



*Value-added bioproducts – Enerkem Technologies Inc.*

The economic viability of commercial-scale production of fuel ethanol from cellulosic biomass can be critically dependent on the associated production of high value co-products. Enerkem is investigating processes to depolymerize the lignin component of biomass to yield valuable fuel additives and chemicals.

*Commercialization – Iogen Corporation*

In April 2004, Iogen began operation of a fully integrated, four million litre/year capacity, pre-commercial demonstration plant for the production of ethanol from wheat straw. The company is now actively engaged in moving to construction of the first commercial-scale cellulosic ethanol plant.

**Conclusion**

Canada's first pre-commercial demonstration plant to produce ethanol from agricultural waste began operation in April, 2004.

CETC-Ottawa is proud of its role in moving ethanol-from-waste out of the laboratory and into the marketplace.



*Iogen Corporation Fermentor*

Your Invitation to Work with Us

We are interested in collaborating with you. Please contact the Business Office to discuss your particular needs.

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*To find out more about CETC-Ottawa's Bioenergy Development Program please contact:*

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Visit the Canadian Biomass Innovation Network Web site: [www.cbin.gc.ca](http://www.cbin.gc.ca)

Visit the Canadian Renewable Energy Network (CANREN) Web site: [www.canren.gc.ca](http://www.canren.gc.ca)

CETC CANMET ENERGY TECHNOLOGY CENTRE

CLEAN ENERGY FROM BIOMASS

CLEAN ENERGY TECHNOLOGIES

ETHANOL – THE GREEN GASOLINE

*Ethanol has many environmental advantages over gasoline - a major contributor to climate change. It is estimated that a litre of ethanol when used to replace a litre of gasoline reduces the accumulation of atmospheric carbon dioxide - a harmful greenhouse gas - by 60-80 per cent.*

**Bioenergy Development Program**

For the past two decades, Natural Resources Canada's CANMET Energy Technology Centre-Ottawa (CETC-Ottawa) has assisted Canadian firms in making ethanol from biomass a commercial reality.

The automotive industry's first investigation into fuel ethanol dates back to Henry Ford's original Model "T" design. While gasoline soon replaced ethanol as the fuel of choice, modern environmental concerns have revived interest in this "green gasoline".

Until recently, environmental concerns were outstripped by the fact that gasoline was far cheaper and more accessible than ethanol. However, with heightened environmental awareness and global commitment to reduce greenhouse gases, ethanol has emerged as an available and desirable option for consumers.



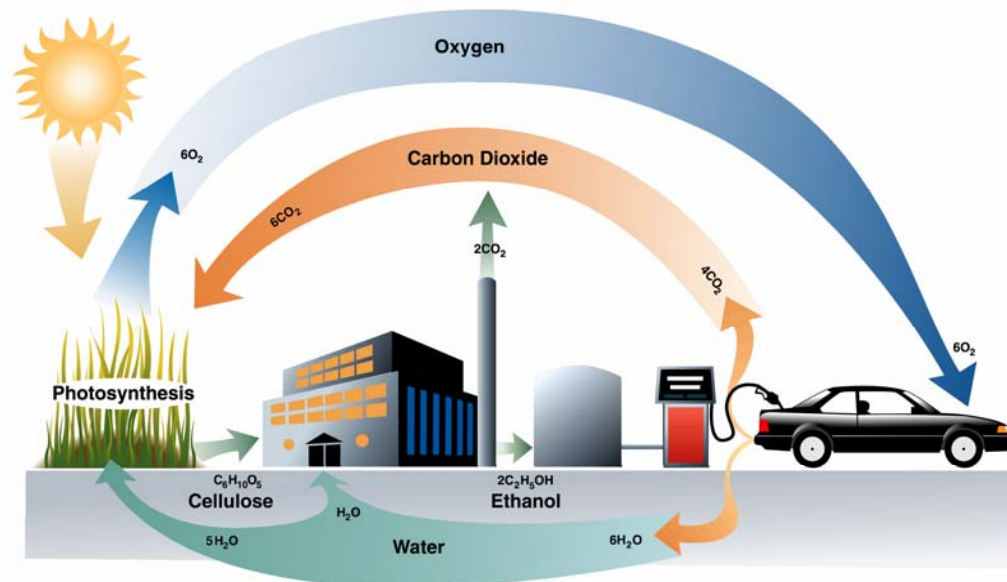
*University of British Columbia Plant*

179 million litres of fuel ethanol are produced in Canada each year from cereal grain and corn. With the addition of new production plants currently under construction, this is expected to increase to 1.2 billion litres over the next few years.

Grain ethanol, as an additive to transportation fuels, has now gained commercial acceptance. Over 1,000 retail outlets across



### CARBON DIOXIDE RECYCLE WITH ETHANOL FUEL



Straw Bales for Biomass

Canada offer E10 - ethanol blend fuels (10% ethanol, 90% gasoline).

#### Biomass Ethanol

Ethanol can be made from feedstocks other than grain. For example, major breakthroughs are being made to convert lignocellulosic biomass products into ethanol.

Currently, the focus of CETC-Ottawa's Biomass Energy and Systems Technologies program is on forestry residues such as wood chips and sawdust, and agricultural feedstocks such as straw and perennial grasses. Great strides are also being made to convert municipal wastes as well.

The amount of lignocellulosic waste currently available in Canada could theoretically provide well in excess of the amount of ethanol required (1.4 billion litres) to achieve the Canadian government's target of 35% of (all) gasoline in Canada being E10 by 2010.

At present, the production of alcohol from lignocellulosic feedstocks is a four stage

process: pre-treatment to expose the cellulose and hemicellulose components, converting the cellulose and hemicellulose components into sugars, fermenting the sugars to produce ethanol and recovering the ethanol.

#### Technology Advancement

Innovative, high-tech systems are being developed to meet the specific requirements of producing ethanol from renewable biomass resources. Basically, they all consist of four unit operations, each with its own technical and economic barriers. Through our partnerships in research and development, we serve as a catalyst to remove these barriers and to make commercial implementation a reality.

#### Program Highlights

*Softwood Pretreatment - University of British Columbia (UBC)*

Canada has an abundant supply of soft wood residues generated from activities in its forest sector. Recent work shows that Lodgepole pine and spruce are more amenable to steam

pretreatment than Douglas fir, the focus of earlier work. This is significant since in British Columbia over the next two decades, large quantities of Lodgepole pine are anticipated to become available for conversion. Work is underway to improve:

- cellulose yield and digestibility
- hemicellulose monomeric sugar yield
- lignin yield

Significant progress has been made in process modeling to analyze the economics of process scale-up. Organosolv pretreatment of pine has also proved to be an effective pretreatment process and yields a lignin with good suitability for co-product manufacture.

*Cellulose Hydrolysis - Iogen Corporation*

Iogen is a world leading biotechnology firm specializing in the conversion of cellulosic biomass to ethanol.

R&D focuses on improvements in efficiency of

cellulase enzymes used for the conversion of the cellulose component of biomass to fermentable sugar to improve the economic viability of the process.

*Improved Ethanol Recovery – Vaperma*

An important cost factor in the ethanol production process is the separation of ethanol from water. This work involves the development of a hollow fibre membrane system for the vapour phase separation of ethanol/water mixtures.

*Syngas/Landfill Gas/Biogas to Ethanol - Syntec Biofuel Inc.*

Canada is taking an increasingly active role in managing residuals from its agricultural, municipal and industrial sectors. Technology is being developed to convert biomass and/or landfill/anaerobic digester gas to ethanol using a thermal chemical conversion route. The two most important aspects of the proposed technology are gasification of the biomass steam reforming of the gas to yield synthesis gas and the subsequent catalytic conversion of the synthesis gas to ethanol.