



Wood-ethanol in Canada: Production technologies, wood sources and policy incentives

by Sylvia Welke

Highlights

- Wood-ethanol production is well-positioned as a growth industry due to increasing oil prices and continued environmental and health concerns over the direct and indirect effects of fossil fuels.
- Most studies suggest that wood-ethanol is an ecologically and environmentally sound choice compared to fossil fuels and some grain-ethanol crops.
- Hardwood (i.e., low-lignin content) is the preferred feedstock for existing wood-ethanol production technologies.
- Research and development is under way to improve softwood-ethanol processes.
- More federal or provincial incentive programs, such as tax concessions, would enhance the viability of wood-ethanol production.

Technological advances in the production of ethanol from wood biomass now facilitate the use of ethanol as an octane-boosting additive for gasoline and a potential replacement fuel. While corn and other agricultural products are currently the largest source of ethanol, research suggests that cellulose- and wood-based ethanol may be more energy efficient and environmentally friendly to produce.

The forest industry is one of Canada's largest energy consumers and one of the top energy users within the transportation sector—Canada's leading contributor of greenhouse gas emissions. With its access to raw materials, the forest industry is well-positioned to reduce its greenhouse gas emissions and diversify its products through wood-ethanol production.

This note gives an overview of wood-ethanol production technologies in Canada, wood sources and current market and policy incentives for production. It is the companion note to the SFM Network Research Note # 23, *Wood-ethanol plantations: implications for sustainable forest management*.

Why ethanol?

Ethanol, a plant-derived fuel, is clean-burning and reduces engine emissions. It has been identified as an alternative to fossil fuels and as a means of decreasing carbon emissions associated with transportation. With rising global oil prices, ethanol has become a price-competitive fuel. In North America, corn is currently the largest source of ethanol, although this source is considered to be highly energy-intensive: the energy cost of growing the corn (fertilizer, planting and harvesting) and converting it to fuel can be greater than the energy actually produced from the corn. As a result, other ethanol sources, particularly

wood and cellulose, are increasingly favoured by governments. Several technologies exist to derive ethanol from wood, with the key ones being fermentation and gasification.

Ethanol production from wood can contribute to Canada’s commitment to the Kyoto Protocol through the establishment of short-rotation tree crops on non-forested land, such as marginal farmlands. These tree crops could increase the amount of carbon stored in the terrestrial carbon sink and, in turn, reduce atmospheric greenhouse gas levels.

Wood-ethanol production technologies

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Fermentation

While ethanol conversion from grain fermentation is a well-established technology, the technology for wood-ethanol conversion is still evolving. It is becoming increasingly attractive as a result of greater availability of low-cost wood residues and increased environmental concerns. The basic process involves: pre-treatment of wood feedstocks, hydrolysis, fermentation and ethanol recovery, although variations on this process exist.

Softwood, the dominant wood feedstock in Canada, is high in lignin, which initially hinders the conversion of sugars into ethanol. This makes hardwoods a preferred feedstock, although current research is focused on refining the processing of high-lignin softwood feedstocks.

Gasification

Gasification (a process that converts woody materials into combustible gas) is another promising technology that is still being developed. Its advantage over the current fermentation process is that many of its technological components are already in use at the industrial scale for other energy processes.

Demonstration projects in Canada

There are several wood-ethanol demonstration projects in Canada. The world’s first full-scale demonstration plant in Ottawa (constructed by Iogen Corporation with assistance from the federal

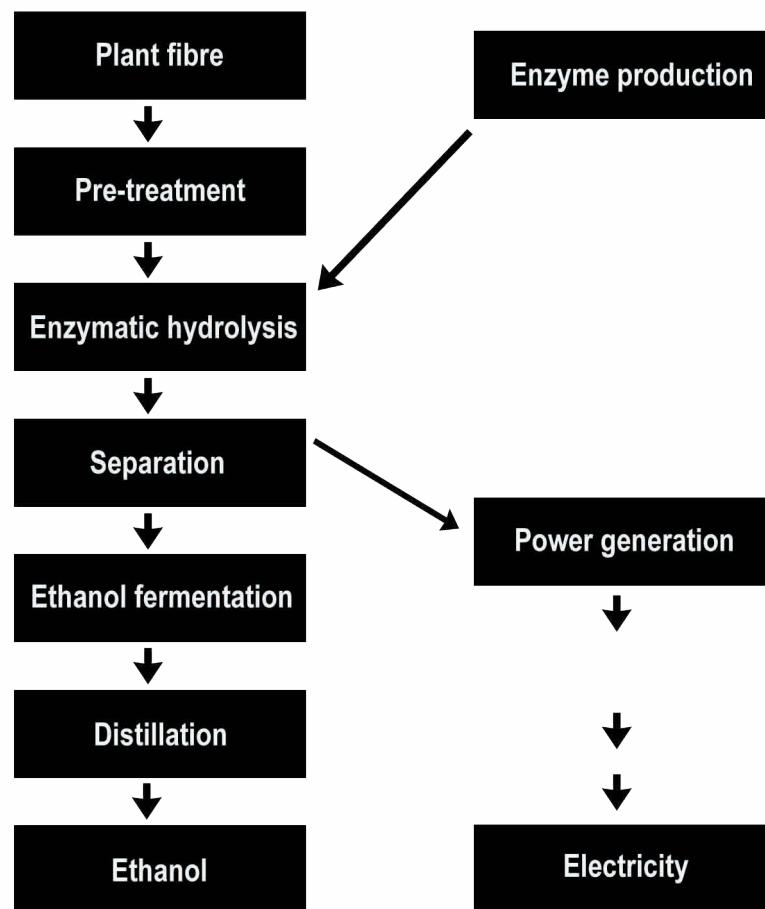


Figure 1. Generalized process for ethanol production, based on cellulosic plant fibre but similar to the processes under experimentation for lignocellulosics.

government and industry) converts agricultural and hardwood wastes to ethanol using enzyme technology. Lignol Innovations Corporation in Vancouver uses a process analogous to that used in an oil refinery to turn cellulosic wastes into ethanol. In a project at Tembec Inc., ethanol is produced by separating the lignin component and then using yeasts and bacteria in a pentose fermentation process.

Sources of wood for wood-ethanol production

The supply and cost of raw material is essential to the feasibility of industrial ethanol plants. Currently the major sources of wood biomass are short-rotation plantations and industrial wood waste (saw- and pulpmill residues).

Fast-growing plantations

The supply of feedstock from tree plantations depends on the cost and availability of land as well as site productivity, species and management. Supply is also dependent on the willingness of landowners to lease their land for afforestation or to accept compensation for planting trees (and society's willingness to pay for this compensation). As an example, hybrid poplar plantations on marginal farmland are considered economically viable for wood-ethanol production. Furthermore, demand for wood biomass from fast-growing plantations is expected to increase as other feedstocks such as grains become more costly.

The companion SFM Network Research Note # 23, *Wood-ethanol plantations: implications for sustainable forest management*, explores some of the forest management implications of plantations grown for wood-ethanol.

Industrial wood waste

Industrial wood waste supply varies with fluctuating annual harvest and allowable cut levels as well as tree species, log condition, type of processing and end product. Industrial wood residues, however, are becoming more valuable and thus, less available with an increasing number of co-generation plants as well as an increased demand for sawmill waste from secondary wood industries such as medium density fibreboard plants.

Forest residue and coarse woody debris

Residual fibre from harvest or silvicultural operations (e.g. thinnings, branches, low-value trees, beetle-killed timber, etc.) could be another source depending on the availability. However, these sources are often not consistently available and are therefore less economically attractive. In addition, forest residue and coarse woody debris play an important ecological role in forests. Trade-off analysis and the ecological implications of using this wood source for ethanol production need to be examined in the context of an integrated resource management approach.



Hybrid poplar plantation in the U.S. Photo courtesy of Manfred Mielke, USDA Forest Service.



Markets for wood-based ethanol in Canada

According to some analysts, the trend in the United States and other countries suggests there is a parallel, untapped market for ethanol in Canada. In the United States, where several industrial bio-conversion plants exist, ethanol accounts for 8 to 10% of the gasoline sold in that country. (Most conventional vehicles can operate on fuels containing up to 10% ethanol without requiring engine modification.) Growth there has been steady and will depend on favourable state legislation, market prices for oil and other alternative fuels, and the increase in sales of vehicles that run on 85% ethanol blends.

In Canada, ethanol is currently used by gasoline companies at more than 1000 service stations in several provinces and the Yukon Territory for different purposes. Mohawk Oil (Alberta) and MacEwen's (Ontario), for example, have developed a niche market in providing ethanol-blended gasoline while Petro-Canada uses it for its octane-boosting characteristics. Manitoba and Saskatchewan have targets of 10% and 7.5% (respectively) ethanol content for all gasoline sold in the province. Other provinces are following suit.

The market for ethanol and other alternative fuels is greatly influenced by the price of oil. Rising oil prices lead to increased demand for alternative fuels such as ethanol. Canada's total ethanol production (currently all from grain)—234 million litres annually (2005 figures)—represents only 0.7% of all gasoline sold and would only amount to 5% if all gasoline was 10% blended. The Government of Canada predicts annual ethanol production will increase to 1.4 billion litres by 2007 and has a target that 35% of all gasoline sold in Canada by 2010 will contain 10% ethanol.

The health and environmental effects associated with other octane-boosting agents such as MMT (methylcyclopentadienyl manganese tricarbonyl) and MTBE (methyl tertiary butyl ether), also indicate that the market share of ethanol should continue to increase.

With the expected technological advances in the wood-ethanol process, the cost of production, which was \$2.50/litre in 1974 and was \$0.30-0.35/litre in 2005, is expected to drop to \$0.22/litre in the next decade. In comparison, the 2006 cost of gasoline production is \$0.18/litre. The cost of crude oil (\$0.50/L), taxes (\$0.34/L) and marketing (\$0.04/L) make up the remaining cost per litre of gasoline.

Policy incentives for ethanol production in Canada

Several policy and tax incentives pertaining to ethanol production (wood and grain) currently exist in Canada.

- There is a Federal Excise Tax exemption for biomass-produced ethanol.
- The Canadian government has made \$118 million available (mid-2005) for ethanol production research and development through the Ethanol Expansion Program.
- To help reduce the risk of future increases in taxes and feedstock prices (or conversely a decrease in oil prices), the National Biomass Ethanol Program (the renewed Federal Fuels Initiative) provides a line of credit to qualified ethanol manufacturers (\$140 million in contingent loan guarantees) and aims to boost Canada's annual ethanol production and use.
- Several provinces have incentive programs for ethanol production ranging from 19.76 and 14.7 cents/litre for ethanol in Quebec and Ontario, to 1.5 and 2.5 cents/litre for fuel containing a minimum of 10% ethanol in Manitoba and Saskatchewan, respectively.

- The Canada Centre for Mineral and Energy Technology (CANMET) Bio-energy Development Program focuses on ethanol production from forestry wastes and biomass. According to 2004 statistics, there is enough wood waste in British Columbia alone to replace half of the gasoline sold in Canada with a 10% wood-ethanol blend.
- Large grain-ethanol plants have been established in Ontario and Quebec as a result of long-term tax incentive agreements and federal programs. These plants could serve as a model for wood-ethanol production in those provinces.
- Canada's international commitments for the reduction of greenhouse gases may maintain the public's interest and demand for ethanol. However, decreasing air quality and its more immediate health effects may be more effective drivers to push policy towards cleaner transportation fuel sources.

Future policy and research directions

Canada approaches the fuel industry through a national marketing and product program, which limits the role that provincial/ territorial incentives can play in stimulating ethanol production. Researchers and policy analysts suggest that the federal government should provide further incentives in the form of tax concessions on ethanol-blended fuel. Increased provincial/territorial incentives would help companies overcome the high initial capital costs and encourage industry to enter into wood-ethanol production. This has already occurred in the United States where tax incentives, loan guarantee programs and regulations have allowed for the establishment of a strong ethanol industry.

The 2006 policy of the Canadian Government that mandates all gasoline to contain 5% ethanol may well stimulate additional ethanol production. A minimum 10% ethanol policy may make wood-ethanol production even more economically feasible.

The following **recommended policy incentives** and **future research areas** would further promote wood-ethanol in Canada:

- Federal tax concessions on ethanol-blended fuel.
- A minimum 10% ethanol policy for all fuel sold in Canada.
- The development of carbon markets by the federal government to enable ethanol producers to sell carbon offset credits to help promote the industry in Canada.
- Tougher air quality laws to promote the increased use and demand for clean-burning fuels such as ethanol.
- Investigation into and development of markets for the lignin co-product of the conversion process.
- Conclusive studies to confirm the energy balance of wood-ethanol production.



Summary

There is a future for wood-ethanol production in Canada provided that the bioconversion technologies become cost- and energy-effective, particularly for high-lignin softwood. The supply of wood biomass would likely come from a combination of industrial wood waste and afforested biomass, both offering year-round consistent supply. With global oil prices predicted to remain high, and with federal and provincial/ territorial governments mandating a proportion of ethanol-blended gasoline on the market by 2007, the growth of the ethanol industry seems very likely.

Further reading

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