluded that the **U.S.** ethanol industry could produce, if required, up to 3.5 Ggal. annually by 2004. The industry expects to easily meet any additional demand for ethanol resulting from the anticipated phase-out of the gasoline additive MTBE. The study also concluded that replacing MTBE with ethanol would increase the price of corn by about US$0.14/bu, and increase household income in the agricultural sector by about US$2 billion.

In November 2000, the U.S. government announced a $300 million program aimed at expanding production of ethanol and other alternative source fuels. Under the two-year program, the USDA will make cash payments to bioenergy companies that increase their use of corn, soybeans and other commodities in the production of ethanol, biodiesel and other biofuels. The program is seen as a good way to use up surplus grain supplies.

For December 2000, the USDA reported record high corn use for ethanol production. At the same time, carry-in stocks of ethanol decreased as relatively high MTBE prices encouraged the use of ethanol as a substitute for MTBE in oxygenated and reformulated gasoline. Although MTBE production could recover with expected lower natural gas prices in 2001, demand for ethanol should remain strong. This is in part due to the Bioenergy Program which provides incentives for companies to increase ethanol production in order to meet proposed clean air requirements. About two-thirds of the 60 companies that produce ethanol have committed to increasing ethanol production which should increase total production by about 246 Mgal.

In the U.S., new ethanol plant construction is currently concentrated in the upper midwest, namely Iowa, Minnesota and South Dakota, where corn prices are reasonably attractive to the industry. There are plants with a combined capacity of 75 Mgal. either being built or in the planning stage. For 2000-2001, the use of corn for ethanol production is estimated to increase by 9%, from the 566 Mbu used in 1999-2000.

In **Canada**, the construction of biomass-based ethanol plants is encouraged under the *Government of Canada Action Plan 2000 on Climate Change* announced in October 2000. This five-year initiative could enable as much as 25% of Canada's total gasoline supply to contain 10% ethanol, a blend that is readily used in all cars.

A recent study commissioned by Agriculture and Agri-Food Canada has concluded that 10% ethanol blends derived from corn in southern Ontario reduced greenhouse gases (GHG) by 230,000 t per year. If the industry were to expand production to 1 GL of ethanol per year, the total GHG reductions would be about 1.47 Mt in carbon dioxide equivalents. For the transportation sector, this represents a significant reduction in GHG of 7%.

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