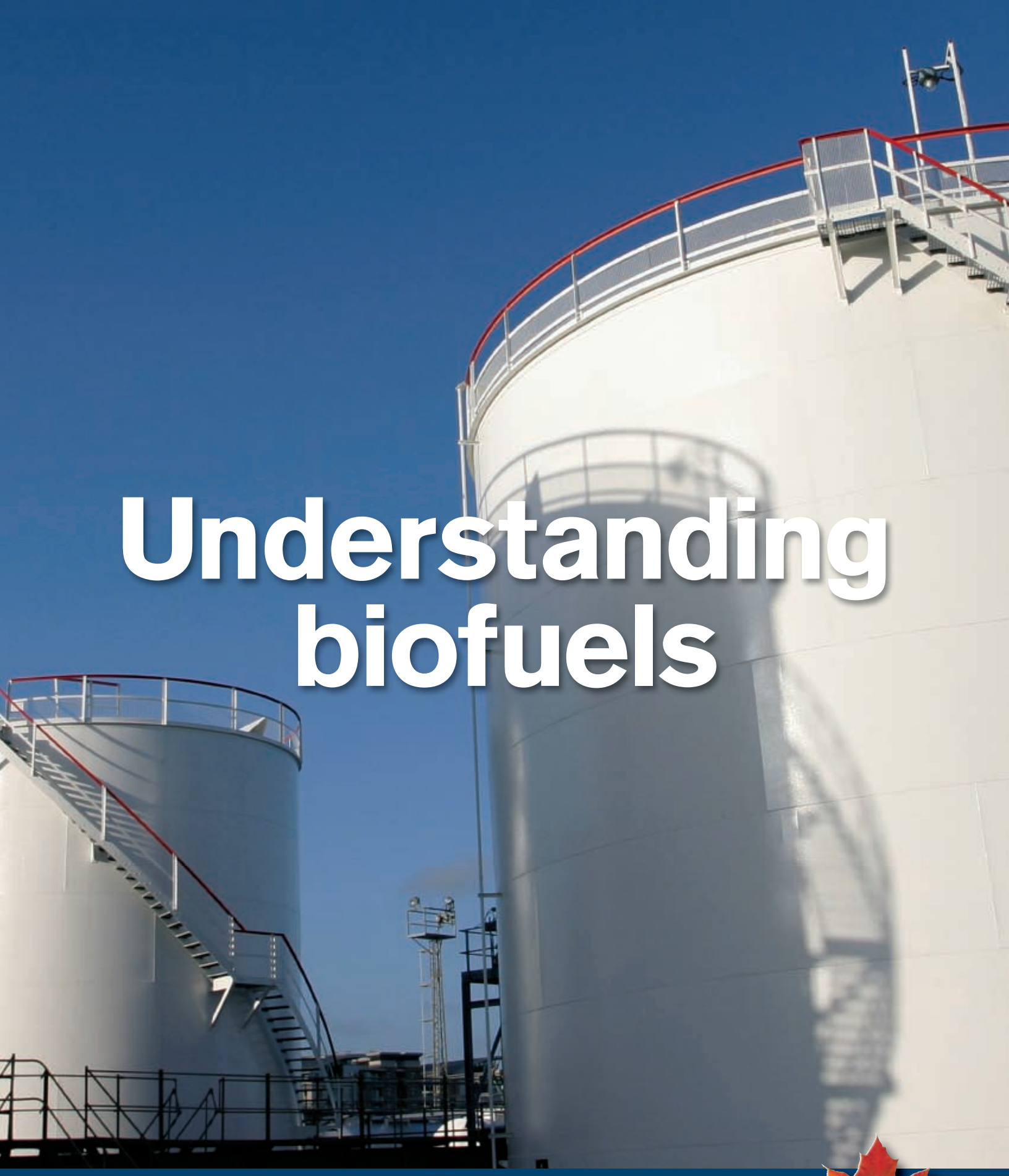


Understanding biofuels

Farm Credit Canada
Advancing the business of agriculture

Canada

Are biofuels an idea whose time has come?

In 1898, Rudolf Diesel used peanut oil to run his original compression-ignition engine. Early in the 20th century, many believed that vegetable-based fuel would be commonplace. Although the diesel engine gained widespread use, biofuels lost their edge to petroleum, which was widely available at a lower cost.

Today, with petroleum-producing fossil fuel in limited supply and a rising commitment worldwide to create a sustainable environment, biofuels are back on the agenda. The increasing demand for wheat, corn, canola and soybeans is filled with opportunities for Canadian producers and agriculture entrepreneurs.

While the biofuel industry grew by leaps and bounds from 2006 to mid-2008 issues like climate change, energy independence, the environment, food prices and land use are feeding a debate.

For the first time in history, the economies of food and energy are competing. Countless biofuel-related studies, papers, online discussions and media stories explore the food versus fuel debate. Opinions range from one extreme to the other and some experts don't believe there is an issue at all.

Plant breeders are focused on developing higher yield crop varieties based on viable ethanol production technologies. Livestock, pork and poultry producers are hunting for feed substitutes and solutions, some of which could come from biofuel byproducts.

In December 2007, the Economist reported that their food-price index was at its highest level since it was created in 1845. In real terms, prices jumped by 75 per cent since 2005.

Almost 95 per cent of the world's biofuel production comes from the U.S., Europe and Brazil, while Canada, China and India produce most of the rest. The International Food Policy Research Institute believes that in addition to substantially reducing carbon emissions, biofuels could contribute to a rise in incomes among rural populations.

The long-term goal is to fill the demand for both food and ethanol inputs. There is both opportunity and challenge for Canadian agriculture.

What are biofuels?

Biofuels are fuels derived directly from organic materials. They have the potential to reduce pollution and greenhouse gas emissions while diversifying the energy supply. Ethanol and biodiesel are the two best known conventional biofuels.

Did you know?

- The International Energy Agency (IEA) forecasts that biofuels will comprise 12 per cent of global liquid fuel supplies by 2030 and 26 per cent by 2050. In 2008, biofuels accounted for slightly over one per cent of total liquid motor fuels.
- Companies like DuPont, Dow and Monsanto are working with car manufacturers to research the potential of using everything from chocolate to coffee to seaweed as feedstock for bio-products.
- CropLife Canada, the trade association representing the manufacturers, developers and distributors of pest control products and plant biotechnology, said in 2007 that by the middle to latter half of the next decade, the demand for crops with an industrial purpose has the potential to grow from current levels of approximately $40 billion to $500 billion a year globally.
- Since corn sweeteners make up 56 per cent of all sugars consumed in the United States, the rising cost of corn due to its use as an ethanol feedstock has had an impact on soft drink and confectionary companies. Some are even investigating alternatives to high-fructose corn syrup.
- Beverage and fuel alcohol are essentially the same, but beverage alcohol is purer. A small amount of gasoline is added to make fuel alcohol or ethanol.

- Biofuel isn't a new idea. In 1908, Henry Ford designed his Model T to run on ethanol.
- Ethanol keeps indefinitely, provided it is sealed from air and water. Due to the hydrogen bonding properties of ethanol, care must be taken with regard to exposure as it can absorb water from the air. If too much water is present in the ethanol when used as an additive to fuel, the water will separate from the mixture and settle to the bottom of the fuel tank.

Ethanol

Ethanol is a fuel-grade alcohol traditionally made by fermenting corn, wheat or sugar cane. It is typically blended with gasoline at a rate of 10 per cent, which can be used in gasoline engines without any modification to the vehicle.

Ethanol blended with gasoline at a rate of up to 85 per cent ethanol (E85) is being produced for use in flexible fuel vehicles. Flex-fuel vehicles can run either on gasoline or on a blend of up to 85 per cent ethanol. They look like gasoline-only models, but the engine and fuel systems have been modified. A flex-fuel vehicle is not the same as a hybrid vehicle, as it is powered by an internal combustion engine only. Hybrids use a mixture of power or fuel sources like engines, electric motors, pneumatics and hydraulics. Fewer than five per cent of vehicles on the road in Canada during summer 2007 were flex-fuel vehicles.

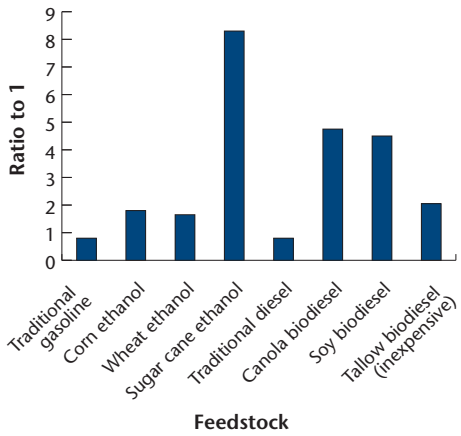
Ethanol acts as an oxygenator in gasoline, contributing to a cleaner burn. The most common oxygenator currently in use is methyl-tertiarybutyl-ether (MTBE), which is under scrutiny as a possible carcinogen and ground water pollutant. Oil refineries are moving to replace MTBE with ethanol and more than 20 U.S. states have passed legislation to ban MTBE, contributing to the demand for ethanol.

Ethanol contains relatively less energy than gasoline. A litre of fuel ethanol contains about 70 per cent of the energy of one litre of gasoline. But in E10 blends, which are 10 per cent ethanol and 90 per cent gasoline, this lower energy density does not lead to a measurable impact on consumption. While higher level blends such as E85 may require that the motorist refuel more often, the cost per kilometre could be more or less, depending on the relative pricing of fuel ethanol and gasoline.

Some reports noted that it takes more energy to produce a unit of ethanol than is derived from the unit. That is no longer the case. Taking into account every single input, University of Minnesota research shows that there is a minimum 1-to-1.25 conversion ratio today, which should improve with new technologies and corn varieties.

Conversion ratios

A conversion ratio is the amount of energy output relative to the energy required to produce, process and deliver it to market. In other words, the higher the conversion ratio, the less energy and resources are required to produce a unit of ethanol. Reported conversion ratios vary by source and time of reporting as production efficiencies are realized. The graph recognizes these ranges and is included only to indicate the variation between feedstock types.



Source: Compiled by FCC

What is cellulosic ethanol?

Cellulosic ethanol is made using materials such as crop residues including corn stalks, rice straw, wheat straw, switchgrass, corn fibre, soy fibre, forestry residue, municipal solid waste and recycled newsprint. Production of cellulosic ethanol involves a highly technical three-step chemical process that begins by extracting the cellulose from the feedstock.

Cellulose is naturally glued together with a tough compound known as lignin. To produce ethanol, the cellulose must be unglued.

The cellulose is then converted to sugar using special enzymes. The resultant sugar is fermented into cellulosic ethanol using a genetically modified form of yeast. Costs of producing fuel alcohol with this technology are still estimated to be 50 to 100 per cent higher than plants using grain as a feedstock.

This technology is still emerging. Small research facilities focused on cellulosic ethanol have intermittently been in operation or are in development. In Canada, there is a demonstration facility operated by the Iogen Corporation in Ottawa. In July 2008, Iogen and Royal Dutch Shell plc announced an extended commercial alliance to accelerate development and deployment of cellulosic ethanol. On September 25, 2008, Iogen shipped the first 100,000 litres of Shell's initial 180,000-litre cellulosic ethanol order.

Biodiesel

Biodiesel is produced from renewable sources such as vegetable oil, recycled cooking oil, animal fat or agro-industry byproducts. Canada and the U.S. use mostly soybeans and canola.

Pure biodiesel is referred to as B100, but biodiesel is usually blended with regular diesel and is referred to by the percentage of the blend. B5, for example, is five per cent biodiesel and 95 per cent petroleum diesel.

Biodiesel-powered engines deliver similar torque, horsepower and kilometres per litre as petroleum-powered diesels. Biodiesel offers the advantages of increased lubricating capacity and the ability to burn extremely clean. However, with the extreme winter weather in parts of Canada, blends with an elevated percentage of biodiesel could gel when too cold. Research and testing are underway to find ways to avoid this. As with cellulosic ethanol, there are a number of emerging biodiesel technologies under study and development.

France is currently the world's largest producer of biodiesel, using it as heating oil and in 50 per cent blends with petroleum diesel.

Biodiesel is safe to handle and transport because it is as biodegradable as sugar, 10 times less toxic than table salt and has a high flashpoint of about 150 C (300 F) compared to petroleum diesel fuel, which has a flashpoint of 50 C (125 F).

Biodiesel production by feedstock

Feedstock	Litres per hectare per year
Soy	375
Canola or rapeseed	1,000
Mustard	1,300
Palm oil	5,800
Algae	95,000

Source: Agriculture and Agri-Food Canada biweekly bulletin – October 27, 2006 Note: 1 hectare = 2.471 acres

Operating basics

Making ethanol

1. Grind corn or wheat kernels in a mill to expose the starch.
2. Mix ground feedstock with water and cook it briefly.
3. Add enzymes to the mixture to convert the starch to sugar. This produces a chemical reaction called hydrolysis.
4. Add yeast to ferment the sugars.
5. Distil the resulting fermented mash to produce ethanol.
6. Treat the ethanol with a small amount of gasoline to convert the ethanol into fuel-grade ethanol.

7. Blend fuel-grade ethanol with conventional gasoline at points along the distribution system or directly at blender pumps.

With corn or wheat as the feedstock, one bushel of grain will produce about 10 litres of ethanol.

Ethanol byproducts

In the dry milling process, the byproduct from extracted wheat or corn starch is called distillers dried grains (DDG). Distillers grains are high in protein and are particularly well-suited as a feed source for ruminant animals such as cattle and sheep.

There are wet and dry versions of distillers grains. Generally, the water is removed prior to shipping, resulting in DDG. Since the drying process requires extra energy, livestock can be fed the wet version, if it is feasible to feed near the production site.

Distillers grains lack one of the amino acids essential in the swine diet, but dried distillers grains with solubles (DDGS) do contain the required amino acid. Although it is a potential substitute to elevated feed prices for hog producers, further research and testing are required.

If corn is used as the feedstock in ethanol production, the wet milling process yields a variety of corn products such as corn gluten, brewer's yeast, corn starch, fibre and gluten meal.

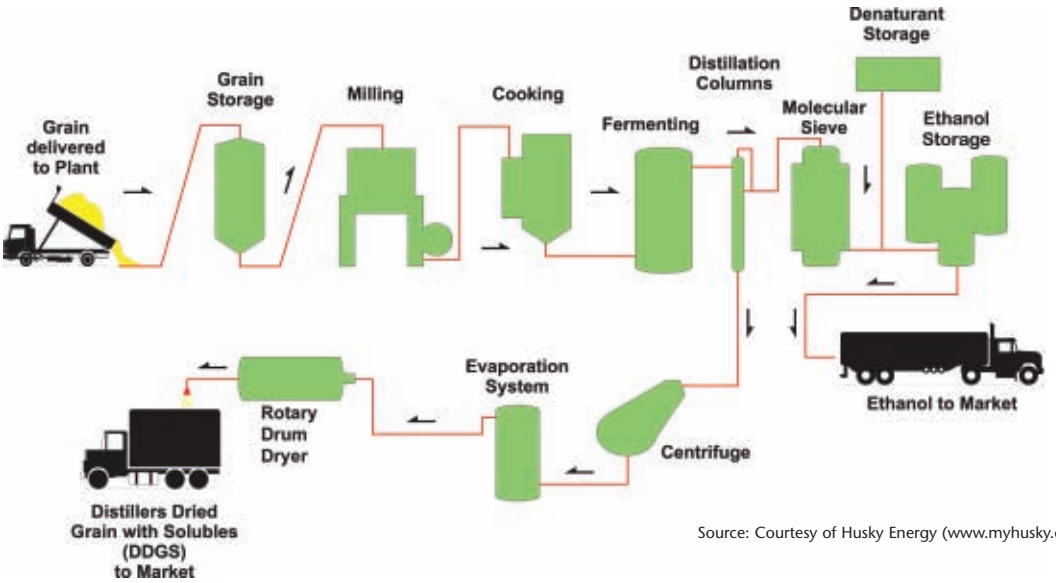
Making biodiesel

Biodiesel is typically created through a chemical process that separates glycerine from the vegetable oil or fat. Methyl esters, the chemical name for biodiesel, are the final product.

When canola is used as the feedstock in biodiesel production, one bushel produces about eight litres of fuel. One bushel of soybeans produces about 5.7 litres.

Biodiesel byproducts

Usable byproducts of biodiesel production are soy meal and canola meal, which is the feedstock with the fat removed. Like DDG, meal can serve as a good feed source when diets are properly balanced. Interestingly, California imports about half the total canola meal exported from Canada (46.1 per cent of the 2007-08 crop exports). Canola meal has proven to be a premium ingredient for dairy cattle. According to the Canola



Source: Courtesy of Husky Energy (www.myhusky.ca)

The dry milling process is pictured here. There is also a wet milling process. The main difference between the two is in the initial treatment of the feedstock. In wet mills, the first step in the ethanol-making process involves soaking the grain in hot water to assist in separating it into its components. The capital cost per gallon of ethanol is lower when using the dry milling process. Dry-mill facilities account for more than 80 per cent of North American ethanol industry capacity. As of May 2008, more than 145 dry mill ethanol plants were operational in the U.S.

Council of Canada, feeding canola meal to dairy cows will increase milk production by one litre per cow per day compared to soybean meal or cottonseed meal.

Another byproduct is crude glycerine. One pound of glycerine is created for every gallon of biodiesel. Glycerine uses are still under study, but scientists at Rice University in Houston recently developed a technology to convert glycerine from biodiesel plants into ethanol. Other potential uses include pellet binding and calcium chloride replacement.

Spotlight on an ethanol production alternative

In March 2007, Japanese researchers announced an ambitious proposal for a large-scale ethanol production venture using seaweed as the main feedstock. The 3,860-square-mile seaweed farm, located in the middle of the Sea of Japan, could produce 5.3 billion gallons of ethanol a year, enough to off-set one-third of Japan's annual gasoline requirements. The plant would use enzymes in floating bio-reactors to convert the seaweed to sugar and then into ethanol. Tankers would transport the ethanol to land.

Programs and standards supporting the industry in Canada

Canadian renewable content standards are now targeted at five per cent for gasoline by 2010. This percentage represents approximately 2.1 billion litres of ethanol per year. According to the Canadian Renewable Fuels Association, this level of renewable content would reduce greenhouse gases by more than four million tonnes, the equivalent of taking more than one million cars off the road.

The federal government also committed to ensuring a minimum renewable content of two per cent in diesel and heating oil by 2012, for a total production of approximately 600 million litres of biodiesel per year.

According to estimates by Agriculture and Agri-Food Canada, feedstock requirements to meet the renewable content standards are in the range of 4.6 million tonnes of corn and 2.3 million tonnes of wheat for ethanol. Biodiesel production is calculated to require 600,000 tonnes of canola and 30,000 tonnes of soybeans.

Learn about Canadian government support programs at:

- http://ecoaction.gc.ca/ecoagriculture/index-eng.cfm
- http://ecoaction.gc.ca/ecoenergy-ecoenergie/biofuelsincentive-incitatifsbiocarburants-eng.cfm
- www.oee.nrcan.gc.ca/transportation/business/fed-gov-doing.cfm?attr=16

On March 28, 2007, Finance Minister Jim Flaherty commented on the government's commitment to clean, renewable fuel production. Read the news release at www.fin.gc.ca/news07/07-027e.html.

In her November 19, 2008, Speech from the Throne, Michaëlle Jean, Governor General of Canada, spoke of the government's continued support of biofuels as well as other initiatives to tackle climate change and preserve Canada's environment. Read an excerpt from the speech at www.sft-ddt.gc.ca/eng/media.asp?id=1378.

Biofuel firms in Canada

This list includes only those plants in production by the end of 2008. There are many proposals for future biofuel plants.

Company	Location	Year	Feedstock	Total capacity (in million litres)
Biodiesel				
Milligan Biotech	Foam Lake, Sask.	2001	Canola	1
Rothsay	Montreal, Que.	2005	Tallow	30
Agri-Green Biodiesel	Sparwood, B.C.	2006	Mixed	2
BIOX	Hamilton, Ont.	2006	Mixed	66
Ethanol				
Husky Energy	Minnedosa, Man.	1981	Wheat	10
Greenfield Ethanol	Tiverton, Ont.	1989	Corn	26
Poundmaker	Lanigan, Sask.	1990	Wheat	12
Greenfield Ethanol	Chatham, Ont.	1997	Corn	150
Permolex	Red Deer, Alta.	1998	Wheat	40
Iogen	Ottawa, Ont.	2004	Wheat Straw	2
NorAmera Bioenergy	Weyburn, Sask.	2005	Wheat	25
Husky Energy	Lloydminster, Sask.	2006	Wheat	130
Suncor Energy	St. Clair, Ont.	2006	Corn	200
Greenfield Ethanol	Varennes, Que.	2007	Corn	130
Collingwood Ethanol	Collingwood, Ont.	2007	Corn	50
Husky Energy	Minnedosa, Man.	2007	Wheat	130
Terra Grain Fuels	Belle Plaine, Sask.	2007	Wheat	150
Greenfield Ethanol	Johnstown, Ont.	2008	Corn	200
IGPC	Aylmer, Ont.	2008	Corn	150

Source: The Canadian Renewable Fuels Association Last updated November 28, 2008

Biofuel in the United States

Have we witnessed the perfect storm? With parties representing agriculture, energy and environment in the U.S. government coming together, the ethanol industry is evolving at an unprecedented pace. The coalition is an extremely powerful policymaking group.

In December 2007, The Energy Independence and Security Act became law, setting a mandatory renewable fuel standard that requires the U.S. production of at least 36 billion gallons of biofuel by 2022. The government has put forward such incentives as:

- blenders' credits, in which oil refineries called blenders receive a subsidy of 45 cents per gallon (reduced by six cents on January 1, 2009, under the 2008 Farm Bill from 51 cents per gallon) on ethanol and $1 per gallon on vegetable oil biodiesel
- corn belt states subsidize ethanol with a number of programs, from refineries grants to tax reductions
- loan guarantees for the construction of ethanol plants
- a small ethanol producer credit up to $1.5 million per producer under 60 million gallons per year
- cellulosic biofuels tax credit up to $1.01 per gallon

Under the 2008 Farm Bill which became law on June 18, 2008, the current $0.54 per gallon ethanol import tariff has been extended for two years through 2010.

These initiatives have resulted in an explosion of plant construction in the U.S. As of November 2008, there were 191 operational ethanol plants with 229 more planned and 48 under construction. Based on the similar reference period, the U.S. has about 176 biodiesel plants in operation and 40 others under construction or expanding.

U.S. President Barack Obama has stated that he is a strong supporter of efforts to reduce the country's dependence on foreign oil. He endorses the development of renewable energy, including biofuels, solar and wind energy. He supports biofuels tax incentives and the renewable fuels standard. His goal is to see 60 billion gallons of U.S. fuel come from biofuels by 2022.

Source: DTN Ethanol Center
http://www.dtnethanolcenter.com/index.cfm?show=10&mid=16&pid=5

*Alaska has one ethanol plant in the planning stage
*Hawaii has one plant in the planning stage and one is on hold

Food for thought, fuel for thought or both?

The food and energy economies, historically separate, are competing. To varying degrees and with varying opinions, countless biofuel-related studies, papers and online discussions touch on the topic of food versus fuel.

Positions vary significantly from one extreme to the other. Some argue that non-food use of grains and oilseeds will contribute to mass starvation. Those at the other end of the spectrum insist that grain companies and farmers are resourceful enough to increase yields and acres so that supply will increase to meet all demands. There is also a school of thought that says that agricultural commodity pricing has been too low for too long.

The economics behind international price movements are complex and include many variables beyond ethanol production. The conclusions of studies can also vary greatly because of different research methodologies and base data. However, in the April 2007 World Economic Outlook, the International Monetary Fund reported that food prices rose by 10 per cent in 2006, mainly by the rise of corn, wheat and soybean oil prices in the second part of the year.

On the high end, the World Bank calculated in a working paper released in July 2008 that 70 to 75 per cent of the increase in internationally traded food prices from January 2002 to June 2008 was due to biofuels and their cascading effect on grain stocks, land use shifts, export bans and speculative activity. In an October 2008 press release, the Canadian Renewable Fuels Association reported that an independent forecasting company concluded that record oil prices and commodities speculation, rather than actual ethanol production, were to blame for increases in the price of food. Global food price increases moderated after June 2008 and Chicago Board of Trade corn futures decreased dramatically from summer 2008 levels of nearly $8 per bushel to under $4 per bushel in early December.

In this new economy, if the fuel value of grain exceeds its food value, the market will move it into the energy economy. When the price of oil climbs, so could the price of food.

Based on currently viable ethanol production technologies, plant breeders are focused on developing higher-yield crop varieties. Livestock, pork and poultry producers are also increasingly looking for feed substitutes and solutions, some of which come from biofuel byproducts.

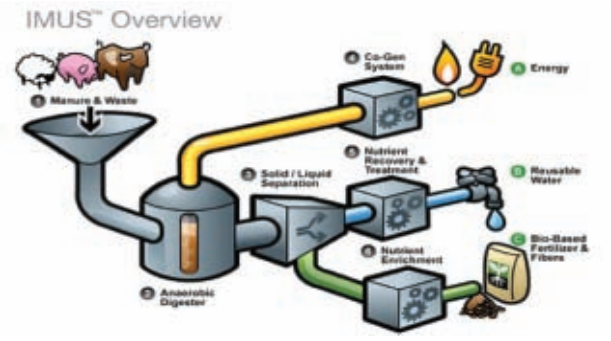
Creating domestic markets for any surplus grains in North America could also curb export programs, which some argue undermine agriculture production in developing nations. In addition, any shift in the feedstock of choice for biofuel or relaxation of import restrictions on foreign biofuel could have a huge impact on the supply and price of corn, wheat or soybean oil and corresponding food prices in the future.

The end goal is to assist in filling demand for food and biofuel inputs, but changes take time.

Other bio-related terminology

Biogas for electricity: another type of biofuel

Anaerobic digestion of biomass, such as manure or organic wastes, produces a combustible fuel called biogas. Biogas consists primarily of methane and carbon dioxide. Depending on the system design, biogas can be used to run a generator producing electricity and heat, or used as a fuel in a boiler or other burner. This energy can be used on the farm or sold to electricity distribution companies.



Source: Highmark Renewables (www.Highmark.ca)

Definitions

- Bio-economy is described by AAFC[1] as the use of biological processes and bio-resources to generate sustainable economic growth while improving human and environmental health.
- Bio-refinery is where biomass is converted to one or many bio-based products.
- Biomass or bio-resources are any organic materials as outlined in the table below.
- Cogeneration, or co-gen or combined heat and power (CHP), is a highly efficient means of generating heat and electric power at the same time from the same energy source. A common example is a power station that creates waste heat as a byproduct. Instead of emitting the heat into the environment, cogeneration captures it for domestic or industrial heating purposes. Less fuel needs to be consumed to create the same amount of useful energy, and less pollution is produced for a given economic benefit. Cogeneration also offers a large amount of flexibility as cogeneration equipment can be fired by fuels other than natural gas. There are installations in operation that use wood, agricultural waste, peat moss, and a wide variety of other fuels.
- Tri-generation is the simultaneous production of cooling, heating and power in one process, and the most environmentally friendly method of generating power and energy.

Considerations, costs and the market

- Biofuels need to be priced competitively with petroleum fuels at the pump, but there is no correlation between the two price structures as biofuel inputs are priced as agricultural commodities.
- Canadian ethanol producers and those working on business plans need to be prepared for price fluctuations in:
  - feedstock
  - byproducts like glycerine and DDG
  - natural gas
  - oil
  - cost of water use or future water charges
  - cost of disposal of materials like a surplus of DDG, if byproduct markets are adversely affected
- Supply and demand for inputs and outputs that are already subject to fluctuating market forces and further impacted by artificial measures like mandated requirements, incentives and subsidies.
- New technologies like cellulosic ethanol, new ways to meet environmental targets through nuclear or wind power, or further emissions controls on vehicles.

The bio-economy uses	and/or	to manufacture
renewable biomass (biological feedstock)	**bio-processes and bio-refining**	**diverse new or existing bio-products**
Trees	Bio-catalysis (enzymes)	**Bio-energy:**
Agricultural crops	Fermentation (micro-organisms)	Biofuels
Agricultural residues	Extraction	Electricity
Animal wastes	Gasification	Heat
Municipal wastes	Co-firing	
Certain industrial wastes	Pyrolysis	**Manufactured products:**
Fish, animals	At least 10 patented technologies like epoxidation and ozonolysis	Chemicals
Algae and water plant life		Bio-materials (transformer fluid)
Any organic residue		Pharmaceuticals

Source: Agriculture and Agri-Food Canada; Ontario Agri-Food Technologies

[1] Agriculture and Agri-Food Canada

- Capital costs are changing rapidly, and it's difficult to keep on top of them. Construction and the cost of stainless steel are huge factors. Unless fixed price contracts were established at the outset, by the time construction is ready to take place, some proposals are no longer viable.
- The capacity of state-of-the-art fuel ethanol plants is in the range of 150 million to 200 million litres per year. There are several U.S. facilities being built at capacities of 800 million litres per year.
- Large operations can be successful because they may be able to mitigate a number of the risks in biofuels production in ways that smaller operations or producer groups may not. Risks need to be understood by all parties involved. Large plants are also in a position to take advantage of economies of scale. American economic studies show that large economies of scale in biofuel manufacturing can be realized. It is estimated that tripling plant size – from 55 to 150 million litres per year for dry-mill plants and from 110 to about 375 million litres for wet-mill plants – reduces operating costs by 15 to 20 per cent and capital costs by up to 40 per cent.
- Mid-sized plants can also be efficient because of smaller batch sizes that are easier to control. Grain supply and byproduct output can be right-sized for the local area, reducing price risk of byproduct revenue and feedstock availability.
- Other critical success factors of ethanol plants: they can weather ups and downs in ethanol prices, gas prices and corn or other feedstock prices; they have specialists in hedging and using the options markets and natural gas markets; and they are prepared to ensure that water is available. With regards to transportation, they understand availability, costs and distances for feedstock, products and byproducts.
- There have been some challenges in moving from the business plan to being operational. Outputs must pass quality control and be 99.9 per cent pure. Some are having water and acid issues.
- It is important to ensure that ethanol DDG markets are secure and within a certain proximity to the plant. Where surpluses exist, some firms have ended up paying large sums to dispose of their DDGs. There can also be challenges with DDGs for shipping because of moisture and spoilage. Integrated plants are insulated from natural gas prices because the DDGs are used on-site and there is no reliance on natural gas and its fluctuating prices to dry the grains.
- Business plans need to recognize their margin's susceptibility to ranges in ethanol, feedstock, oil and natural gas prices, and need to have practices in place for mitigating risk around price, supply and demand. Business plans must also account for the plant location as it relates to feedstock sourcing and proximity to transportation networks.

Resources

Natural Resources Biofuels (Renewable Fuels)
What the government of Canada is doing
www.oee.nrcan.gc.ca/transportation/business/fed-gov-doing.cfm?attr=16

Canadian Renewable Fuels Association www.greenfuels.org/

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www.ers.usda.gov/Publications/FDS/2007/05May/FDS07D01/fds07D01.pdf

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Renewable Fuels Association
www.ethanolrfa.org/

National Biodiesel Board
www.biodiesel.org/

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08-067-022-02 E 03/31/09 AS

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