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# Ethanol and Biodiesel in Canada: Can They Help Meet Canada's Kyoto Commitment?[1]

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## The Issue

The Canadian government ratified the Kyoto Protocol in December 2002. The protocol calls for greenhouse gas emissions to be reduced by 6 percent below the 1990 level (approximately 35 percent below what they are expected to be in a business-as-usual situation) by 2008–2012. To help meet this target, both federal and provincial governments in Canada have developed programs (in some cases mandates) for ethanol and biodiesel production and use in fuel blends. Various subsidy schemes have been

designed to stimulate development of a biofuels industry in Canada. While the programs have been promoted on the basis of environmental concerns, a major driver has been the search for new markets for Canadian agricultural commodities that face chronically depressed prices. The purposes of this article are to review the current state of policies, programs and production of ethanol and biodiesel in Canada and to assess the prospect of these biofuels to significantly reduce production of greenhouse gases in Canada.

## Implications and Conclusions

Increased use of ethanol and biodiesel offers several environmental advantages to Canadian society, including decreased greenhouse gas emissions and decreased criteria air contaminants in tailpipe emissions. Even if ethanol and biodiesel use in Canada were to achieve the targeted and mandated levels established by governments, the total direct greenhouse gas emission reduction would represent only 1.4 percent of the approximately 200 million tonne annual reduction needed to meet the targets of the Kyoto Protocol. Existing technologies do not appear to make the manufacture of these biofuels a profitable venture for private sector companies without substantial government assistance. It is clear that the Canadian public is supportive of cleaner, more environmentally friendly fuels. But much research is required to make production of the biologically produced fuels less costly. Research is needed on higher yielding crops and biomass, development of new high-value co-products from the production process, and improved methods to cheaply extract sugars from cellulosic raw materials. Until such research bears greater fruit, the prospect for significant greenhouse gas reduction through the production and use of bio-fuels will not be great.

## Introduction

The Canadian government ratified the Kyoto Protocol in late 2002. The protocol calls for the reduction of greenhouse gas (GHG) emissions by 2008–2012 to 565 million tonnes per year of $CO_2$ equivalent (94 percent of their 1990 level). Greenhouse gas emissions are projected to increase to 763 million tonnes per year by 2010 under business-as-usual (BAU) conditions; thus, the protocol targets require a reduction of more than 35 percent below the BAU situation. While an implementation plan to achieve this reduction has not yet been agreed with the provinces and industries, increased use of ethanol, biodiesel and other biofuels has been promoted as integral to successfully achieving this target.

The purposes of this article are to review the policies and programs aimed at increasing production of ethanol and biodiesel in Canada, examine the progress made to date, and assess the potential contribution of these biofuels to fulfilling Canada's commitment to greenhouse gas emission reductions as agreed in the Kyoto Protocol.

## Policies and Programs for Ethanol and Biodiesel in Canada

The federal and most provincial governments of Canada have initiated programs to increase the production and consumption of ethanol and biodiesel. A summary of the major elements of these government programs is provided in table 1. The programs are described in more detail below.

**Table 1** Tax Exemptions for Fuel Ethanol and Biodiesel by Province

| Govt. | Category | Provincial fuel tax exemptions (¢/litre) | Eligibility for the subsidy | Duration |
|---|---|---|---|---|
| AB | ethanol | 9.0 | No restriction on ethanol source | 5 years after the start-up of an ethanol production plant |
| | biodiesel | 0.0 | - | - |
| BC | ethanol | 14.5 | For E85 to E100 and E5 to E25 Ethanol must be produced in BC | |
| | biodiesel | 15.0 | For B5 to B50 | |
| ON | ethanol | 14.7 | No restriction on ethanol source | Until 2010 |
| | biodiesel | 14.3 | No restriction on ethanol source | From June 2003 |
| SK | ethanol | 15.0 | Ethanol must be produced and consumed in SK | 5 years |
| | biodiesel | 0.0 | - | |
| QC | ethanol | 16 to 20 (under project) | Ethanol must be produced in QC | 1999–2012 |
| | biodiesel | 0.0 | - | |
| MN | ethanol | 20 until Aug. 2007<br>15, Sept. 2010–Aug. 201<br>10, Sept. 2010–Aug. 201<br>(also, 1.5¢/l excise tax reduction for gasoline blended with 10% Manitoba-made ethanol) | Ethanol must be produced and consumed in MN | No duration specified |
| | biodiesel | 0.0 | - | |
| Federal | ethanol | 10.0 | No restriction on ethanol source | No duration specified |
| | biodiesel | 4.0 | No restriction on ethanol source | From Feb. 18, 2003 |

Sources: Cheminfo Services, $(S\&T)^2$ Consultants, and Cemcorp, 2000; Government of Manitoba, 2002, 2003b; British Columbia Ministry of Provincial Revenue, 2004; Department of Finance Canada, 2003; Ministry of Agriculture and Food Ontario, 2003

### *Federal Government*

The federal government in Canada promotes the development of a fuel ethanol industry through two main instruments. The first is an exemption from excise tax on gasoline and diesel fuel (amounting to 10 cents per litre on ethanol and 4 cents per litre on biodiesel). The federal excise gasoline tax is not imposed on the portion of ethanol or biodiesel contained in the final product – often called gasohol for gasoline-burning engines. The

second major federal initiative is the Ethanol Expansion Program[2] (EEP). The EEP establishes a national target of increasing the consumption of fuel ethanol in Canada. The program calls for at least 35 percent of Canadian consumption of gasoline by 2010 (mid-point of the 2008–2012 assessment period in the Kyoto Protocol) to be E10 (10 percent ethanol and 90 percent gasoline). If this target is to be met, ethanol production will have to increase to 1.4 billion litres per year by 2010 (from the existing 0.238 billion litres). Imports of U.S.-produced fuel ethanol are eligible for the Canadian federal excise tax exemption on ethanol-blended fuels (Government of Manitoba, 2002). All fuel ethanol use in Canada, whether from domestic or foreign sources, enjoys the same tax exemption. NAFTA countries also pay no import duty (Tupper, 2004).

The Ethanol Expansion Program provides support for ethanol in three ways: $140 million for contingent loan guarantees; $100 million for the financing of fuel ethanol production facilities (subsidy cannot represent more than 25 percent of total project costs minus other federal, provincial/territorial and municipal government contributions); and $3 million for public awareness financing to provide market information for consumers. The contingent loan guarantee program was created to offset any reduction or elimination of the excise tax exemption that could affect the viability of new ethanol plants. The program will come into effect if reductions are imposed prior to December 31, 2014 (Farm Credit Canada, 2004). The contingent loans would be repayable at commercial rates of interest (Government of Canada, 2001).

The Ethanol Expansion Program is expected to help finance seven ethanol plants that would have production capacity of 739 million litres per year. Figure 1 shows the location and capacity of existing and EEP-financed ethanol plants. Plans are in the works for 19 other projected ethanol plants that would provide additional production of 1,200 million litres per year. In part, these plants are to be assisted financially by provincial governments.

In addition to the EEP and the exemption of excise taxes, the federal government shows leadership by operating its E85 poly-fuels vehicle fleet, which can use all ethanol-gasoline blends up to 85 percent ethanol (Coopérative Fédérée de Québec, 2004).

Figure 2 shows the evolution of Canadian ethanol supply from 1976 to present and the projected supply for the next 10–20 years (based on EEP-financed plants and projected capacities of planned plants). Ethanol production capacities in Canada have increased substantially from the mid 1990s to present and this increase is expected to continue exponentially until 2020 due to the construction of plants financed partially by public funds.

The financial support for biodiesel offered by the federal government amounts to $11.9 million allocated from the 2003 budget. This contribution will be used to support research and provide incentives for industrial-scale biodiesel pilot plants and to support demonstrations of its effectiveness to encourage broader use of this cleaner-burning alternative to conventional diesel fuel (Government of Canada, 2003b).

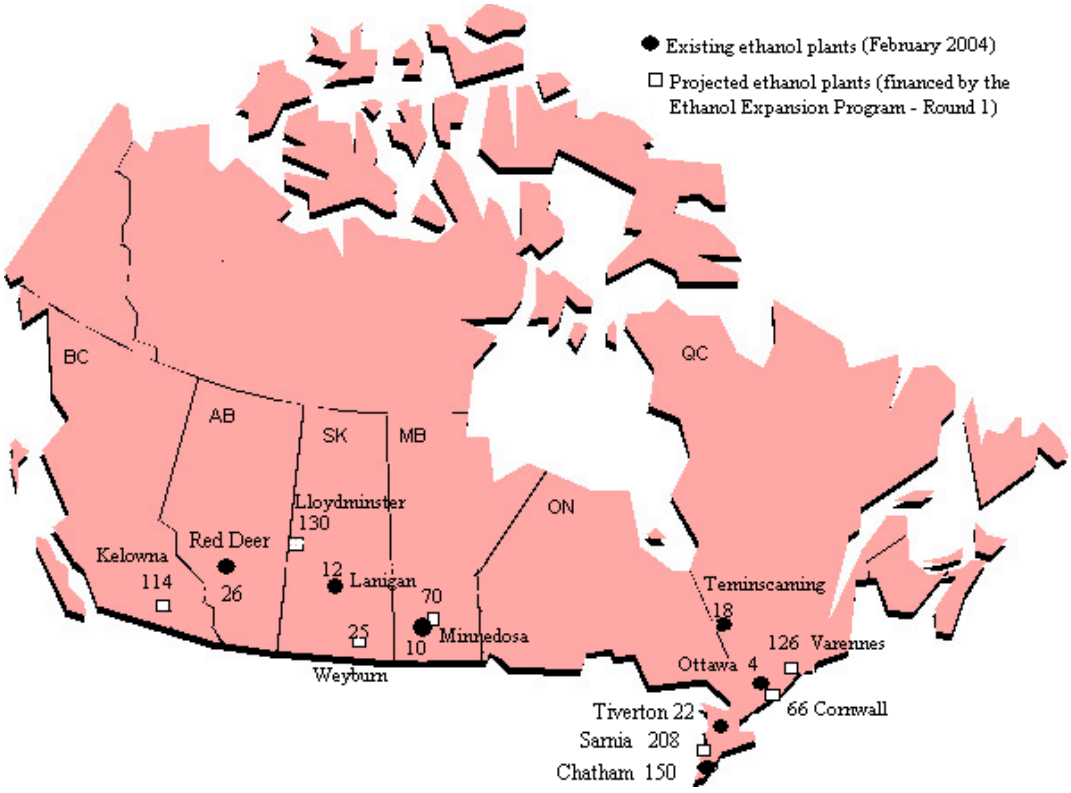


**Figure 1** Existing and projected ethanol plants in Canada (million litres/year).

If the federal government targets are met, it is estimated that the renewable resource–associated GHG reductions will be in the order of 2.8 million tonnes of $CO_2$ per year, which includes a 1.7 million tonne reduction due to the targeted use of 1.4 billion litres of ethanol, and a 1.1 million tonne reduction due to the targeted use of 500 million litres of biodiesel (Government of Canada, 2002), compared to the BAU scenario (Government of Canada, 2003a).

### *Provinces*

Provincial policies on fuel ethanol are driven mainly by the characteristics of the provinces' economies. The governments of Manitoba and Saskatchewan have a conciliatory ethanol expansion policy since they consider expansion of ethanol use as a potential boost for their rural economies. The government of Alberta offers lower subsidies than do other provinces, perhaps due to the importance of its oil industry.

British Columbia is interested in the commercial feasibility of cellulose-based ethanol production technology because of residues associated with forestry. On June 11, 2004, the government of British Columbia announced that, effective July 1, 2004, ethanol blended with gasoline will be exempt from the 14.5 cent per litre excise tax, provided the blended product contains at least 5 percent and no more than 25 percent ethanol (Canadian Taxpayers Federation, 2004; British Columbia Ministry of Provincial Revenue, 2004).

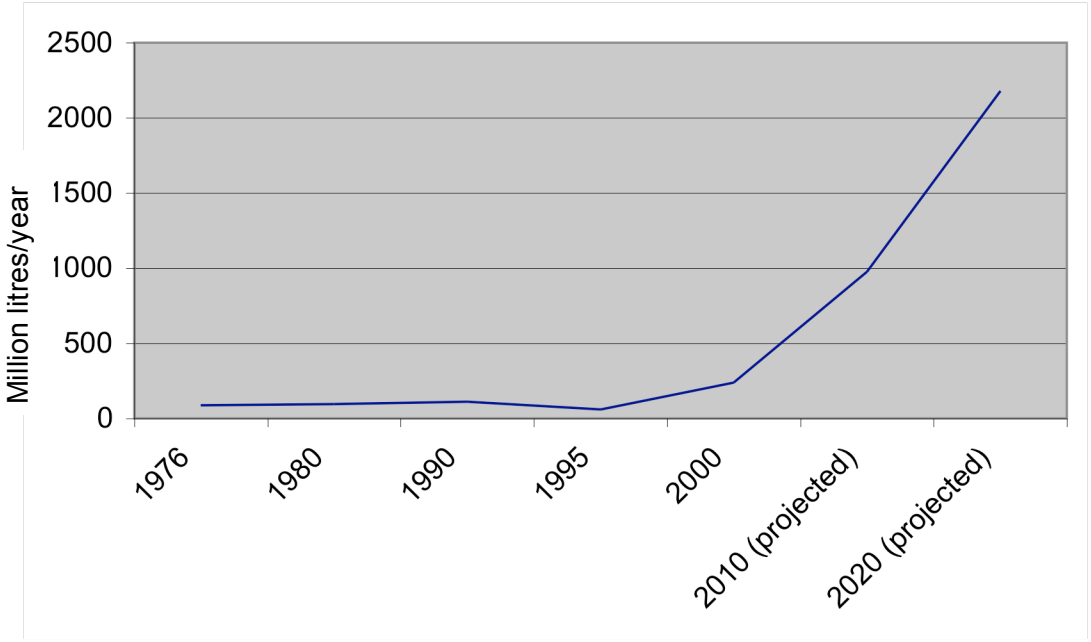


**Figure 2** Canadian ethanol production capacity.

Sources: Cheminfo Services, (S&T)$^2$ Consultants and Cemcorp, 2000; Government of Canada, 2004

The Alberta government has had an ethanol program in effect since 1993. The program guarantees that the exemption of provincial fuel tax payable on vehicle fuel will continue for a period of five years after the start-up of an ethanol production plant. The exemption is currently 9 cents per litre of ethanol sold in the province (Cheminfo Services Inc., (S&T)$^2$ Consultants Inc. and Cemcorp Ltd., 2000). The Government of Alberta maintains its ethanol fuel tax exemption for ethanol sold in the province regardless of where it is produced (Tupper, 2004).

For several years, the government of Saskatchewan subsidised the Lanigan ethanol plant owned by Pound-Maker Agventures Ltd. at the level of 40 cents per litre of ethanol (Freeze and Peters, 1999). The Saskatchewan government's ethanol policy was changed in the March 2000 budget, when the province reinstated an exemption of 15 cents per litre for ethanol blended with gasoline. Then, in March 2002, the Saskatchewan government announced a plan to develop an ethanol industry in the province (Government of Saskatchewan, 2002). One component of the plan is the Ethanol Fuel Act passed in 2002 and amended in 2004. The amended act mandates that fuel volumes must contain 2 percent ethanol by May 1, 2005 and 7.5 percent ethanol by November 1, 2005 (Government of Saskatchewan, 2004). A second part of the program is the obligation for distributors to buy at least 30 percent of their ethanol from plants that produce 25 million litres per year or less (Briere, 2002). The regulation promotes producer-owned facilities.

Manitoba has no oil refineries and imports all of its gasoline (Manness, Nicholson and Nicolaou, 2002). In December 2003, the Government of Manitoba passed the Biofuels and Gasoline Tax Amendment Act. The act mandates that 85 percent of all gasoline sold

in the province must contain 10 percent ethanol by September 2005. The act also outlines an incentive structure whereby producers would receive a 20 cents per litre incentive until August 31, 2007, reduced to 15 cents per litre for the next three years and 10 cents per litre for the following three years (Government of Manitoba, 2003b). As in the case of Saskatchewan, the Manitoba subsidy is available only for ethanol that is produced and consumed in the province. As a result, an ethanol producer in Manitoba that is not engaged in the distribution or retail sale of gasohol does not qualify for the tax preference (Manness, Nicholson and Nicolaou, 2002). The Manitoba ethanol program also provides a declining tax preference averaging approximately 1.5 cents per litre of gasoline that is blended with 10 percent Manitoba-made ethanol. This component of the program is scheduled to end in 2013 (Government of Manitoba, 2003a).

Despite having the most generous incentives in Canada, the Manitoba ethanol industry has not changed for over two decades. However, the announcement of an ethanol mandate apparently has stimulated interest from the oil industry and ethanol producers from across North America in building ethanol plants in Manitoba (Manness, Nicholson and Nicolaou, 2002).

Since 1980, Ontario has provided an exemption from its road and usage tax on gasoline for the ethanol portion of ethanol-blended fuels sold in the province. The current value of the exemption is 14.7 cents per litre of ethanol (Seaway Valley Farmers Energy Co-operative Inc.). Since October 1994, the province has entered into project-specific agreements (Ontario Ethanol Manufacturers' Agreement) with ethanol producers that use renewable feedstock. This guarantees that the financial benefit of the 14.7 cent exemption to producers will remain until 2010, even if the tax structure is changed by administrative or legislative action in the interim (Seaway Valley Farmers Energy Co-operative Inc.). Two other government initiatives for sustaining the domestic ethanol industry are a $5 million grant to Commercial Alcohols Inc. for building its Chatham plant and the use of ethanol blends in the government vehicle fleets (Government of Ontario, 2002). The Government of Ontario, in early 2004, established a target to have ethanol represent 5 percent of the gasoline pool by 2007 and 10 percent by 2010 (which would require around 1.4 billion litres of ethanol). Policy development is underway to determine how best to achieve this target (Tupper, 2004).

There is no fuel ethanol plant at this time in Quebec – the plant in Temiscaming produces industrial ethanol only – but it is expected that a fuel ethanol plant will be built in Varennes using the financial support offered through the federal government's Ethanol Expansion Program. The provincial tax policy to support the Varennes plant features a tax exemption amounting to from 106 to 130 percent of the provincial road tax of 15 cents per litre, or 16 to 20 cents per litre of ethanol. The formula to be applied to compute the exemption has yet to be finalized, so there is still some uncertainty with respect to the final amount of public support for this venture.

The governments of New Brunswick and Prince Edward Island are studying the feasibility of establishing ethanol production facilities in their provinces based on agricultural and forest resources. In June 2004, the PEI government released its Energy Framework and Renewable Energy Strategy, which mentions the pursuit of an ethanol and biofuels industry in the province. Through the Atlantic Energy Ministers' Forum, there may be an opportunity to develop a regional ethanol facility (Tupper, 2004).

Provincial incentives for the biodiesel industry are much less important than for the ethanol industry. Only Ontario and British Columbia offer tax exemptions for biodiesel. Ontario, which taxes regular diesel fuel at 14.3 cents per litre, was the first province to exempt biodiesel from this tax (from June 2003). British Columbia provided the 14.3 cents per litre exemption in July 2004, but only for the biodiesel contained in B5 to B20 blends (5 percent to 20 percent biodiesel).

## Feedstocks, Production Costs and Capacities

### *Feedstocks*

Ethanol can be produced from two main categories of feedstock: grains and cellulose. Ethanol is obtained from grains by fermentation of sugars (starch) and from cellulose by conversion of the cellulose into sugars and their fermentation afterwards. Grain-based ethanol is obtained mainly from sugar cane, corn, wheat or barley, whereas cellulose-based ethanol comes from waste biomass or dedicated energy crops (like switchgrass, prairie grasses and fast-growing trees). Ethanol production in North America primarily uses corn as feedstock. The exception is in Western Canada where wheat has been the dominant feedstock. This is due to the lack of corn production in the Prairies, where wheat affords lower production costs than would importing corn into the region. The area generally does not have enough heat degree days and moisture for corn production.

In Canada, the grain-based production process is used for 93 percent of actual production capacity: corn (73 percent), wheat (17 percent) and barley (3 percent) (Commercial Alcohols, Husky Energy, API Grain processors, Pound-Maker Ethanol). Agricultural and forestry waste is used as feedstock for 7 percent of ethanol production (Iogen Corporation and Tembec).

All classes of wheat can be used for ethanol production, but the favored feedstock for a dry milling ethanol plant is medium hard Canadian Prairie Spring (CPS) wheat. A study published by Freeze and Peters (1999) found that CPS wheat cultivated on dark brown and black soils generated the highest revenues for an ethanol plant because of its high starch content and low price.

Barley can also be used for ethanol production and is the feedstock in the Saskatchewan plant at Lanigan; however, it has lower starch and higher fibre contents than wheat, making it less desirable. Some of the carbohydrates in barley are beta glucans that are difficult to hydrolyze and ferment. The barley hulls can cause erosion of ethanol

plant equipment. The lower cost of barley is insufficient to overcome the disadvantages of processing it. This results in production costs for ethanol being higher for barley than for wheat (Cheminfo Services Inc., $(S\&T)^2$ Consultants Inc. and Cemcorp Ltd., 2000).

Iogen Corporation, based in Ottawa, is a world leader in cellulose ethanol technology. Iogen has produced 3 to 4 million litres of ethanol per year in a demonstration plant in Ottawa (using about 40 tonnes of plant residues per day as feedstock). The company announced in April 2004 that it is searching for a location to situate a commercial facility that will process about 1,500 tonnes per day of feedstock and produce around 170 million litres of ethanol per year. This will be the first commercial plant in the world to process biowastes into ethanol.

Biodiesel has been developed with the use of lipids from plants (e.g., soybean oil, canola oil) and animals (e.g., chicken fat) as feedstock. Biodiesel can also be made (unconventionally) from agricultural, forestry and municipal biomass residues that are high in energy but low in lipids through techniques such as gasification and Fischer-Tropsch synthesis (Holbein, Stephen and Layzell, 2004).

### *Costs of Production*

The main factors influencing ethanol production are costs and tax exemptions. Thomassin and Baker (2000) estimated that feedstock cost represented 57 percent of the total production cost for a 200 million litres per year corn ethanol plant located in southern Ontario. MacLean (2004) estimated "near-term" production costs of ethanol from corn stover to be in the order of 42 to 52 cents per litre. She expected that technological improvements in the "mid-term" would bring these costs down to 27 to 37 cents per litre. MacLean (2004) estimated the cost of producing a litre of ethanol from switchgrass (a commonly suggested feedstock) to range from 49 to 72 cents per litre in the near term, decreasing to 32 to 50 cents per litre in a few years. A study conducted for the Government of Alberta in 2000 estimated the breakeven ethanol price for a 100 million litres per year facility to approximate 28 cents per litre. The plant in the study used, advantageously, a raw material (wheat) price of $100 per tonne and a co-product (Distiller's Dried Grain) price of $160 per tonne (Cheminfo Services Inc., $(S\&T)^2$ Consultants Inc. and Cemcorp Ltd., 2000). In 2003 it was estimated that the cost of producing biodiesel exceeds the cost of petro-diesel by 7 to 18 cents per litre (Gustafson, 2003).

At present, the costs of producing ethanol and biodiesel appear to be significantly higher than the costs of producing petroleum-based gasoline and diesel, though the difference narrows with each increase in the price of oil and improvement in technology of producing the biofuel.

### *Co-products*

The unit production cost for ethanol is the sum of feedstock and processing costs per volume of ethanol, after subtracting the value of the co-products (Baker, Thomassin and

Henning, 1990). The main co-product of cellulose-based ethanol is lignin, which is burned to produce steam for the ethanol production process, with the excess potentially being converted into electricity for sale to the power grid (Manness, Nicholson and Nicolaou, 2002).

Only the starch component of the grain is converted to ethanol. The fibre, protein, minerals, carbon dioxide and vitamins remain and are recovered as co-products. The co-products of grain-based ethanol may be described under two general categories of ethanol production: dry milling and wet milling. Dry milling is the dominant process in Canada's relatively small ethanol plants. The only wet milling ethanol plant in Canada is the one located in Red Deer, Alberta, owned by API Grain Processors/Permolex and integrated with a feedlot. The economics of production in Canada favour the dry milling process, in contrast to many large U.S. plants that are able to exploit the scale efficiencies of wet milling technology (Agriculture and Agri-Food Canada, 2002).

There are three main co-products of the wet milling production process: gluten meal, gluten feed and germ. In the case of wheat, the primary outlet for gluten is for bakery products. Gluten is added to white pan bread, rolls, diet breads, and other products. The addition of gluten to baked goods improves dough-handling properties and quality of the finished product. Supplementing flours that have poor baking qualities and low protein content with gluten permits a reduction in the number of flour types required for baking and tends to increase production flexibility. Addition of gluten to buns and rolls improves hinge strength and produces the type of crust most desirable in commercial markets where buns are steamed. Gluten finds some use as a supplemental source of protein in breakfast cereals. Gluten can also be used as a texturizing protein and meat substitute in meat-like vegetable products (Cheminfo Services Inc., $(S\&T)^2$ Consultants Inc. and Cemcorp Ltd., 2000).

While the market for gluten for human consumption is expected to rise slowly, significant growth is anticipated in pet foods where gluten is used as a supplement and/or replacement for meat due to its very high protein content (i.e., 80 percent+). Vital gluten is an attractive alternative to pet food processors because of the higher prices of meat (based on protein content) (Cheminfo Services Inc., $(S\&T)^2$ Consultants Inc. and Cemcorp Ltd., 2000).

Fewer than half a dozen producers dominate the wheat gluten market in North America. The major Canadian producer of wheat gluten is Archer Daniels Midland (ADM) in Lachine, Quebec but this facility does not make ethanol. Its capacity is estimated to be 20 kilotonnes of gluten per year, representing nearly twice the annual use of the product in Canada. ADM exports gluten to the United States. The only ethanol facility in Canada producing wheat gluten as a co-product is API Grain Processing in Red Deer, Alberta. Its capacity is smaller than ADM's, with a substantial portion of its production potentially used for its enriched flour products (Cheminfo Services Inc., $(S\&T)^2$ Consultants Inc. and Cemcorp Ltd., 2000).

### *Production Capacity in Canada*

Total ethanol production capacity in Canada mid-2004 is 238 million litres per year (table 2). Fuel ethanol is the major product, with 67 percent of total capacity, while industrial ethanol constitutes the remaining 33 percent. Production of fuel ethanol is concentrated in southeastern Ontario (72 percent) where Commercial Alcohols has two plants: 150 million litres per year production capacity at Chatham and 22 million litres per year capacity at Tiverton (fuel ethanol represents 65 percent of total ethanol production of both plants).

The plant in Minnedosa, Manitoba, owned by Husky Energy Inc., was the first Canadian plant to produce fuel ethanol (Agriculture and Agri-Food Canada, 2001). This plant started its operations in 1980 with a capacity of 4 million litres per year, but operates in 2004 at a capacity of 10 million litres per year. During the 1976–1990 period, four other ethanol plants were operating, for a total production capacity of 92 million litres per year, but they produced industrial ethanol only.

Unlike ethanol production, biodiesel production exists only at demonstration scale. Three firms have begun limited production of biodiesel: Milligan BioTech Inc. (Foam Lake, Saskatchewan), Biox Corporation Inc. (Oakville, Ontario) and Rothsay/Laurenco

**Table 2** Canadian Ethanol and Biodiesel Plant Capacities during the 1976–2003 period (million litres/year)

| | Company | Location | 1976 | 1980 | 1990 | 1995 | 2000 | Dec. 2003 |
|---|---|---|---|---|---|---|---|---|
| Ethanol | Ontario Paper | Thorold, ON | 4 | 4 | | | | |
| | St Lawrence Starch | Mississauga, ON | 15 | 15 | | | | |
| | Commercial Alcohols | Varennes, QC | 70 | 70 | 70 | | | |
| | North West | Kerrobert, SK | | 3 | 3 | | | |
| | Mohawk Oil | Minnedosa, MB | | 4 | 9 | 10 | 10 | 10 |
| | Commercial Alcohols | Tiverton, ON | | | 12 | 22 | 22 | 22 |
| | Tembec Enterprises | Temiscaming, QC | | | 18 | 18 | 18 | 18 |
| | Pound-Maker Agventures | Lanigan, SK | | | | 10 | 12 | 12 |
| | API Grain Processing | Red Deer, AB | | | | | 26 | 26 |
| | Commercial Alcohols | Chatham, ON | | | | | 150 | 150 |
| Biodiesel | Milligan BioTech Inc. (demonstration plant) | Foam Lake, SK | | | | | | 0.5 |
| | Biox Corporation (demonstration plant) | Oakville, ON | | | | | | 1 |
| | Rothsay/Laurenco (Maple Leaf Group) (biodiesel supplier of BioBus in Montreal) | Montreal, QC | | | | | | 0.5 |
| | *Total ethanol* | - | 89 | 96 | 112 | 60 | 238 | 238 |
| | *Total biodiesel* | - | - | - | - | - | - | 2 |

(Maple Leaf Group, Montreal, Quebec). Their total estimated production capacity is around 2 million litres of biodiesel per year (table 2). Most of their production serves for demonstration projects such as the BioBus Projects in Montreal and Saskatoon (Science West, 2004; Comité du projet BioBus, 2003). The biodiesel distribution network began with the development of the first retail biodiesel fuel pump, which opened on March 2, 2004 in the Toronto area (Topia Energy Inc., 2004).

Given the high cost of production and the availability of cheaper fuels, construction of an ethanol plant is very sensitive to government regulations and public funding. Development of a commercial ethanol and biodiesel industry is likely to be highly dependent on technological improvements that reduce production costs and increase environmental benefits.

## Discussion

Increased use of ethanol and biodiesel offers several environmental advantages to Canadian society, the most important of which are decreased GHG emissions and lower levels of criteria air contaminants (CAC) in tailpipe emissions. The reduction in GHG emissions is due to the displacement of gasoline on a volumetric basis. Calculated on a full fuel cycle basis, reductions in GHG emissions amount to 30 to 40 percent per litre for grain-based ethanol (3 to 4 percent for E10) and 60 to 80 percent per litre for cellulose-based ethanol (6 to 8 percent for E10) in comparison to petro-fuels (Natural Resources Canada, 2003). Because lignin and not fossil fuel is used in the production process, the cellulose-based EcoEthanol produced by Iogen Corporation diminishes GHG emissions by 90 percent (Iogen Corporation, 2004). Concerning CAC emissions,[3] ethanol blended with gasoline diminishes carbon monoxide (CO), hydrocarbons (VOCs), particulate matter (PM) and sulphur oxides (SOx) but increases nitrogen oxides (NOx) and aldehyde (VOC) (Cheminfo Services Inc., (S&T)$^2$ Consultants Inc. and Cemcorp Ltd., 2000). (Aldehyde emissions are handled mostly by vehicle catalytic converters [Government of Manitoba, 2002].) The United States Environmental Protection Agency complex model estimates that total tailpipe emissions are reduced by 4.08 percent when E10 is used rather than pure gasoline (Manness, Nicholson and Nicolaou, 2002). Use of biodiesel has been shown to result in decreased emissions of air contaminants (Holbein, Stephen and Layzell, 2004).

The government of Canada is investing $255 million in the ethanol and biodiesel industries through programs outlined above. This amount represents 9 percent of the $2.7 billion that the Canadian government has invested in climate change initiatives up to 2003 (Government of Canada, 2003c). Millions more are being spent by provincial governments, most in the form of excise tax relief. If the program targets were met, the total direct GHG reduction would be 2.8 million tonnes per year (1.7 from ethanol and 1.1 from biodiesel). Such a reduction would represent only 1.4 percent of the approximately

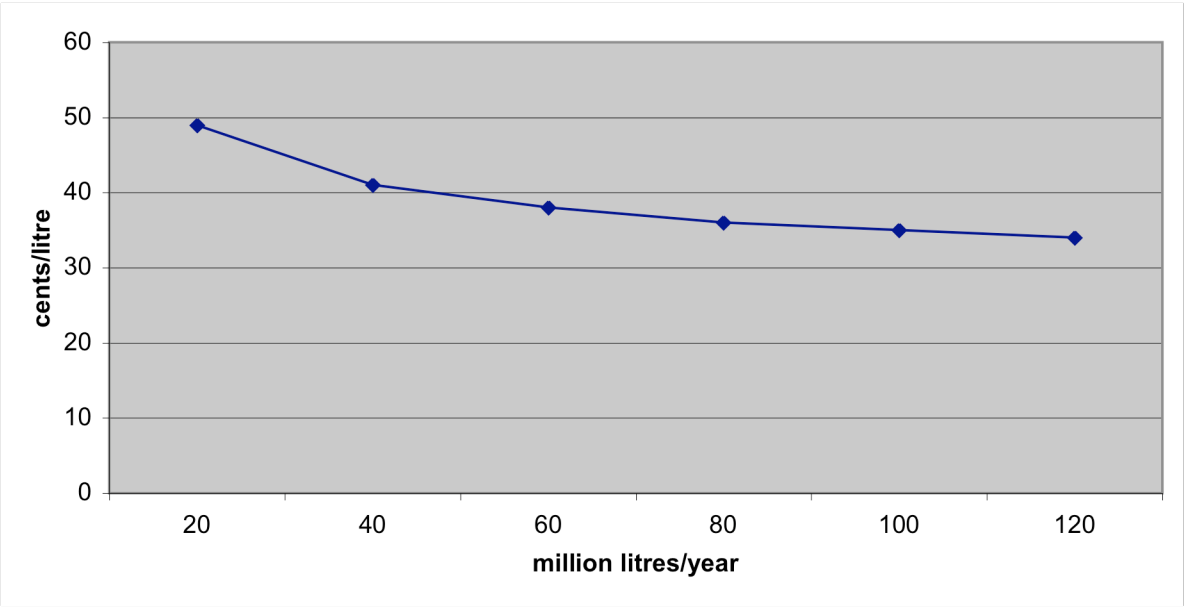


**Figure 3** Ethanol production costs by plant size.
Source: Manness, Nicoholson and Nicolaou, 2002

200 million tonne annual reduction needed to meet the targets of the Kyoto Protocol (Government of Canada, 2002; 2003a).

It is interesting to ask why Canadian federal and provincial governments have invested so much in encouragement of ethanol and biodiesel industries when, even if successful in meeting their stated targets, these programs will contribute so little to GHG reduction. It appears that GHG reduction is not the only objective pursued by governments in their biofuels policies. Indeed, while the programs have been promoted on the basis of environmental benefits, a major driver undoubtedly reflects the search for new markets for low-priced agricultural commodities in Canada. There is some indication that returns to corn producers in the Midwest United States have benefited from slightly higher prices as a result of local ethanol plants. However, this form of indirect subsidisation of agricultural producers in Canada is likely to be costly and not very effective.

Encouraging the development of a biofuels industry might have demonstration effects. Ethanol and biodiesel are substitutes for highly visible goods that are purchased by the vast majority of the population on a continuing basis. Publicity surrounding ethanol and biodiesel might stimulate consumers to develop "green habits" in other areas such as improving the insulation in their houses. Also, further technological developments are likely to reduce the average costs of producing these biofuels over time.

Still, the complexity and heterogeneity of provincial tax exemptions (amounts, eligibility and duration) represent important barriers to interprovincial trade and productivity improvements. For example, Alberta's single ethanol plant exports almost all its production to the United States because Saskatchewan's tax exemption applies only to

Saskatchewan-produced ethanol. On the other hand, Saskatchewan ethanol producers can sell their production in Alberta, where the tax exemption does not impose any restriction on the source of the ethanol. These types of provincially competitive programs may do more in the long run to diminish the viability of an emerging biofuels industry than to stimulate and sustain it. Furthermore, measures such as those in Saskatchewan, where distributors are obliged to buy at least 30 percent of their ethanol from plants that produce 25 million litres per year or less, limit producers from taking advantage of economies of scale, which clearly are apparent in a study conducted for the Government of Manitoba (see figure 3) (Manness, Nicholson and Nicolaou, 2002).

## Concluding Note

Increased production of ethanol and other biofuels can result in some reduction of greenhouse gas production in Canada. However, existing technologies do not appear to make the manufacture of ethanol a profitable venture for private sector companies without government assistance. Since Canada has committed to reduce greenhouse gases through its ratification of the Kyoto protocol, a number of government regulations have been imposed that mandate minimum content percentages of ethanol for automobile fuels. In addition, both federal and provincial governments have put in place various types of subsidies to encourage development of a viable ethanol industry in Canada. A Canadian company, Iogen Corporation, has developed a promising technology based on production of ethanol from cellulose. Following more than 25 years of research and several years of operating a demonstration plant, the company announced recently that it plans to develop a full-scale commercial plant as soon as it can determine the best location. The prospect that wastes and residues can be used in the commercial production of ethanol offers exciting potential for adding to and diversifying the feedstock for this important alternative fuel.

It is clear that the Canadian public, through their elected politicians, have been pushing for cleaner, more environmentally friendly fuels that can be produced from biological rather than petrochemical processes. However, much research remains to be done to make the biologically produced fuels less costly to produce. Research is required on higher yielding crops and biomass, development of new high-value co-products from the production process, and improved methods to inexpensively extract sugars from cellulosic raw materials.

## References

Agriculture and Agri-Food Canada. 2001. Ethanol. *Bi-weekly Bulletin,* May 2001. http://dsp-psd.communication.gc.ca/Collection/A27-18-14-9E.pdf.

Agriculture and Agri-Food Canada. 2002. Canada: Primary processing of grains, oilseeds, pulses and special crops. *Bi-weekly Bulletin,* July 19, 2002. http://www.agr.gc.ca/mad-dam/e/bulletine/v15e/v15n14e.htm.

Baker L., P. J. Thomassin, and J.C. Henning. 1990. The economic competitiveness of Jerusalem artichoke (Helianthus tuberosus) as an agricultural feedstock for ethanol production for transportation fuels. *Canadian Journal of Agricultural Economics* 38: 981-990.

Briere, Karen. 2002. Ethanol special report. *The Western Producer*, November 21, 2002. http://www.producer.com/articles/20021121/special_report/media/ethanol_sr.pdf.

British Columbia Ministry of Provincial Revenue. 2004. Notice to collectors: Changes to the taxation of alternative motor fuels. Victoria, BC: British Columbia Revenue Programs Division,

Canadian Renewable Fuels Association. http://www.greenfuels.org.

Canadian Taxpayers Federation. 2004. 2004 tax rates by province. http://www.taxpayer.com/Facts/index.html.

Cheminfo Services Inc., $(S\&T)^2$ Consultants Inc. and Cemcorp Ltd. 2000. Ethanol production in Alberta. Final report prepared for the Government of Alberta, April 2000. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/agc6751/$FILE/ethanol percent20production percent20in percent20alberta percent20final.doc.

Comité du projet BioBus. 2003. Démonstration et evaluation du biodiésel à la Société de transport de Montréal (STM). Rapport de fin de projet, March 2003.

Coopérative Fédérée de Québec. 2004. Éthanol: Les enjeux d'un carburant 'écolo'. January 2004. http://www.coopfed.com/COOPERATEUR/contenu/janv_2004/page34.htm.

Department of Finance Canada. 2003. Budget 2003 – Annex 9, Tax measures: Supplementary information and notice of ways and means motion (cont'd). February 18, 2003.

Farm Credit Canada. 2004. National Biomass Ethanol Program. June 2004. http://www.fcc-sca.ca/en/Products/Partnerships/nbep_e.asp?main=2&sub1=partnerships&sub2=nbep.

Freeze B. S., and T. Peters. 1999. A note on the profitability of wheat-ethanol-feedlot production in Alberta. *Canadian Journal of Agricultural Economics* 47: 67-78.

Government of Canada. 2001. Future Fuels Initiative, National Biomass Program, http://www.climatechange.gc.ca/english/newsroom/2001/steps/steps_future.asp.

Government of Canada. 2002. Climate change plan for Canada. November 21, 2002. http://www.climatechange.gc.ca/plan_for_canada/plan/pdf/full_version.pdf.

Government of Canada. 2003a. Ethanol Expansion Program invitation to proponents – Round 1. October 20, 2003.

http://climatechange.gc.ca/english/publications/announcement/pdf/invitation.pdf; this site no longer available.

Government of Canada. 2003b. Budget 2003. Climate change investments to date from budget 2003. http://www.climatechange.gc.ca/english/newsroom/2003/budget/bg_budget.asp.

Government of Canada. 2003c. Government of Canada announces $1 billion toward implementation of the Climate Change Plan for Canada. August 12, 2003. http://climatechange.gc.ca/english/newsroom/2003/budget/20030812_budget.asp.

Government of Canada. 2004. Government of Canada announces successful proposals in Ethanol Expansion Program. February 13, 2004. http://www.nrcan-rncan.gc.ca/media/newsreleases/2004/200402_e.htm.

Government of Manitoba. 2002. Homegrown energy: Manitoba energy development initiative. In *Ethanol backgrounder*. http://www.gov.mb.ca/est/energy/ethanol/ebckgrder2.html#Benefits. http://www.gov.mb.ca/est/energy/ethanol/ebckgrder1.html#Intro.

Government of Manitoba. 2003a. Province introduces proposed legislation to mandate 10 per cent ethanol blends by 2005. November 2003. http://www.gov.mb.ca/chc/press/top/2003/11/2003-11-21-03.html.

Government of Manitoba. 2003b. The Biofuels and Gasoline Tax Amendment Act. December 2003. http://web2.gov.mb.ca/laws/statutes/2003/c00503e.php.

Government of Ontario. 2002. Ontario supports clean, renewable power generation. October 2002. http://www.ene.gov.on.ca/envision/news/2002/102401fs.htm.

Government of Saskatchewan. 2002. Greenprint for ethanol production in Saskatchewan. April 2002. http://www.ir.gov.sk.ca/adx/asp/adxGetMedia.asp?DocID=3288,3286,2937,2936,Documents&MediaID=4734&Filename=Greenprint.pdf.

Government of Saskatchewan. 2004. Increased ethanol in fuel May 1st, 2005. June 10, 2004. http://www.gov.sk.ca/newsrel/releases/2004/06/10-354.html.

Gustafson, Cole R. 2003. Biodiesel – An industry poised for growth? *Choices (A publication of the American Agricultural Economic Association),* August 2003. http://www.choicesmagazine.org/archives/2003/q3/2003-3-03.pdf.

Holbein, Bruce E., Jamie D. Stephen, and David B. Layzell. 2004. Canadian biodiesel initiative: Aligning research needs and priorities with the emerging industry. Working paper, BIOCAP Canada Foundation. Prepared for Natural Resources Canada. Draft, June 2004.

Iogen Corporation. 2004. A fully integrated facility. http://www.iogen.ca/2200.html.

MacLean, Heather L. 2004. Evaluation of the economic and sustainability implications of a lignocellulosic ethanol industry for Ontario: An augmented life cycle system. Report to Innovation and Risk Management Branch, Ontario Ministry of Agriculture and Food, Guelph, Ontario.

Manness G., T. Nicholson, and C. Nicolaou. 2002. Ethanol made in Manitoba. A report made by the Ethanol Advisory Panel to the Government of Manitoba, December 2002. http://www.gov.mb.ca/est/energy/ethanol/ethanol2-low.pdf.

Ministry of Agriculture and Food Ontario. 2003. Biodiesel. June 12, 2003. http://www.gov.on.ca/OMAFRA/english/policy/lifesciences/biodiesel.html.

Natural Resources Canada. 2003. Ethanol policy and programs in Canada. Presentation for the World Summit on Ethanol for Transportation, November 3, 2003.

Science West. 2004. Saskatoon Transit's BioBus. January 2004. http://www.science-<west.ca/GettingAround/educators/pdf/CaseStudy1.pdf.

Seaway Valley Farmers Energy Co-operative Inc. The project. http://www.glen-net.ca/ethanol/project.html.

Thomassin P. J., and L. Baker 2000. Macroeconomic impact of establishing a large-scale fuel ethanol plant on the Canadian economy. *Canadian Journal of Agricultural Economics* 48: 67-85.

Topia Energy Inc. 2004. Canada's first retail biodiesel pump opens in Greater Toronto Area. March 2, 2004.

Tupper D. 2004. Agriculture and Agri-Food Canada. Ottawa. Personal correspondence, June 2004.

## Endnotes

[1] Funding support from the Social Sciences and Humanities Research Council and BIOCAP Canada is gratefully acknowledged.

[2] The Ethanol Expansion Program includes the Future Fuels Initiative program, which includes the National Biomass Ethanol Program.

[3] The National Pollutant Release Inventory (NPRI) considers as criteria air contaminants (CACs) the pollutants emitted predominantly to the air. Seven types of CACs are measured: total particulate matter (TPM), particulate matter with a diameter less than 10 microns ($PM_{10}$), particulate matter with a diameter less than 2.5 microns ($PM_{2.5}$), carbon monoxide (CO), nitrogen oxides (NOx), sulphur oxides (SOx), and volatile organic compounds (VOC).