BIOENERGY AND BIOFUELS

CANADIAN INDUSTRY AND MARKET OPPORTUNTIES

Compiled for IRAP PACIFIC, Clean Technology Group

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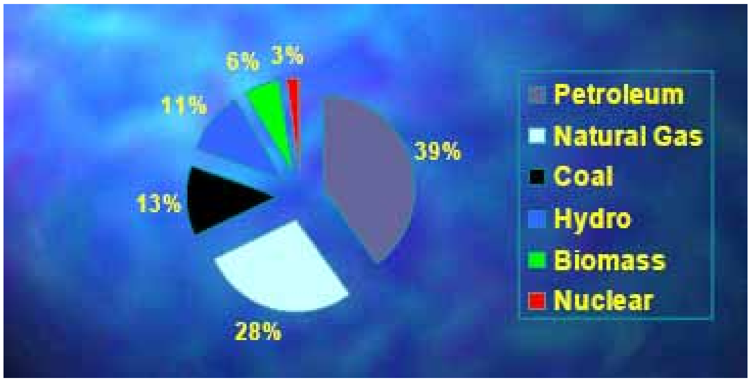
Introduction

This report summarizes recent information gathered from a wide variety of sources: government publications, industry reports and news releases, statistical information, academic and industrial conference papers, and a variety of materials made available by government, industry, environmental organizations, and other entities on the Internet.
The separate file Literature contains an extensive, but not exhaustive, list of resources used in compiling this report.

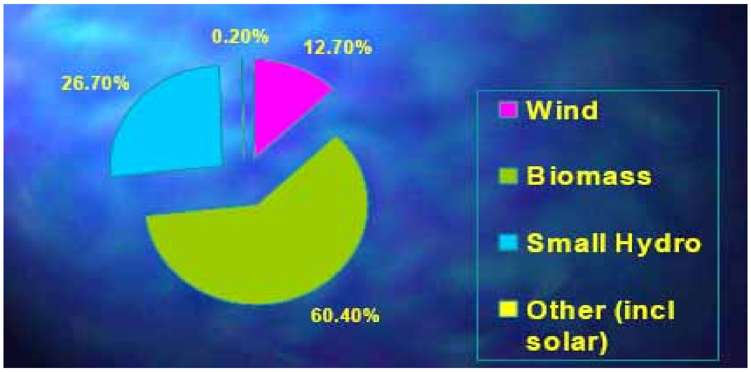
1. Bioenergy in Canada - Overview

Biomass currently provides about 15 per cent of the energy used by people around the world and meets 35 per cent of the energy needs of developing countries.
Currently, Canada meets about **six per cent of its total energy needs from biomass**, compared to three per cent for both the European Union and the United States.

Canadian Primary Energy by Source



Renewable Generating Capacity



From: *Biomass in Canada - Development and Trade Options, Business Forum on Sustainable Biomass Production for the World Market, Campinas, Brazil- Dec 1, 2005, Doug Bradley*
http://www.bioenergytrade.org/downloads/bradleynovdec05.pdf

In Canada, millions of tonnes of biomass are harvested every year as trees and crops from forests and farms. However, BIOCAP Canada Foundation estimates that, if collecting and processing it were feasible, the amount of unused biomass left on fields and forest cut sites after harvest could supply 27 per cent of the energy we now get from fossil fuels. The university based research organization also calculates that a 25 per cent increase in today's tree and crop production could meet a further 15 per cent of the energy demand now being filled by fossil fuels.[1]

Bioenergy production represents Canada's second largest renewable energy source after hydro. Most bioenergy is produced from organic refuse and used with the facilities in which the energy conversion takes place. The pulp and paper industry produces and uses most of Canada's bioenergy. Industrially produced heat and electricity, independent power producers' electricity, electricity from urban wastes and residential wood heat are all considered commonplace in Canada's energy mix.

Home heating with wood usually takes the form of stand-alone wood stoves, wood furnaces with hot water or forced-air systems, fireplaces with advanced combustion inserts, high-efficiency fireplaces or high-thermal-mass masonry heaters. About 3 million Canadian households use wood for home heating. Canadians usually prefer round wood, but alternatives include wood chips and pellets.

Corn and other agricultural products are also used to generate ethanol and biodiesels for the transportation market.

2. Biomass Resources

Canada is well endowed with natural bioresources. It has 10 percent of the world's forests. The BIOCAP Canada Foundation estimates that Canada's reserve of timber resources is equivalent to 69 times its annual consumption of fossil fuels. On an annual basis, the renewable resource residues from forestry, agriculture and related manufacturing industries are equivalent to approximately 18–27 percent of the energy Canada derives from fossil fuels.[2]

Land Area: Of Canada's 998 million hectares of total land area, about 42 percent is forested, with about 245 million hectares or 25 percent of the total considered timber productive forest. A further 67.5 million hectares (6.8 percent) make up agricultural land, of which 36.4 million hectares (3.6 percent of total) are cropland.

Standing Biomass / Bioenergy Stock:
The 245 million hectares of timber productive forest in Canada have a biomass carbon stock of about 15 835 million tonnes of carbon. The energy content of this resource amounts to 566 exajoules, or about 69 times Canada's annual energy demand met by fossil fuels.

Annual Harvest: The annual biomass harvest from Canada's forestry and agricultural sectors is about 143 million tonnes of carbon. This level is similar to the annual atmospheric emissions of carbon from fossil fuel use in Canada, which amounted to about 150 million tonnes of carbon in 1998. The annual energy content of the biomass harvest in Canada amounts to 5.1 exajoules, which is 62 percent of the energy derived from fossil fuel combustion. A 25-percent increase in forestry and agricultural production in Canada could provide about 1.25 exajoules a year in biomass energy, an amount equal to about 15 percent of the energy that Canada now derives from fossil fuels.

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[1] *Primer on Bioproducts,* 2004
http://www.biocap.ca/images/pdfs/BioproductsPrimerE.pdf

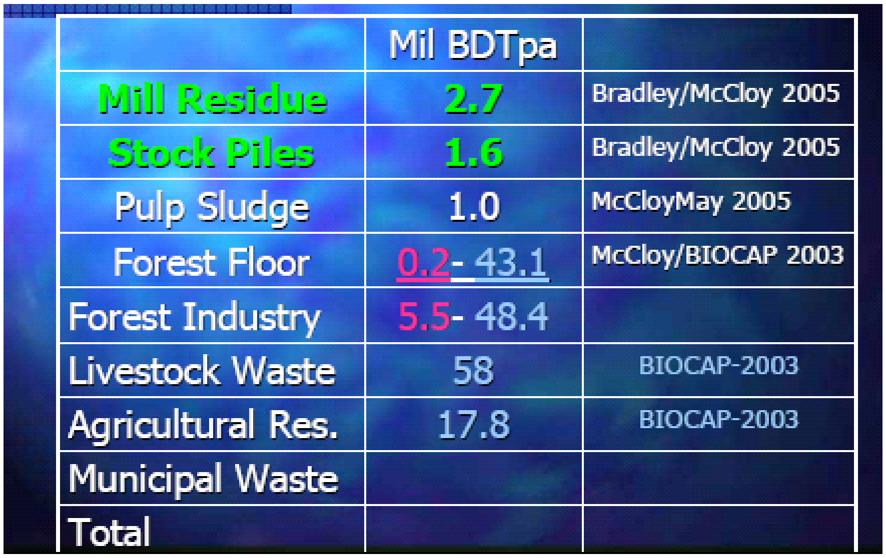
[2] *Innovation Roadmap on Biobased Feedstocks, Fuels and Industrial Products,* 2004
http://www.bio-productscanada.org/pdf/en_roadmap_book.pdf

Residue Biomass: There are large residual or residue biomass carbon streams that are associated with existing agriculture and forestry or with municipalities:

- Of the more than 66 million tonnes of carbon a year in the residual or waste biomass carbon stream, about 60 million tonnes may be considered "available" feedstock for a bio-based economy. This represents about 42 percent of the entire forestry and agricultural harvest.
- The energy content of this biomass resource, conservatively estimated to be in the range of 1.5–2.2 exajoules a year, is equivalent to 18–27 percent of the energy that Canada derived from fossil fuels in 2000.

In addition, residue products from fisheries and aquaculture could provide considerable amounts of valuable fish oils, fatty acids and chitin. The potential of alginates in conversion to energy and chemicals requires further study and could be significant.

Biomass Supply



	Mil BDTpa	
Mill Residue	2.7	Bradley/McCloy 2005
Stock Piles	1.6	Bradley/McCloy 2005
Pulp Sludge	1.0	McCloyMay 2005
Forest Floor	0.2- 43.1	McCloy/BIOCAP 2003
Forest Industry	5.5- 48.4	
Livestock Waste	58	BIOCAP-2003
Agricultural Res.	17.8	BIOCAP-2003
Municipal Waste		
Total		

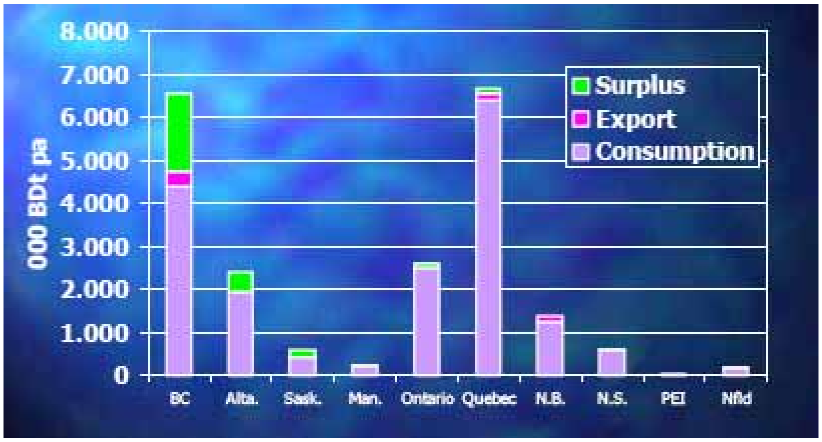
From: *Biomass in Canada - Development and Trade Options, Business Forum on Sustainable Biomass Production for the World Market, Campinas, Brazil- Dec 1, 2005, Doug Bradley*
http://www.bioenergytrade.org/downloads/bradleynovdec05.pdf

2.1. Biomass from Forest Resources

2.1.1. Wood Products Mill Residues

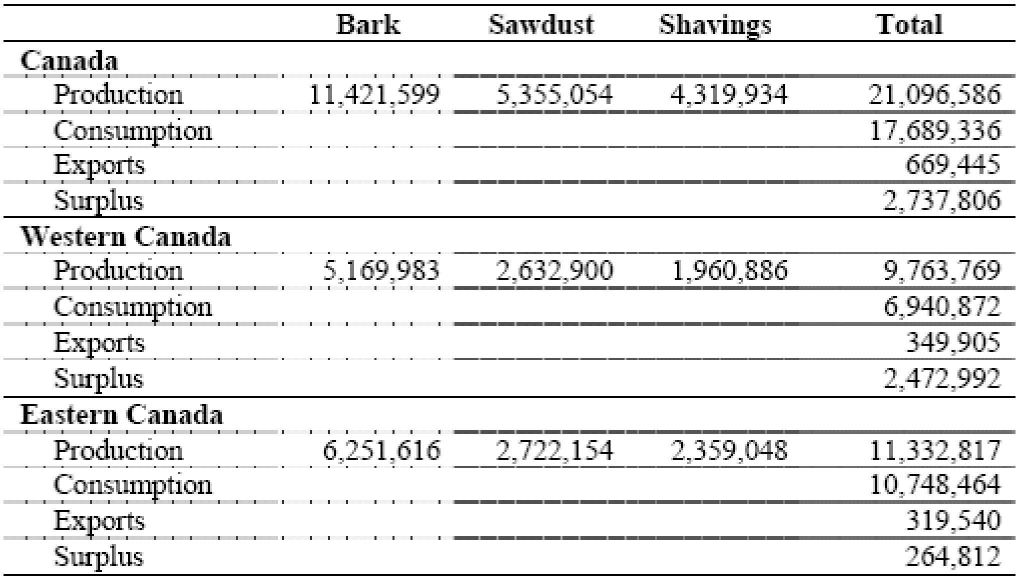
Canadian sawmills are responsible for the majority of forest mill residues produced. In 2004, lumber production in Canada was 35,510 MMfbm. Over 71 percent of this production occurred in British Columbia (47%) and Quebec (24%). Alberta and Ontario accounted for approximately 10% each. The coastal region of British Columbia was not considered in this analysis because there are very little residues available in this region, if any.

Annual Mill Residue Production- Canada, 2005



From: *Biomass in Canada - Development and Trade Options, Business Forum on Sustainable Biomass Production for the World Market, Campinas, Brazil- Dec 1, 2005, Doug Bradley*
http://www.bioenergytrade.org/downloads/bradleynovdec05.pdf

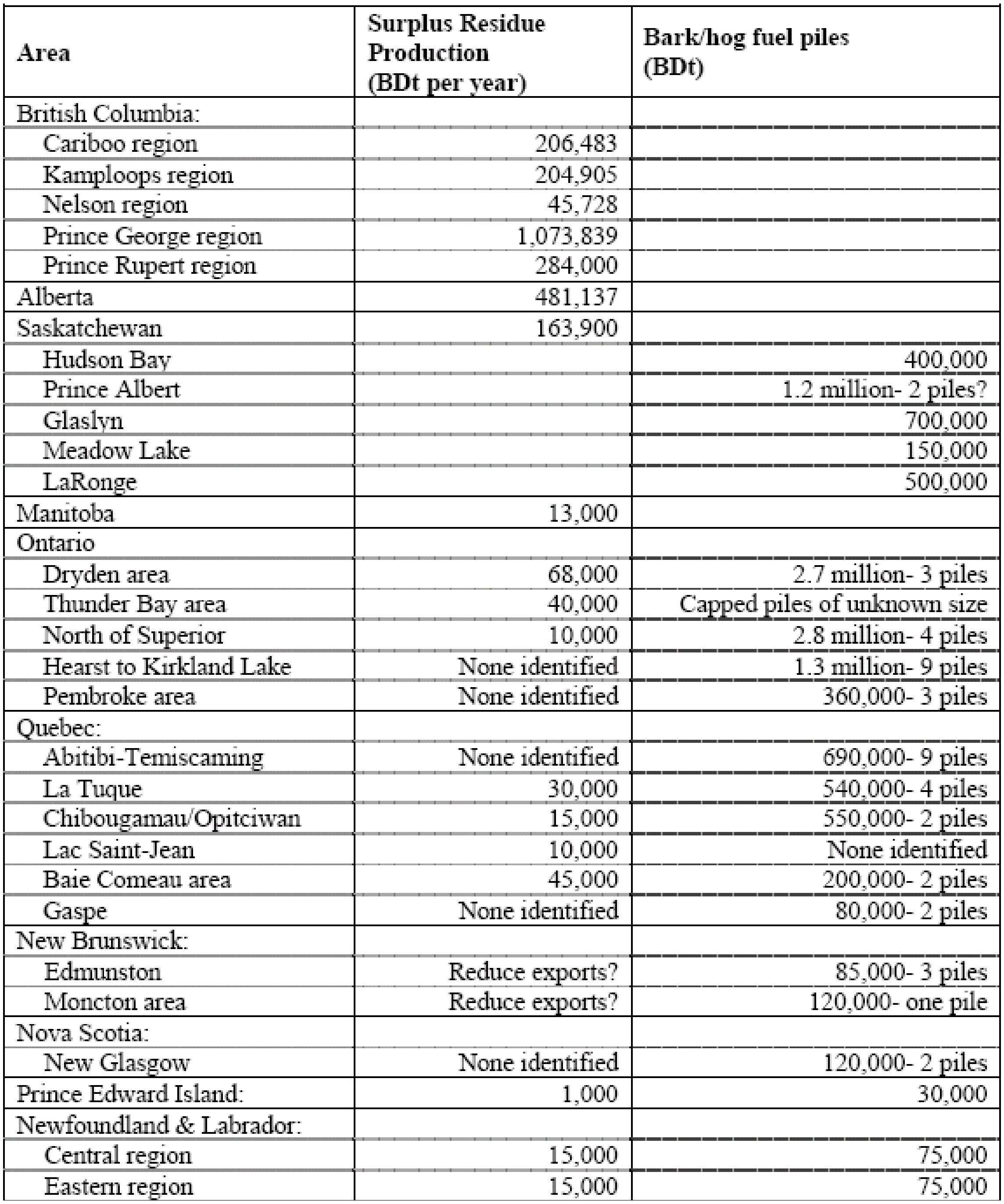
Eastern and western Canada summary of mill residues (BDt)



	Bark	Sawdust	Shavings	Total
Canada				
Production	11,421,599	5,355,054	4,319,934	21,096,586
Consumption				17,689,336
Exports				669,445
Surplus				2,737,806
Western Canada				
Production	5,169,983	2,632,900	1,960,886	9,763,769
Consumption				6,940,872
Exports				349,905
Surplus				2,472,992
Eastern Canada				
Production	6,251,616	2,722,154	2,359,048	11,332,817
Consumption				10,748,464
Exports				319,540
Surplus				264,812

From: *Estimated Production, Consumption and Surplus Mill Wood Residues in Canada – 2004, National Report,* 2005,
http://www.fpac.ca/Mill%20Residue/Mill%20Residue%20Inventory%20Canada_Final%20November%202005.pdf

Potential zones of bioenergy development



Area	Surplus Residue Production (BDt per year)	Bark/hog fuel piles (BDt)
British Columbia:		
Cariboo region	206,483	
Kamploops region	204,905	
Nelson region	45,728	
Prince George region	1,073,839	
Prince Rupert region	284,000	
Alberta	481,137	
Saskatchewan	163,900	
Hudson Bay		400,000
Prince Albert		1.2 million- 2 piles?
Glaslyn		700,000
Meadow Lake		150,000
LaRonge		500,000
Manitoba	13,000	
Ontario		
Dryden area	68,000	2.7 million- 3 piles
Thunder Bay area	40,000	Capped piles of unknown size
North of Superior	10,000	2.8 million- 4 piles
Hearst to Kirkland Lake	None identified	1.3 million- 9 piles
Pembroke area	None identified	360,000- 3 piles
Quebec:		
Abitibi-Temiscaming	None identified	690,000- 9 piles
La Tuque	30,000	540,000- 4 piles
Chibougamau/Opitciwan	15,000	550,000- 2 piles
Lac Saint-Jean	10,000	None identified
Baie Comeau area	45,000	200,000- 2 piles
Gaspe	None identified	80,000- 2 piles
New Brunswick:		
Edmunston	Reduce exports?	85,000- 3 piles
Moncton area	Reduce exports?	120,000- one pile
Nova Scotia:		
New Glasgow	None identified	120,000- 2 piles
Prince Edward Island:	1,000	30,000
Newfoundland & Labrador:		
Central region	15,000	75,000
Eastern region	15,000	75,000

From: *Estimated Production, Consumption and Surplus Mill Wood Residues in Canada – 2004, National Report,* 2005, http://www.fpac.ca/Mill%20Residue/Mill%20Residue%20Inventory%20Canada_Final%20November%202005.pdf

2.1.2. Forest Floor Residues

In eastern Canada, there is very little surplus mill waste, and a number of companies are starting to look seriously at harvesting forest floor residues and undesirable species in mixed wood stands. A Timberjack 1490D bundler was brought to the US and Canadian west coast in the fall of 2003 for some demonstration trials by Timberjack dealers, including Brandt in BC and Alberta.

The machine was kept busy throughout the summer of 2004 doing demo trials across Canada, from BC to the Maritimes. Trials have taken place on Weldwood limits near Hinton, AB, on Tembec limits near Kapuskasing, ON, and on JD Irving lands in the Sussex area of New Brunswick.

Bundler operator Tim West (who was hired by Timberjack to demonstrate the machine) felt that the machine performed very well in varying Canadian conditions with average production of 20 bundles per hour and going up to 35 in some cutovers. Processing was done following both short wood and roadside harvesting systems.[3]

2.1.3. Biomass from BC Mountain Pine Beetle Infested Forest

The forestry industry of the Province of British Columbia is facing a major problem due to mountain pine beetle (MPB) infestation. According to current estimates the area of infestation in British Columbia was 4.2 million hectares in 2003. This infestation is expected to result in about 500 million m3 of infected wood biomass over three years.[4]
It is estimated that in 2006 alone 90 million m3 of wood will be infected. And the number will reach 1 billion in 2016. Up to 50% of this biomass is forecast to remain non-recoverable.
A project funded by BIOCAP Canada Foundation evaluated the feasibility of producing electricity from surplus Mountain Pine Beetle (MPB) killed trees in the Province of British Columbia. The authors of the study evaluated four different case scenerios for building a biomass power generation facility and concluded that by building a power plant in the range of 200 to 400 MW for beetle infested pine, Canada and BC would position themselves at the forefront of power generation from biomass at the very time that this technology will undergo intense scrutiny around the world as a means by which countries can meet their Kyoto targets. In addition to the direct benefit of using beetle infested pine to generate power, Canadian firms would be well positioned to design and/or develop projects in other locations around the world. Given Canada's large forestry resource, it makes sense for it to be a leader in power from wood. [5]

2.2. Agricultural Biomass

According to a study by the BIOCAP Canada Foundation[6], biomass residues in Canada are estimated to be:

- agricultural crop residues - 17.8 million dried tonnes per year
- forestry residues – 92 million dried tones, forestry residues - easily accessible surplus say mill residues account for about 5.4 million dried tonnes per year

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[3] *Making A Bundle With Biomass,* 2004
http://forestcommunications.com/cfi/Issues/nov-dec04/biomass.html

[4] *British Columbia's Beetle Infested Pine: Biomass Feedstocks for Producing Power,* 2005
http://www.biocap.ca/images/pdfs/2005-04-30_Final_Report.pdf

[5] *Feedstock Availability and Power Costs Associated with Using BC's Beetle-Infested Pine*, 2005
http://www.biocap.ca/files/reports/2005-11-03_MPB_Study-Phase2-Final_Report.pdf

[6] *A Canadian Biomass Inventory: Feedstocks for a Bio-based Economy*, 2003
http://www.agwest.sk.ca/bioproducts/documents/BIOCAP_Biomass_Inventory_000.pdf

In the 2003 study, the BIOCAP Canada Foundation estimated agricultural crop residues in 2001. Total crop production was estimated at 78.3 M Odt (million oven-dry tonnes), of which 70% was wheat, barley or tame hay. 56.1 M Odt of production was straw or stover, some of which must be returned to the soil to maintain soil fertility and carbon content. Residues recoverable and sustainably removable were estimated at 29.3 Odt annually, however some of this goes to traditional uses such as animal bedding and mulching. Agricultural biomass available for energy may be 17.3 M Odt annually, equivalent to 309 TJ annually[7]

The breakdown for the five top agricultural crop residues in Canada is as follows (in million dried tonnes per year):
< wheat - 7.49
< corn - 3.33
< barley - 3.04
< canola - 2.76
< oats - 0.75.

Large, capital intensive biomass-to-ethanol plants require access to huge supplies of agricultural residues**.** **Iogen**, for example, believes economies of scale are reached with a feedstock through put of 750,000 tonnes per annum. There are not many locations in Canada where either corn stover, wheat straw, or forest mill residues will be able to cost-effectively provide this amount of feedstock.

The relative lack of feedstock availability in Canada is an important issue that will ultimately place limits on the economic viability and sustainability of Canadian bio-based industries that intend to serve large commodity markets. Unless programs are put in place to expand biomass production in Canada (e.g., switchgrass, fast growing poplars, hemp, etc.) Canada may find itself constrained to competing for niche markets.

2.2.1. Ethanol Feedstock Supplies

Canada has a rich resource base that could be used for the production of ethanol. About 20 million hectares in Canada are devoted to the production of starch producing grains suitable for use in ethanol production, such as wheat, barley, oats, and corn.

The following table is a comparison of feedstock supply and ethanol demand in different provinces in Canada.

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[7] *Ethanol and Other Chemicals from Sugars,* 2003, http://www.agr.gc.ca/misb/spec/bio/pdf/ethanol2_e.pdf

Comparison of Feedstock Supply and Ethanol Demand

	Ethanol Demand (mln L)	Corn (mln L)	Wheat (mln L)	Barley (mln L)	Potatoes (mln L)	Total Supply (mln L)
B.C.	162	0	0	0	0	0
Alberta	181	0	400	74	0	474
Sask.	61	0	666	60	0	726
Manitoba	51	0	266	15	0	281
Ontario	539	400	0	0	0	400
Quebec	300	120	0	0	0	120
N.B.	110	0	0	0	3.5	3.5
N.S.	37	0	0	0	0	0
P.E.I.	8	0	0	15	6	21
Nfdl.	21	0	0	0	0	0
Yukon	2	0	0	0	0	0
NWT	1	0	0	0	0	0
Nunavut	0	0	0	0	0	0
Canada	1,473	520	1332	164	9.5	2,025.5

From*: Economic, Financial, Social Analysis and Public Policies for Ethanol, Phase I, November 2004,*
http://www.greenfuels.org/ethanol/pdf/OConnor-Report-Ethanol-2004.pdf

An additional 17.8 million dried tonnes per year of crop residues are also potentially available for industrial use. Supplementing these feedstock sources are forestry residues, which account for another 97 million dried tonnes per year.[8]

Comparison of Lignocellulosic Feedstock Supply and Ethanol Demand

	Ethanol Demand (mln L)	Corn Stover (mln L)	Straw (mln L)	Wood Residues (mln L)	Forest Residues (mln L)	Total Supply (mln L)
B.C.	162	0	0	680	2,024	2,704
Alberta	181	0	430	300	280	1,010
Sask.	61	0	500	0	0	500
Manitoba	51	0	200	0	0	200
Ontario	539	640	0	0	1,312	1,952
Quebec	300	384	0	540	1,789	2,713
N.B.	110	0	0	0	615	615
N.S.	37	0	0	0	0	0
P.E.I.	8	0	0	0	0	0
Nfdl.	21	0	0	0	0	0
Yukon	2	0	0	0	0	0
NWT	1	0	0	0	0	0
Nunavut	0	0	0	0	0	0
Canada	1,473	1,024	1,130	1,520	6,340	11,467

From*: Economic, Financial, Social Analysis and Public Policies for Ethanol, Phase I, November 2004,*
http://www.greenfuels.org/ethanol/pdf/OConnor-Report-Ethanol-2004.pdf

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[8] *Non-Food/Non-Feed Industrial Uses for Agricultural Products, Phase 2 and 3 Summary*, 2004,
http://www.agr.gc.ca/misb/spec/bio/pdf/non2_e.pdf

These large potential feedstock sources have led some to argue that Canada enjoys a "green advantage." However, some ethanol experts warn against being overly optimistic.[9] They argue that the current market for ethanol (E10) combined with potential expansion to higher ethanol blends (E20/E25 and E85), E-Diesel, fuel for mobile and stationary fuel cells, and expansion into biochemical production will vastly out-pace feedstock availability.

Even the most optimistic projections would suggest that agricultural and forestry residues and municipal cellulose waste streams in Canada can produce only 27% of domestic fossil fuel production - assuming these feedstocks can all be economically and sustainably collected.

In order to realize the full potential of the new biobased economy, Canada will have to develop new dedicated energy crops such as switchgrass, hemp, and other specialty crops to extend its feedstock resources. In some jurisdictions, like Ontario, there will also have to be an emphasis on importing cheap corn from the US in order to capture the downstream processing and manufacturing benefits from the new bio-based economy. Wheat straw will also be an important new raw material source for ethanol production.

2.2.2. Biodiesel Feedstock Supplies

Some potential biodiesel feedstock is available in all provinces and territories. The feedstock potential in the Prairie Provinces is higher because of the availability of canola oil.

Potential Biodiesel Feedstock Availability and Biodiesel Demand

	Biodiesel Demand (mln L)	Animal Fats (tonnes)	Yellow Grease (tonnes)	Canola Oil (tonnes)	Soya Oil (tonnes)	Marine Oils (tonnes)	Total (tonnes)
B.C.	70	2,416	6,761	1,560	0	0	10,737
Alberta	104	34,800	5,083	86,200	0	0	126,084
Sask.	32	7,846	1,652	107,040	0	0	116,538
Manitoba	19	8,055	1,879	69,400	3,000	0	82,333
Ontario	137	21,889	19,703	1,640	34,560	0	77,793
Quebec	81	23,177	12,172	940	7,700	1,532	45,541
N.B.	19	770	1,235	0	0	0	2,006
N.S.	17	564	1,542	0	0	0	2,106
P.E.I.	2	736	228	0	100	0	1,065
Nfdl.	14	43	868	0	0	1,382	2,293
Yukon	1	0	49	0	0	0	49
NWT	4	0	68	0	0	0	68
Nunavut	-	0	49	0	0	0	49
Canada	500	100,297	51,290	266,800	45,360	2,914	466,660

Adapted from: Economic, Financial, Social Analysis and Public Policies for Biodiesel, Phase I, November 2004
http://www.greenfuels.org/biodiesel/pdf/OConnor-Report-Biodiesel2004.pdf

However, at present, the US and Canada only have enough surplus vegetable and animal fat surplus feedstocks to supply about 3% of the diesel fuel market.[10] As a result, attention must be

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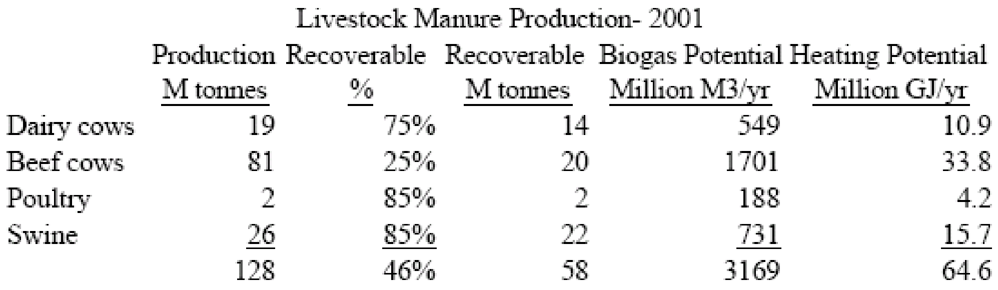
[9] *Ethanol and Other Chemicals from Sugars,* 2003,
http://www.agr.gc.ca/misb/spec/bio/pdf/ethanol2_e.pdf

[10] *Biodiesel and Other Chemicals from Vegetable Oils and Animal Fats*, 2004,
http://www.agr.gc.ca/misb/spec/bio/pdf/diesel2_e.pdf

turned to developing a dedicated biodiesel crop (e.g., industrial mustard or high erucic acid rapeseed) that could supply feedstocks at low cost.

2.2.3. Biomass from Livestock Waste

In the 2003 study, the BIOCAP Canada Foundation also estimated biomass from livestock waste.[11] Livestock manure is a readily available source of waste biomass. Manures are used extensively as soil amendments though direct application causes contamination of surface and groundwater, and manure causes emission of methane gas and nitrous oxide, two potent greenhouse gases. As shown in the below table, manure production is approximately 128 Mt (million tonnes) of which 58 Mt, or 46%, is considered recoverable. This represents a biogas potential of 3.2 billion M3 pa, or heating value of 65 M GJ pa, although the energy is expected to supply on-farm requirements.



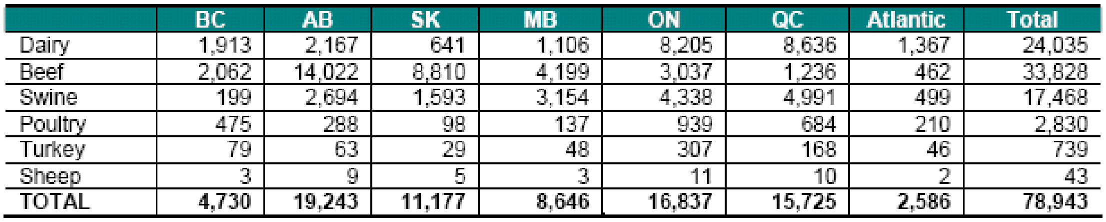
Livestock Manure Production- 2001

	Production M tonnes	Recoverable %	Recoverable M tonnes	Biogas Potential Million M3/yr	Heating Potential Million GJ/yr
Dairy cows	19	75%	14	549	10.9
Beef cows	81	25%	20	1701	33.8
Poultry	2	85%	2	188	4.2
Swine	26	85%	22	731	15.7
	128	46%	58	3169	64.6

From: *Canada Biomass-Bioenergy Report,* 2005, http://www.fairbiotrade.org/downloads/douglascanadacountryreport.pdf

The following table provides a graphical view of livestock concentrations in Canada. Although overall livestock numbers are also highest in the Prairies, the highest local livestock concentrations can actually be found in British Columbia (various locations) and along the St Lawrence River in Québec, as well as in Southern Ontario. This means that transport distances to central facilities may be higher in the Prairies, which could influence decisions to utilize these resources for energy production purposes.

Availability of Livestock Manure in Canada, in tonnes x 1,000 [based on REAP 2002(1), Table 1]



	BC	AB	SK	MB	ON	QC	Atlantic	Total
Dairy	1,913	2,167	641	1,106	8,205	8,636	1,367	24,035
Beef	2,062	14,022	8,810	4,199	3,037	1,236	462	33,828
Swine	199	2,694	1,593	3,154	4,338	4,991	499	17,468
Poultry	475	288	98	137	939	684	210	2,830
Turkey	79	63	29	48	307	168	46	739
Sheep	3	9	5	3	11	10	2	43
TOTAL	**4,730**	**19,243**	**11,177**	**8,646**	**16,837**	**15,725**	**2,586**	**78,943**

From: Identifying Environmetally Preferrable Usees for Biomass Resources. Stage 1 Report: Identification of Feedstock-to-Product Threads, 2004
http://www.cec.org/files/pdf/ECONOMY/Biomass-StageI_en.pdf

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[11] *A Canadian Biomass Inventory: Feedstocks for a Bio-based Economy*, 2003
http://www.agwest.sk.ca/bioproducts/documents/BIOCAP_Biomass_Inventory_000.pdf

2.3. Biomass from Municipal Waste

In Canada approximately 750 kg per person of municipal solid waste (MSW) is generated annually. MSW is considered in three categories: urban and residential, industrial commercial and institutional, and demolition, landscaping and construction (DLC). Most waste is landfilled, though some small communities have limited combustion programs. The 2003 BIOCAP study estimated annual waste at 23 Mt (million tonnes), of which the combustible fraction is 19.4 Mt wet (or 15.0 Mt dry). The approximate carbon yield is 6.2 Mt, which at 35.76 GJ/t is equivalent to 224 TJ annually.[12]

2.4. Overview of Bioresources in BC

Bioresources in BC – classified by type and costs

Bulk residual low cost	
Forest fibre in Lower Mainland	200,000 tonnes
Forest fibre Interior	1,600,000 tonnes
Urban wood	850,000 tonnes
Fibre from fruit-tree replacement	300,000 tonnes
Construction and demolition	250,000 tonnes
Total Fibre	**3,200,000 tonnes**
Animal manure	3,700,000 wet tonnes
Paper mill sludge	190,000 wet tonnes
Biosolids	100,000 wet tonnes
Greenhouse waste & culls	27,500 wet tonnes
Urban food waste	105,000 wet tonnes
Total wet resources	**4,122,500 wet tonnes**
Bulk residual - high costs	
Straw	275,000 tonnes
Mushroom manure	260,000 tonnes
Animal oils/fats	95 m L
Specialty residual – low to high cost	
Fish waste	
Pumace	82,000 tonnes
Whey and buttermilk	6,900 tonnes
	4,000 tonnes
Harvested wood fibre – high cost	
Annual allowable cut	75m m3 per year
Pine beetle wood	15m m3/ 10 years
Bulk agricultural commodities – high costs	
Grain	236,000 tonnes
Oil seeds	37,000 tonnes
Specialty resources – high costs	
Agricultural crops	
Harvested sea resources - high costs	
Kelp	145,600 wet tonnes
Phyto plankton	2,400 tonnes

From: *Progress Report #1 – Bioresources Final, 2005*
http://www.bcbioproducts.ca/documents/timminga2.pdf

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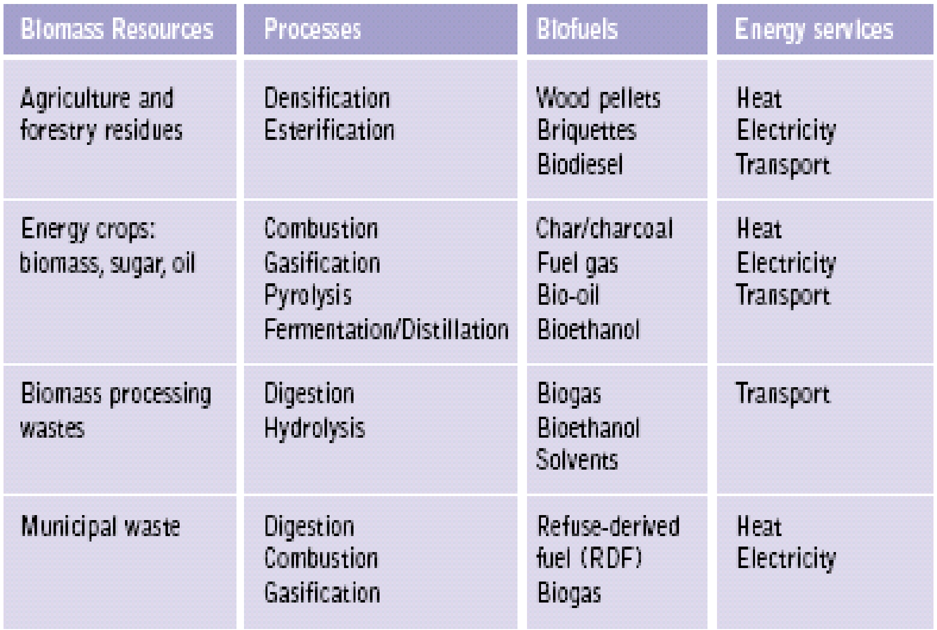
[12] *Canada Biomass-Bioenergy Report,* 2005,
http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

3. Canadian Bioenergy and Biofuels Industry

Technologies through which biomass can be converted into fuels and energy include fermentation, combustion, anaerobic digestion, pyrolysis, thermal depolymerization and gasification.

Routes for converting biomass into energy products and services



Biomass Resources	Processes	Biofuels	Energy services
Agriculture and forestry residues	Densification Esterification	Wood pellets Briquettes Biodiesel	Heat Electricity Transport
Energy crops: biomass, sugar, oil	Combustion Gasification Pyrolysis Fermentation/Distillation	Char/charcoal Fuel gas Bio-oil Bioethanol	Heat Electricity Transport
Biomass processing wastes	Digestion Hydrolysis	Biogas Bioethanol Solvents	Transport
Municipal waste	Digestion Combustion Gasification	Refuse-derived fuel (RDF) Biogas	Heat Electricity

From: *Benefits of Bioenergy*, 2005, http://www.ieabioenergy.com/media/52_BenefitsofBioenergy.pdf

3.1. Heat and Power (Cogeneration) from Biomass

Energy from forest products biomass supports both industrial and commercial usages. The Canadian pulp and paper sector has embraced the potential of biomass energy and is now the largest industrial source of cogeneration capacity. Today, 58% percent of the pulp and paper sector's energy consumption comes from biomass. **More than 45 plants in Canada** now use cogeneration techniques to create process steam and power their operations – with several more mills in the final stages of planning new installations. With continued investment and advances world-wide in biomass energy research, an energy self-sufficient pulp and paper industry is conceivable. [13]

The use of mill waste is growing rapidly in western Canada, where substantial increases in the price of natural gas have finally begun to push forest companies like **Canfor** to start making some major investments in biomass-fired CHP plants. Some of these installations are being financed and operated by such third party investors as **Canadian Hydro Developers in Grand Prairie, AB.** Other Canadian companies that invest in biomass power plants include: **Northland Power, Trans Canada Pipelines, Algonquin Power and the Probyn Group.**

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[13] *Embracing Bioenergy – Greener Energy and Canada's Forest Products Industry, March 2004,* http://fpac.thinkup.com/interim/en/pdfs/BIOENERGY2.pdf

Examples of cogeneration plants in BC include:

NW Energy Co-generation plant in Williams Lake - generating 60MW of power from biomass,
Norske Skog in Powell River - the fluidized bed boiler at with 32MW,
Crestbrook - 40MW,
Howe Sound Pulp and Paper - 80 MW,
Talbot in Mackenzie - power boiler generating 14MW,
Riverside in Armstrong - 20MW.
Canfor in Prince George - 48MW
Weyerhaeuser in Kamloops - 30 MW

In Canada, 80 percent of biomass-fired electrical generation is by the pulp and paper sector. Forest industry biomass energy producers are now able to export unused energy for broader consumption. Examples include:

- **Hydro-Quebec** recently announced that it was purchasing 74 megawatts of power from three Quebec biomass cogeneration (combined heat and power) plants based on residues (such as bark) from a sawmill and two paper mills – enough to power nearly 60,000 typical homes.
- **BC Hydro** is also pursuing several new cogeneration opportunities with BC pulp and paper companies.
- In 2003, **Kruger's Corner Brook** mill inaugurated **Newfoundland and Labrador's** first cogeneration plant—a $30 million biomass facility that supplies 15 MW to the provincial grid.
- **Weyerhaeuser Canada's Grande Prairie, Alberta**, pulp mill is supplying surplus steam from its biomass-fired boiler to help power a 30 MW steam turbine, part of a new 80 MW cogeneration project on a site owned by TransCanada Energy Ltd.

As technologies advance, biomass energy from forest products also has the potential to contribute to the energy self-sufficiency of remote and rural communities. The **Williams Lake Power Plant** – the largest biomass power plant in North America – has reduced land-fill and air quality problems for the forest community. It burns 550,000 green tonnes annually of wood waste, including bark, chips and sawdust from area sawmills to generate electricity. Today, the plant has a capacity of 60 megawatts, of which BC Hydro buys 55 megawatts under contract. In the **Town of Ajax**, a biomass-powered district energy system provides energy to the community centre, Ajax-Pickering Hospital, the Ajax Works Department and more.[14]

Heat and power can also be produced from solid municipal waste. Examples of waste-to-energy facilities include:

- The **City of Charlottetown in Prince Edward Island** has the country's largest municipal waste incineration facility. Three small district heating plants were built in Charlottetown in the 1981–85: the first burned all the provinces municipal solid waste to provide steam heat to a hospital, the second burned woodchips to provide steam and hot-water heat to buildings in the downtown area, and the third system was based at the local university. In 1995, **Trigen Energy Canada** purchased and connected the three separate systems together, consolidated heat generation, installed a new heat-recovery boiler for the garbage combustion system, and added a high-efficiency biomass plant to burn sawmill waste.[15] Today, the energy-from-waste plant converts about 30,000 tonnes of municipal waste into steam, which, with the heat from the wood-waste burning plant, provides heat to more than 80 buildings in the area and generates electricity for use in the plant and the local grid.

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[14] *Primer on Bioproducts,* 2004
http://www.biocap.ca/images/pdfs/BioproductsPrimerE.pdf

[15] *Canada Biomass-Bioenergy Report,* 2005,
http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

- The **Waste-to-Energy Facility in Burnaby, BC** turns approximately 250,000 tonnes of garbage into 800,000 tonnes of steam every year. The steam is enough to supply an adjacent paper recycling mill and to create 15 megawatts of electricity that is sold to BC Hydro – enough to supply 15,000 homes.[16]
- **Algonquin Power Income Fund** owns a waste to energy facility located in **Brampton, Ontario.** The facility is designed to incinerate non-recyclable materials, including municipal solid waste to produce steam. Steam is used to drive a turbine generator to produce electricity. The facility processes 500 tonnes of municipal solid wastes per day and produces a maximum of 15 MW of electrical energy. The electrical energy produced at the facility is sold to the Provincial utility, under a long term Power Purchase Agreement.[17]

A detailed overview of the state of the biomass cogeneration sector and wider energy scene in different provinces can by found in the article "*Industrial Cogenration in Canada"* by Gordon Robb posted on the COGENCanada website.[18]

3.2. Biofuels Production in Canada

3.2.1. Ethanol Production

The Canadian ethanol industry is substantially smaller than the U.S. industry. Current production capacity of the **five production facilities** in Canada is around **240 million litres per year**, or about 3% of current U.S. production capacity. This includes 65 million litres industrial ethanol and 175 million litres fuel ethanol. Canada imports 90–100 million litres a year from the United States. Most of these imports are destined for Ontario and Quebec.[19]

The Canadian ethanol industry is fairly concentrated in **Ontario**. Roughly **75% of the total production capacity** is located in that province and is owned by **Commercial Alcohols Inc**. In addition, Ottawa's **Iogen Corporation** is Canada's leader in enzyme research and has plans to build a pilot plant to test its enzymatic cellulose feedstock conversion technology. The **Seaway Valley Farmer's Energy Co-operative**, Canada's only co-operatively owned ethanol production initiative, is also located in Ontario.

Western Canada is home to three ethanol production facilities, one in each of the prairie provinces. The **three plants** make up roughly **20% of Canada's current production capacity**. Both Saskatchewan and Manitoba are planning to expand ethanol production, but it is too early to tell what the new production capacity will be or how the industries will be structured.

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[16] *Waste-to-Energy Facility, Fact Sheet,* 2004, http://www.gvrd.bc.ca/recycling-and-garbage/pdfs/WasteEnergyFactsheet.pdf

[17] *Algonquin Power Energy From Waste Inc.,* http://www.algonquinpower.com/business/facility/alternative_peel.asp?choice=segment

[18] *Industrial cogeneration in Canada,* 2005 http://www.earthscan.co.uk/news/article/mps/uan/319/v/4/sp/

[19] *Innovation Roadmap on Biobased Feedstocks, Fuels and Industrial Products,* 2004, http://www.bio-productscanada.org/pdf/en_roadmap_book.pdf

Existing Ethanol Production Plants

Company	Location	Year	Capacity	Feedstock	Comments
Husky Oil Marketing Company	Minnedosa, Manitoba	1981	10 mln liters/year	Wheat, 27,000 tonnes (t) of grain	Will be expanded (see table below)
Commercial Alcohols Inc.	Tiverton, Ontario	1989	20 mln liters/year	Corn, 7 mln liters for fuel	
Pound Maker Agventures	Lanigan, Saskatchewan	1990	13.5 mln liters/year	Wheat, integreated feedlot	
Commercial Alcohols Inc.	Chatham, Ontario	1998	150 mln liters/year	Corn, 120 mln liters for fuel	
Permolex Ltd.	Red Deer, Alberta	1998	26 mln liters/year	Wheat, mostly exported	$1.1 million EEP funding to expand its existing facility

From: *Economic, Financial, Social Analysis and Public Policies for Ethanol, Phase I*, November 2004, http://www.greenfuels.org/ethanol/pdf/OConnor-Report-Ethanol-2004.pdf

The support of the federal and provincial governments has been crucial to the development of the ethanol industry. Tax incentives, research, procurement policies and political will are providing a kick-start to the efforts of farmers, manufacturers and environmentalists to make ethanol an excellent alternative to conventional fuel sources for Canadians.

The Ethanol Expansion Program, announced on August 12, 2003, is intended to expand fuel ethanol production and use in Canada and reduce transportation-related greenhouse gas (GHG) emissions that contribute to climate change. Under round one of the Ethanol Expansion Program, seven new ethanol plants across Canada were awarded $72 million in contributions toward construction costs. The second round invested an additional $46 million.

The table below lists ethanol production plants that are currently under construction.[20]

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[20] From following sources: *Ethanol Expansion Program: Profiles of successful proponents, December 2004,*
http://oee.rncan.gc.ca/transportation/fuels/ethanol/eep-profiles.cfm?attr=16
Five Ethanol Plants Receive $46 Million in Government of Canada Funding, July 2005,
http://www.nrcan.gc.ca/media/newsreleases/2005/200550_e.htm
Grain Trade & Market Development Committee – Notes for OCPA Semi-Annual Meeting, September 2005,
http://www.ontariocorn.org/about/semi_gtm05.htm
Lloydminster Ethanol Plant, April 2005,
http://www.huskyenergy.ca/about/downloads/FS_Ethanol.pdf
Suncor Energy's St. Clair Ethanol Plant officially breaks ground, June 17, 2005,
http://www.suncor.com/default.aspx?ID=1630
Weyburn Ethanol Driving Forward, April 2005
http://www.nrcan-rncan.gc.ca/media/newsreleases/2005/2005NBC_e.htm

Ethanol Production Plants – Under Construction

Company	Location	Targeted Year of Completion	Cost/ Funding	Capacity	Feedstock	Comments
Suncor Energy	St. Clair, Sarnia-Lambton region, Ontario	Sept-Oct 2006	$120 mln /$22 mln (EEP)	208 mln liters/year	20 mln bushels of corn	
Husky Oil Marketing Company	Minnedosa, Manitoba	Est. mid-2007.	$145 mln /$10.4 mln (EEP)	130 mln liters/year	210,000 tonnes of locally sourced grains	
Commercial Alcohols Inc.	Windsor, Ontario	January 2007	$120 mln /$15 mln (EEP)	199 mln liters/year	15 million bushels of corn annually	The plant will also produce carbon dioxide for the beverage industry and more than 200,000 tons of high-protein grain for the agricultural feed markets
Integrated Grain Processors Co-Operative Inc.	Brantford, Ontario	January 2007	86 mln /$11.9 mln (EEP)	125 mln liters/year	12 million bushels of corn/year	The plant will also produce approximately 96,000 tonnes of Dried Distillers Grains with Solubles (DDGS) annually
Power Stream Energy Services Inc.	Collingwood, Ontario	May-June 2006	/$7.3 mln (EEP)	55 mln liters/year	5.5 million bushels of corn/year	Conversion of moth-balled Nacan corn wet mill facility
Husky Energy	Lloydminster, Saskatchewan	second quarter of 2006	95 mln /$7.8 mln (EEP)	130 mln liters/year	350,000 tonnes of locally grown grain or 12.9 million bushels annually, primarily CPS Red, CPS White, winter wheat, durum and others	In addition, 134,000 tonnes of DDGS, a non-animal based, high-grade protein, will be produced as a feed supplement for livestock producers
Commercial Alcohols, Inc.	Varennes, Quebec		$105 mln / 18 mln (EEP)	126 mln liters/year	12 million bushels of corn	In addition, more than 100,000 tonnes of distillers' grain for consumption by the domestic beef and dairy industry, as well as more than 90,000 tonnes of carbon dioxide for industrial use annually will be produced
NorAmera BioEnergy Corporation (NABEC)	Weyburn, Saskatchewan	early 2006	$25 mln /$3,5 mln (EEP)	25 mln liters/year	67,000 tonnes or 2.5 million bushels of locally grown wheat	It will also produce 24,000 tonnes of high-protein grain residues
Okanagan Biofuels Inc.,	Kelowna, B.C.		$90 mln/ $10 mln (EEP)	114 mln liters/year	300,000 tonnes of low-grade wheat feed stock a year	An additional product is distillers' dried grains – 90,000 tonnes/year

The projects supported under both rounds of the Ethanol Expansion Program expect to be producing a total of about 1.2 billion litres of fuel ethanol per year by the end of 2007. This would bring Canadian production to approximately 1.4 billion litres per year, seven times what it was prior to the launch of the program, and enough to meet the Government of Canada's climate change target for ethanol production two years ahead of schedule. This target is to have 35 percent of all gasoline in Canada contain a blend of 10-percent ethanol by 2010. Additionally, the $118 million in funding the Government of Canada has allocated under the EEP will result in close to a $1-billion investment from the companies involved in the projects.[21]

In addition, a number of companies are considering constructing ethanol production plants in Canada (see following table)[22]

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[21] *Five Ethanol Plants Receive $46 Million in Government of Canada Funding*, 2005, http://www.nrcan.gc.ca/media/newsreleases/2005/200550_e.htm

[22] Information compiled from the following sources:

Associated Engineering leads design of Integrated Ethanol and Feedlot Facility, 2002
http://www.ae.ca/aetoday/020303.html

Ethanol on back burner - Plant won't become reality for 4-5 years, December 2005

http://www.beausejourreview.com/story.php?id=202827

Ethanol Expansion Program: Backgrounder, December 2004 ,
http://oee.nrcan.gc.ca/transportation/fuels/ethanol/eep-backgrounder.cfm?attr=8

Governments Commit More than $1 Million to Two Ethanol Projects, March 2005

http://www.wd.gc.ca/mediacentre/2005/mar29-02a_e.asp?printVersion=1

Deals in works to build two new ethanol plants, January 19, 2005,
http://www.meia.mb.ca/?action=weeklyfyi&id=157
Ethanol proponents optimistic with company's straw search: Ottawa-based Iogen has Birch Hills as one of three proposed sites , March 2005,
http://archives.foodsafetynetwork.ca/agnet/2005/3-2005/agnet_march_21.htm
Husky Plans Second Large Canadian Ethanol Plant, June 2005,
http://www.planetark.com/dailynewsstory.cfm/newsid/31197/newsDate/10-Jun-2005/story.htm
Outlook's Alliance with Econcept, Results in the Formation of Nexum Bio-Energy Corporation, October 2005,
http://www.findarticles.com/p/articles/mi_m0EIN/is_2005_Oct_18/ai_n15698377

Plans continue to progress for the new ethanol plant being proposed for the Shaunavon area, May 2002,
http://www.cypressagrienergy.com/press.htm
Saskatchewan grain firm to build ethanol plant, February 2005,
http://www.soyatech.com/bluebook/news/viewarticle.ldml?a=20050224-7

Scope of proposed ethanol project widens , November 2005,
http://www.tillsonburgnews.com/story.php?id=193885
Status of Ethanol Projects in Ontario, September 2005,
http://www.ontariocorn.org/about/semi_gtm05.htm

Ethanol Production Plants – Proposed

Company	Location	Year	Cost //Funding	Capacity	Feedstock	Comments
Seaway Grain Processors, Inc.	Cornwall, ON	no construction commencement date announced	/$10.5 mln	66 mln liters/year	6.8 mln bushels corn/year	
Nipawin Ethanol Co-operative	Nipawin, Sask.	no construction commencement date announced	$2.1 mln /$950,000 (WEPA)	75 mln liters/year	residual ligno-cellulosic fibre from agricultural sources	Construction of plant are still a few years away, scientists at Saskatchewan Research Council are testing the technology to make ethanol from biomass in a lab
Brokenhead First Nation	Beausejour, Man.(?)		/ 100,000 (Resource Access Negotiations Program)	80 mln liters/year		Exploring options
Nexum Bio-Energy Corp (former Outlook Resources); Parkland Biofuels Inc.	Grandview, Man.	Mid 2006	$75 mln	150 mln liters/year	410,000 metric tons of feed wheat	Plant will also produce 31.6 MW of "Green Power"
Husky Energy	Prince George, BC			350 mln liters/year		Considering
Upper Canada Malting (UCM) Engineered Fuels	Barrie, Ontario	no construction commencement date announced		300 mln liters/year	30 million bushels of corn/year	Conversion of moth-balled Molson brewery facility
Cypress Agri Energy Inc.	Shaunavon, Sask.		$100 mln	150 mln liters/year	14 million bushels of CPS wheat	Proposed; by-product: 100,000 tonnes of dried distillers grains
279 Beef Producers Inc.	Nokomis, Sask.		$30 mln	22.5 mln liters/year		Proposed
Nexum Bio-Energy Corp; North West Terminal Ltd.	Unity, Sask.		$75 mln	150 mln liters/year	410,000 metric tons wheat, barley, peas and/or corn	Proposed
Iogen Corporation	Birch Hill, Sask.		$250 mln		800,000 tonnes of straw	Considering
MEMS USA	Northern Ontario		$150 mln	227 mln liters/year		
Nexum Bio-Energy Corp; Belledune Biofuels Inc	Port of Belledune, NB			150 mln liters /year	410,000 metric tons of corn, barley and or feed wheat	The plant will also produce 31.6 MW of "Green Power".

Nexum Bio-Energy Corp; CP Biofuels Incorporated	Poplar Bluff Industrial Park, Municipality of Portage La Prairie, Manitoba			150 mln liters /year	410,000 metric tons of feed wheat	The plant will also produce 31.6 MW of "Green Power".
Nexum Bio-Energy Corp.	Tillsonburg, Ont.		$140 mln	200 mln liters/year	multi-feedstocks, incl. sweet potatoes, new crops of millet and sorghum, and rye	By-products: electricity, fertilizer and bio-gas
BioVision	Nova Scotia			30 mln liters/year	lignocellulosic biomass.	

Most of ethanol fuel now available in Canada is produced from corn. The starch in the corn is chemically processed into glucose (a simpler sugar), which, in turn, is fermented into alcohol using yeast. The cost and availability of suitable crops are considered major hurdles to the larger commercial development of bioethanol in Canada. Additionally, the environmental benefits of converting corn and grain to ethanol (e.g., lower greenhouse gases) can be compromised by the large amounts of energy, fossil fuels and fertilizer needed to farm these crops.

New biotechnology that is promising large scale conversion of the tough, fibrous parts of plants (i.e., the **cellulose** in stalks, corn cobs and straw) to bioethanol may be more environmentally attractive than current technologies. Many of the technologies needed to manufacture cellulose-based ethanol on a commercially viable scale are still in development.

Iogen Corporation of Ottawa has become a world leader in the development of this technology. The company has developed an enzyme hydrolysis technology that readily breaks down cellulose — the tough, woody material found in straw, corn stalks, wood and orchard trimmings — so that it can be converted to bioethanol fuel. Ethanol from biological sources has been promoted as a fuel alternative that can help reduce the greenhouse gas emissions associated with gasoline. One problem has been that the only easy way to get ethanol from plants is to convert it from starchy plants, such as corn and grain. Iogen, which has built a substantial business developing novel industrial uses for natural enzymes, is now able make environmentally friendly fuel from the parts of food crops traditionally underused or abandoned in the fields. Iogen’s demonstration-scale plant for producing “EcoEthanol” can process about 40 tonnes wheat, oat and barley straw every day and has the potential to produce three to four million litres of ethanol each year.[23]

One tonne of dry cellulose biomass yields about 350 litres of ethanol, and about half the biomass will be a lignin residue. Therefore, 1.4 billion litres of ethanol, if it came from cellulose, would result in 2 million tonnes of residual lignin that could be converted into chemical feedstock. The residual stocks provide opportunities for research and development to discover marketable by-products to provide additional revenues for the entire production stream, thereby lowering the overall costs of producing the biofuel.[24]

Lignol Innovations Corp. of BC owns patented technology for biorefining ethanol and other valuable co-products from renewable and readily available biomass. The company anticipates commercial

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[23] *Primer on Bioproducts*, 2004 http://www.biocap.ca/images/pdfs/BioproductsPrimerE.pdf

[24] *Innovation Roadmap on Biobased Feedstocks, Fuels and Industrial Products,* 2004, http://www.bio-productscanada.org/pdf/en_roadmap_book.pdf

production of ethanol from woody fibre using its process in 2006. Lignol claims that it will have the lowest production cost for ethanol. If it is successful Lignol may be able to make use of extensive supplies of mill residue and mountain pine beetle fibre in BC to manufacture meaningful amounts of ethanol.[25]

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3.2.2. Biodiesel Production

Currently, 98 percent of the biodiesel produced in the world is produced in Europe. Germany is the country with the highest production capacity. In Canada, biodiesel remains in the early stages of market development. In 2004, there were no commercial-scale biodiesel production facilities in Canada, although several pilot plants were in operation and demonstration projects to test the viability of biodiesel as a fuel for city transit and public works fleets have been established in a number of municipalities, including **Kingston, Montreal, Saskatoon, Brampton, Guelph, Vancouver, Whistler, Halifax and Toronto**.[26]

The potential for biodiesel in Canada is considerable with its abundance of feedstock resources, and the fact that the federal government has stated a commitment that Canada will produce **500 million litres/year by 2010**. Canada's federal government took a big stride towards increasing the viability of biodiesel production and use in the country with the removal of the four-cent-per-liter federal excise tax on biodiesel, making the alternative fuel nearly tax-free in some areas of Canada where the provincial fuel tax has also been removed (e.g. Ontario, BC, and Manitoba)

The following companies are engaged in biodiesel production in Canada:[27]

Ocean Nutrition Canada (Mulgave, Nova Scotia)
- First company in Canada to commercially produce and use biofuel,
- Poduces 5+ million litres/year for home heating fuel purposes.
- Uses a chemical process to extract Omega 3 fatty acids from fish oil
- The by-product can be used as a biofuel
- Ocean Nutrition has been using almost 1 million litres per year of the waste biodiesel as a boiler fuel without problem since 1999
- A large plant expansion will result in an additional 4-6 million litres/year of waste by-product.
- The company has signed a 10-year deal to sell Wilson Fuels Inc. 5 million litres per year of the waste biodiesel fuel
- Wilson Fuels will mix the fish oil biodiesel with home heating oil in 5-20% blends to ensure it does not gel in cold weather.
- In addition to this "green" home heating fuel there are now 20 buses in Halifax running efficiently on fish-oil biodiesel, and this winter a number of government buildings will reduce their reliance on 100 percent carbon-containing fuels by using the new fish-oil biodiesel from ONC and Wilson Fuels.

Rothsay (Ville Ste. Catharine, Quebec)
- A division of Maple Leaf Foods
- Canada's first large-scale biodiesel plant in Montreal unveiled in November 2005
- the 35 million litre biodiesel plant uses rendered animal fat and restaurant grease as a feed stock
- the small pilot plant provided biodiesel for the City of Montreal's BIOBUS demonstration project

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[25] *Canada Biomass-Bioenergy Report,* 2005, http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

[26] *Primer on Bioproducts* , 2004 http://www.biocap.ca/images/pdfs/BioproductsPrimerE.pdf

[27] *Biodiesel and Other Chemicals from Vegetable Oils and Animal Fats*, 2004, http://www.agr.gc.ca/misb/spec/bio/pdf/diesel2_e.pdf

Topia Energy Inc. (Sudbury, Ontario)
- One of Canadian leading biodiesel producer and distributor
- Operates a 20 million litre a year biodiesel production facility in Sudbury, Ontario (opened in May 2005)
- involved in setting up a number of smaller production plants across the country
- distributes more than 15,000,000 litres of biodiesel annually in Canada and US

Biox Corporation (Oakville, Ontario)
- Intents to scale up their existing 1 million litre pilot plant Oakville, Ontario to a 60 million litre per annum facility. When completed, the Hamilton facility will be the largest biodiesel plant in the world and will increase the North American supply of biodiesel by approximately 50%. Construction of the plant is on schedule, and it will officially be completed before the end of the first quarter of 2006[28]
- A continuous process that is not feedstock specific (i.e., the process can handle oilseed feedstocks as well as waste cooking greases and animal fats
- Claims to be 40% cheaper in capital costs and 50% in operating costs compared to other biodiesel processes.
- Claims to be the only technology capable of converting high fatty acid feedstocks into biodiesel cost effectively with 1:1 yields.
- -- Its business model involves the construction and operation of turn-key biodiesel facilities.

Bifrost Bio-Blends (Arborg, Manitoba)
- plant launched in February 2005
- current capacity - 1,600 litres a day
- the plant uses a variety of off-grade oil seed crops to produce the fuel
- Manitoba Hydro announced it was purchasing 50,000 litres of Manitoba-made biodiesel to fuel its fleet vehicles.

Milligan Biotech (Foam Lake, Saskatchewan)
- Milligan is the only company in Saskatchewan making bio-diesel additive
- Operates a small pilot plant that produces canola methyl esters for use as a lubricity additive to reduce engine wear and improve fuel economy.

Innovation Place Bioprocessing Centre (Saskatoon, Saskatchewan)
- Owned by the Province of Saskatchewan
- Pilot plant capable of producing biodiesel in batches of about 30 tonnes per day

Celtic Powers & Machining Ltd. (Rapid City, Manitoba)
- pre-commercial biodiesel production facility
- first commercial application - provided biodiesel produced from restaurant wastes to Brandon transit
- have a project in Germany to install a power plant that will run on 100% vegetable oil.
- also involved in a power plant project for the United Kingdom where the fuel will primarily be tallow.
- their aim is to promote industrial applications that will produce power from renewable resources such as waste vegetable and animal by-products.

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[28] *Update on Biox Corp. and Progress of Hamilton Biodiesel Plant, January 13, 2006,* http://tyler.blogware.com/blog/_archives/2006/1

3.2.2.1 Biodiesel Developments in British Columbia

Currently, most of the biodiesel in BC is imported from the U.S. About 40 fleets in B.C. are running biodiesel, comprising about 1,000 vehicles.

A government-funded feasibility study conducted in 2004 determined that community-based production, using recycled restaurant and food processing fryer oils, offers a good opportunity for biodiesel in B.C, given that the province has little available agricultural land to produce vegetable oils in large volumes.[29]

Until now there has been no commercial-scale biodiesel production in BC. However, in the end of January 2006, **Agri-Green Biodiesel Ltd**. has begun production at its biodiesel plant in **Fernie.** There are four other companies that are planning production facilities that will turn canola and other renewable oils into fuel. Two larger multimillion-dollar facilities are planned to be in the Lower Mainland. **West Coast Biodiesel,** a subsidiary of West Coast Reduction Ltd., a company that currently stores and distributes biodiesel, is looking to build a production plant in Vancouver within the next year. The company plans on using animal fats to make between seven and 10 million litres a year. Also, Vancouver-based **Canadian BioEnergy Corp**., which was instrumental in the municipal biodiesel pilot program, is in the final stages of setting up its $15 million, 40 million litre-a-year production plant. Other B.C. green companies planning plants are Victoria-based **Wise Energy** and **Flower Power** in the Okanagan.[30]

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The following biodiesel activities took place in BC in 2005/2006:

- In January 2006, the BC Environment Ministry awarded a $25,000 grant to the Fraser Basin Council in order to support of market development of biodiesel as a sustainable fuel alternative.[31] Fleet Challenge BC and the BC BioFleet Biodiesel Market Development Program are managed by the Fraser Basin Council. The national organization, Fleet Challenge Canada, was established to reduce overall greenhouse gas emissions from fleet vehicles.

- Also in January 2006, Autogas Propane opened North America's first multi-blend biodiesel dispenser in Delta, two million litres of biodiesel per year. There are two other retail outlets in B.C. -- in Burnaby and Port Alberni. The Port Alberni biodiesel retail pump opened in April 2005 and was the first biodiesel pump in Western Canada. The Tofino Bus company who has been running on biodiesel for the past 1.5 years was the main motivator in making this happen. The Burnaby pump is a retail truck stop, selling biodiesel to commercial truckers and the general public. It was opened on July 8th, 2005 by United Petroleum Products Inc. (UPPI). The company plans to open additional biodiesel retail outlets in the Lower Mainland over the summer.

- Developed and managed by WISE Energy, the Vancouver Island Biodiesel Evaluation Study (VIBES) was completed on June 10th, 2005. The VIBES project is the largest cross-sector test of its kind ever undertaken in Canada. The project had seen eight public and private fleets operate 17 vehicles on B20 biodiesel for 6 months in the Greater Victoria region. Participating fleets included BC Mail, BC Transit, Canada Post (first federal fleet on biodiesel), City of Victoria, Columbia Fuels, District of Saanich, School District 62 (first school bus on biodiesel in Western Canada) and Vancouver Island Powerline. The project displaced more than 40,000 litres of diesel and reduced over 140 tonnes of GHGs.

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[29] *Biodiesel in British Columbia - Feasibility Study Report, April 2004,* http://www.wd.gc.ca/rpts/research/biodiesel/full_e.pdf

[30] Information from: *Biodiesel Set to Drive New Industry in B.C. - Business in Vancouver, Jan 31-Feb 6, 2006; Issue 84* and *Clean-Burning Biodiesel Looking Forward to Boom Times, The Province, Jan 27, 2006*, http://www.agri-greenbiodiesel.com/news/index.html

[31] *British Columbia Supports Biodiesel as Sustainable Alternative, January 27, 2006,* http://www.municipalsuppliers.com/news_detail.asp?ID=45938

- On March 30th, 2005, the municipalities of Vancouver, Whistler, North Vancouver, Burnaby, Richmond and Delta announced that they have agreed to purchase up to 80 million litres of various biodiesel blends over the next five years. Additional municipal, provincial, Crown corporation and private sector fleets will also participate in the program.

- The University of British Columbia in partnership with the Environmental Youth Alliance have developed "The Biodiesel Project". With the help of the UBC Campus Sustainability Office, a research plant at UBC collects waste fry oil from campus restaurants, processes it, studies the process and supplies biodiesel for UBC lawnmowers. Most tanks are filled with a concoction of up to 20 per cent biodiesel and 80 per cent regular diesel.

- Ecofuels Canada formed the Vancouver Biodiesel Cooperative to supply individuals and small businesses with an accessible biodiesel source.

British Columbia is positioning itself to be a worldwide leader in the biodiesel production industry over the next four years; however, there are fuel-quality, pricing and distribution issues that need to be solved.

3.2.2.2 Biodiesel Developments in Manitoba

To encourage production in Manitoba, the province and Natural Resources Canada announced that it will provide a $1.5-million request for proposals support package to Manitoba biodiesel producers who wish to either increase production of biodiesel or to start a new venture.

As a result at least a dozen communities across southern Manitoba have begun creating business plans and expressing interest in building a biodiesel plant. For example:

- A new bio-diesel processing plant now under construction at **Brandon's** Eastview landfill could produce 2,500 litres of fuel a week and allow the city to run two buses on 100 per cent bio-diesel.

- **Shoal Lake**, northwest of Brandon, will soon be home to a biodiesel plant that will produce 11 million litres per year of environmentally friendly fuel and give area oilseeds producers another market for their crops. The plant is expected to cost $1.2-$1.5 million and construction will begin early next year. The aim is to be up and running by fall 2006. The plant will begin by producing four million litres of biodiesel in the first year and will grow to 11 million litres within 20 months. Seventy per cent of its feedstock will come from No. 1 and 2 grade canola and the remaining 30 per cent will come from salvage and waste oilseeds.[32]

– Also the cities of **Dauphin, Dugald and Beausejour** are considering building biodiesel production plants

The reason for so many small plants is that giant, economy-of-scale plants aren't really more cost-effective when it comes to biodiesel. About 70 per cent of the cost of biodiesel is the foodstock, not labour. Plus, an ethanol plant costs a minimum $60-$70 million, versus $1-$2 million for a biodiesel plant. Six biodiesel plants are expected to be running in Manitoba by this time next year, and another six are likely to follow.[33]

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[32] *Shoal Lake Lands Biodiesel Plant*, *November 8th, 2005*, http://www.brandonsun.com/story.php?story_id=9711

[33] *Biodiesel Boom, January 06, 2006,* http://www.brandonsun.com/story.php?story_id=14996

3.2.2.3 Biodiesel Developments in Other Provinces

Currently, the Alberta bio-energy industry is very small but the interest is emerging.

In December 2005, the Australian Biodiesel Group Ltd. and the Calgary Biodiesel Centre reached a $7 million deal to build a biodiesel facility with annual production of 22 million litres in the Municipal District of Rocky View. The plant will use a combination of used cooking oil, new vegetable oil and tallow as feedstock. Plant commissioning is planned for the first half of 2007.[34]

Also Saskatchewan sees the great opportunities for the developing of biodiesel fuel in the province. However, a provincially appointed task force stated that there must be a national plan for renewable fuels to make this happen.[35]

3.2.3. BioOil Industry

Canada is regarded as a leader in BioOil technology and BioOil development. There are three systems at an advanced stage:

- **Dynamotive Energy Systems**- Uses a patented fast-pyrolysis process that converts forest and agricultural residues such as bark, sawdust and sugar cane bagasse into liquid BioOil, and focusing on modular plants of 100, 200 and 500 tpd.

- **Ensyn Corp**- Uses its core technology (Rapid Thermal Processing or RTP™) to transform carbon-based feedstocks, either wood "biomass" or petroleum hydrocarbons, to more valuable chemical and fuel products.

- **Ontario Ministry of Natural Resources**- Is undertaking a biorefinery pilot to develop and test mobile 50-tpd BioOil units to convert harvest waste in Northern Ontario to liquid BioOil

DynaMotive Energy Systems of Vancouver

After successful production of BioOil in its 15-tpd pilot plant, the company is moving to commercial production.

The company’s highlights in 2005/2006 were as follows: [36]

- In 2005, DynaMotive Energy Systems Corporation and Magellan Aerospace Corporation have commenced power generation in **West Lorne, Ontario** utilizing BioOil produced at the facility. Power was generated, as part of the demonstration phase of the West Lorne BioOil Cogeneration Project, from Magellan Aerospace, Orenda division's OGT2500 gas turbine, and delivered to the Ontario energy grid. The BioOil fuelled turbine successfully established comparable performance

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[34] *New Partners Pitch Biodiesel Fuel Plant Facility to Open in 2007 Using Vegetable Oil and Tallow, December 2005,* http://www.biodieseladvocate.com/newsletter.cfm

[35] *Growth for Biodiesel Fuel in Sask: Task Force, January 12, 2006,* http://www.canada.com/saskatoonstarphoenix/news/story.html?id=135486b3-09a3-475a-9d69-aa73beb3c08f&k=93880

[29] *World's First BioOil Powered Cogeneration Facility Delivers Power to Ontario Grid; West Lorne BioOil Cogen Project Delivers Green Energy*
http://www.livepowernews.com/stories05/0629/007.htm

[36] Information obtained from DynaMotive’s website and news releases
http://www.dynamotive.com/news/

to that of natural gas and diesel. This marks the world's first BioOil fuelled gas turbine to generate power at a combined heat and power facility.

Up to 48 tonnes of BioOil per day (two-thirds of the fuel production capacity of the plant) will be utilized to fuel the gas turbine producing up to 2.5 MW of electricity per day - enough to serve 2,500 households - to meet the power requirements of Erie Flooring and to export electricity to Ontario's electrical energy grid. Heat generated by the turbine will produce up to 12,000 pounds of steam per hour for Erie Flooring's industrial operations.

After successfully demonstrating the use of BioOil in heat and power application at West Lorne, DynaMotive is currently validating the use of BioOil as a displacement of hydrocarbons with large industrial users in Canada. The company expects to commence shipments of BioOil to Europe and to other markets for these purposes in 2006.

- In June 2005, DynaMotive announced the licensing of a 200-tpd plant to **Megacity Recycling Inc.**, an **Ontario** based company. Megacity has acquired an option for a further 200 tonnes per day plant to be developed in 2006. In addition, Dynamotive and **E&F Langille of Nova Scotia** disclosed they are analyzing the feasibility of developing a 500-tpd facility to be possibly located near the port of Pictou in Nova Scotia. The proposed plant would utilize wood chips and other biomass sources in the area. The proposed plant is to be completed in two stages, comprising an initial 200-tpd facility with a further module added at a second stage of development.

- In the same month, Dynamotive announced that the international engineering firm **Tecna Proyectos Y Operaciones, S.A. (Tecna)** completed the conceptual design for a 200 tonne per day modular plant, putting DynaMotive in a position to commence procurement and construction of its next plant totally within its control. The Company is currently evaluating projects of this capacity in Europe, Latin America and Asia.

- Also in June 2005, Dynamotive announced it will ship 15 tonnes of BioOil to the research institute **Forschungszentrum Karlsruhe (FZK**), **Germany,** for testing conversion of BioOil to Syngas via gasification. FZK has developed a new biomass-to-liquid (BTL) process to produce tar-free syngas from a mixture of BioOil and pyrolysis char (slurry). Dynamotive also signed a MOU with **Future Energy GmbH of** Freiberg, Germany to establish a strategic alliance for joint implementation and marketing of both companies' technologies (fast pyrolysis and entrained flow gasification)

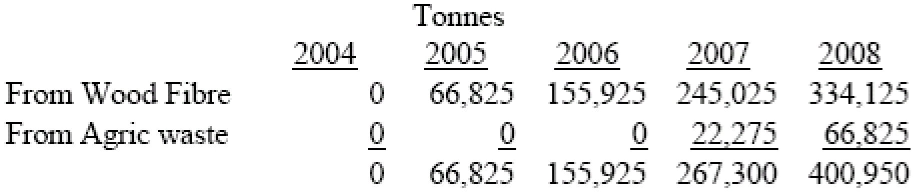
- DynaMotive is also focused on the development of BioOil emulsions with diesel and fuel oil, the testing of BioOil in slow speed diesel generators, and production of synthetic (mobile) fuels from BioOil. Test shipments of BioOil have been completed to Germany, France and the US.

- In December 2005, DynaMotive signed MOU with **Mitsubishi Canada Ltd**. for marketing and distribution of DynaMotive's fast pyrolysis technology in Canada and internationally.

- In January 2006, DynaMotive Signed licensing agreement for **Ukraine and Baltic States** including interim arrangements for two 200 tonnes per day BioOil plants.

Dynamotive has projected its BioOil production in Canada to be 400,000 tonnes by 2008, chiefly from wood fibre, but also from agricultural waste. It is anticipated that a significant amount will be exported.

Projected BioOil Production by Dynamotive in Canada



		Tonnes			
	2004	2005	2006	2007	2008
From Wood Fibre	0	66,825	155,925	245,025	334,125
From Agric waste	0	0	0	22,275	66,825
	0	66,825	155,925	267,300	400,950

From: *Canada Biomass-Bioenergy Report,* 2005,
http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

Ensyn Corp., Ottawa, Ontario, the second major BioOil producer in Canada, is focusing on developing and commercially exploiting applications for its core technology, Rapid Thermal Processing (RTP□).[37]

Ensyn’s technology is most similar to that of DynaMotive and like DynaMotive, Ensyn is actively working with engine and turbine manufacturers to develop commercial applications for its fuel. The Company is also working with petroleum companies in both North America and Europe to develop, and ultimately commercialize, blended fuels that include its BioOil. Furthermore, the Company is presently commissioning a commercial demonstration facility in California that it hopes will confirm the economic viability of the RTP™ process in small-scale heavy oil partial upgrading applications (upgrades to lighter oil).

Ensyn's bio-fuel has been used commercially for industrial heat since the early 1990's. It has also been successfully tested as a boiler fuel by government laboratories, utilities, and independent research facilities in Europe and North America. Ensyn’s current BioOil production capacity is approximately 5 million gallons per year. By 1996, four RTP™ plants were in commercial operation, and a 100 green (i.e. ‘wet’) ton/day facility was completed in 2002. A sixth plant was put in service in 2003, and numerous other facilities are at various stages of development. The most recent and largest plant has an input design capacity of 160 tons of wood per day and is nearing completion in Renfrew, Ontario. The Renfrew Plant, although commercial in size and capability, also includes R&D capabilities and has received government subsidies for over 50% of the capital cost. In addition, most of the Ensyn plants have relied primarily on relatively low-cost waste wood for raw material. These plants mainly produce liquid smoke, in addition to some liquid fuel and charcoal that are combusted on-site for process and space heat. The Company also exports large quantities of its fuel for use in testing programs designed to broaden the applications for the fuel and develops other projects with strategic partners in Canada, the USA and Europe

The third BioOil development involves the **Ontario Ministry of Natural Resources** partnering with the private sector in a bio-pilot project to convert forest waste to bio-oil to advance the development of clean, renewable energy sources.[38] As part of the bio-refinery pilot project, the Ministry of Natural Resources is investing $771,000 to build a mobile plant to convert forest waste into bio-oil. A related project is determining how much forest waste is available in Ontario. The prototype bio-refinery, to be built by **Advanced BioRefinery Inc**., is portable, self-contained and

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[37] Information obtained from Ensyn Corp. website and news releases
http://www.ensyn.com/index.htm

[38] *Province Invests in Alternative Energy - Pilot Project Will Benefit Northern Ontario Communities, August 22, 2005,*
http://www.mnr.gov.on.ca/mnr/csb/news/2005/aug22nr%5F05.html

can process 50 tonnes of forest biomass every day. The plant will undergo testing and be ready for operation in 2006. The pilot project is for a period of three years.

A plan will be developed to consider the supply and production of bio-oil, as well as distribution and markets. The key market sectors are energy, specialty chemicals and materials manufacturing. Potential benefits of this project include supplying bio-oil to produce heat and electricity for communities in northern Ontario, where some areas are not on the power grid and still depend on diesel oil and other areas that are on the grid could switch to a district energy system, providing opportunities for small- and medium-sized businesses, as well as jobs for communities in northern Ontario, using forest biomass to make value-added bio-products such as plastics and glue, which are currently made from fossil fuels .

There are a few other companies that have related capabilities even though none of them have the current capability to build and operate a bio-refinery. For example, **Enerkem Technologies Inc.**, headquartered in Montreal, is a small R&D and engineering services company that is in the process of developing a complete technology platform for the production of alcohol biofuels derived from complex wastes, using municipal solid waste as the demonstration feedstock.

3.2.4. Biogas Production

Biogas — a mixture of methane and CO2 — is a renewable fuel that can be produced from organic waste. Facilities producing biogas include landfill sites, sewage treatment plants and anaerobic digestion organic waste processing facilities.

The main source of biogas (60-70% methane) in Canada is from landfill sites. There are currently over 30 sites that contain and utilize the biogas from the landfills for electricity generation, for the co-generation of steam and electricity, and for heating.

There are three anaerobic digestion plants in Canada. The **Canada Composting Inc**. facility in the **Town of Newmarket, Ont.,** uses BTA (a German technology) and can process up to 150,000 tonnes/year of SSO, plus some mixed waste loads. The plant feeds organic waste into an anaerobic digestion process producing compost and creating biogas, which is used to generate electricity. At full capacity the plant will produce 2,500 kilowatts of electricity and 60,000 tonnes of compost.

A second facility using BTA was constructed at **Toronto's Dufferin Transfer Station** and has been operational since September 2001. The facility is designed to process 25,000 tonnes of SSO per year, but can be expanded to 165,000 tonnes per year. It is being used to test system performance with different loads of mixed and source separated waste. A facility in the **City of Guelph, Ont**., developed by the **Super Blue Box Recycling Corporation (SUBBOR),** uses a unique two stage design with a steam explosion process after the first stage to increase gas production in the second stage. Negotiations between SUBBOR and potential customers have been largely unsuccessful so the plant has announced its forthcoming closure.[39]

Although the current sites utilizing biogas are larger facilities, there is a focus on involving the medium and smaller sized facilities.

The **municipality of Kitchener–Waterloo**, for example, together with **Toromont Energy**, use naturally created **landfill gases** — gases that were once simply burned off — to produce

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[39] *Solid Waste as a Resource: Review of Waste Technologies, May 2004,* http://kn.fcm.ca/file_download.php?URL_ID=5925&filename=10860356811SW_Guide_Technology.pdf&filetype=application%2Fpdf&filesize=2463834&name=SW+Guide+Technology.pdf&location=user-S/

electricity. A network of subterranean pipes collects the gases from the landfill and uses them to fuel an electrical generating station.[40]

In **Lethbridge, Alberta, ECB Enviro** is building a pilot facility that will produce biogas energy (as well as treated water and fertilizer) using pig farm manure generated by area hog operations. The company expects the plant, which began construction in 2003, to use 100,000 tonnes of manure per year, while generating enough electricity for about 900 homes.[41]

Manitoba's first major anaerobic digester (AD) for hog manure was recently constructed by **DGH Engineering**, at a 6,000-head hog feeder farm owned by **Cook Feedlot in Teulon**. The "Bio-Terre" system is a commercial prototype of a widely heralded Canadian design intended to capture the usual benefits of such systems (generating methane to heat farm buildings with reduction in odours, air emissions and GHGs, and soluble COD in the slurry) while overcoming the difficulties traditionally facing such technology in cold climates.[42]

Engineering studies are under way at **Winnipeg's Brady landfill**, with preliminary work highlighting the possibility of capturing enough methane from the decaying organic material to produce 7 MW of electricity, while reducing GHG emissions by 500,000 tonnes annually.[43]

A research project is also underway at the **Olds College School of Innovation (OCSI) in Alberta**. The project is proving that enough renewable energy can be produced from agricultural and municipal waste to light and heat a small community. The OCSI research project is determining how a biogas plant in Olds would handle a mixture of wastes. No other biogas facility in Canada co-digests the variety of waste available, including green waste from the community, sewage sludge, slaughterhouse residuals and manure.[44]

Five model demonstration pilot plants for energy co-generation and crop nutrient production from agricultural and municipal wastes were established over a period of 2002-2006 under the National Program on Energy Co-generation from Agricultural/Municipal Wastes[45].

The projects include:

- **Alberta Research Council** - Xiaomei Li
  The development of an Integrated Manure Utilization System (IMUS) Phase III
- **Bio-Terre Systems Inc.** - Richard Royer
  The establishment and demonstration of a low temperature anaerobic digestion and co-generation system for hog manure management
- **Lynn Cattle Inc., Lucan Ontario** - Nils Semmler
  The establishment and demonstration of the Lynn Cattle Turnkey Integrated Manure (T.I.M.) Processing Plant, using biogas co-generation technology
- **Clear-Green Environmental Inc. -** Ben Voss
  Production of Energy using of Anaerobic Digestion and Post-Treatment Technology beside a Commercial Hog Operation

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[40] *Primer on Bioproducts* , 2004
http://www.biocap.ca/images/pdfs/BioproductsPrimerE.pdf
[41] ibid
[42] *The 2004 Manitoba Budget Papers: Biofuels & Bioproducts,*
http://www.gov.mb.ca/iedm/invest/busfacts/economy/ec_biofuels.html
[43] Ibid
[44] *Olds College News - Generating energy from waste, November 2005,*
http://www.oldscollege.ab.ca/news/releases/2005-11-25-Generating%20energy%20from%20waste.htm
[45] *National Program on Energy Co-generation from Agricultural/Municipal Wastes: Project Summaries, 2001-2006,*
http://res2.agr.gc.ca/initiatives/manurenet/en/hems/ecoamu_summaries.html

- **Enerkem Technologies Inc.** - Esteban Chornet
  Using Agri-Food and Municipal Wastes for the Co-generation of Energy and Nutrients in Sustainable Closed Loop System

3.2.5. Bio-Methanol Production

Methanol is the simplest alcohol, typically made from natural gas. Wood, municipal solid waste and sewage and therefore manure can also be used to produce methanol, which is called biomethanol when made from these sources. Though there are no biomethanol plants currently in Canada, technology to produce methanol from biomass is evolving. Methanol production is carried out in two steps. First, the feedstock is converted into a synthesis gas stream consisting of carbon monoxide (CO), carbon dioxide (CO2), water (H2O), and hydrogen. In the second step, the methanol is manufactured from the synthesis gas. The synthesis of methanol is very exothermic (produces heat), and most plants are designed to use this extra energy to generate electricity needed in the process.

Canada produces over 1.5 billion litres of methanol annually, with large amounts being exported to the United States and Europe.

Methanex Corporation, one of Canada's major methanol producers, has marketing offices and production facilities worldwide, and supplies over 20 percent of the global demand for methanol.[46]

3.2.6. Pellets Production

3.2.6.1 Wood Pellets Industry

Wood pellets are a relatively recent development. They are made from compressed sawdust and are typically cylindrical in shape, 6 mm (1/ 4 in.) in diameter by 10 to 35 mm (2 to 12 in.) long. This fuel is easily stored and transported, and allows automated fuel feed with comparatively few problems. Other waste materials such as bark and agricultural residues can also be pelletized for fuel.

The residential wood pellet fuel industry in North America was created in the early 1980s as a response to the energy crisis. Today, almost **one million tons of pellets are sold each year** – to heat nearly **500,000 pellet stoves and fireplace inserts** in homes the **United States and Canada**. Consumption is greatest in the Pacific Northwest and Northeastern states where pellets are manufactured from sawmill and wood product residues and where heating energy requirements are significant.

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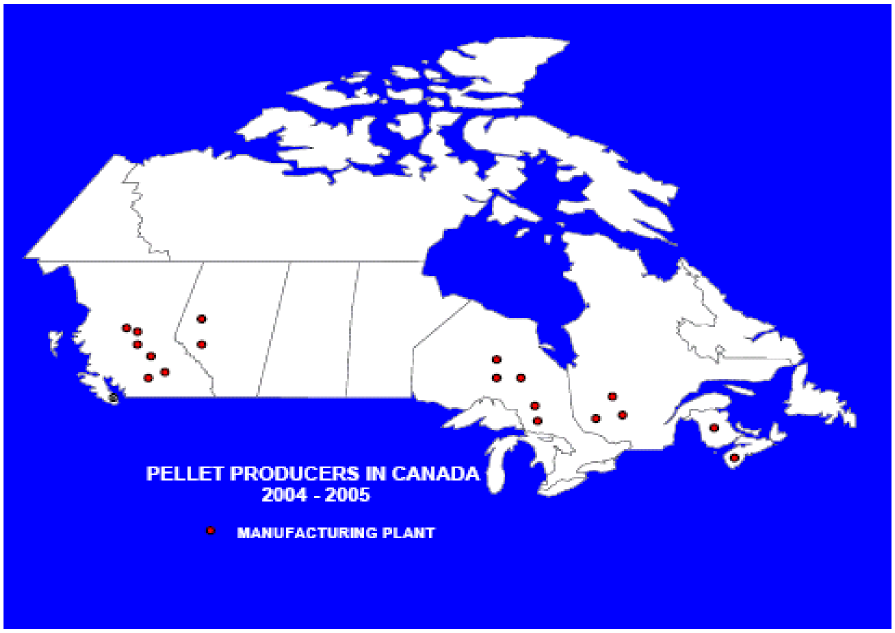
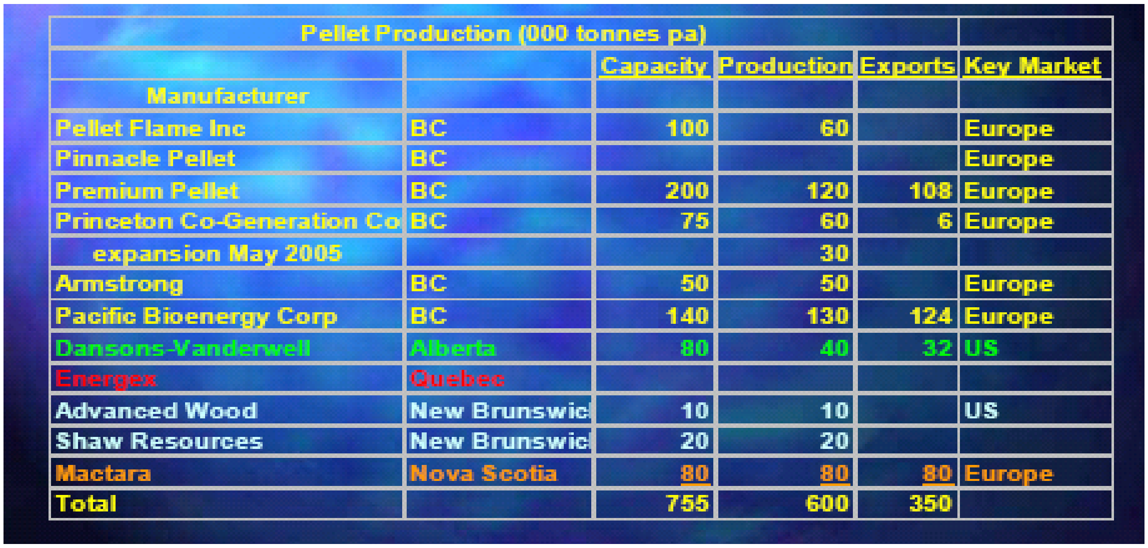
[46] *Clean Energy Canada: Biofuel,* http://www.cleanenergy.gc.ca/canada/items_list_e.asp?mode=act

Geographical Concentration of Wood Pellet Producers in Canada – 2004-2005



Wood Pellet Production in Canada – 2004-2005



Pellet Production (000 tonnes pa)					
		Capacity	Production	Exports	Key Market
Manufacturer					
Pellet Flame Inc	BC	100	60		Europe
Pinnacle Pellet	BC				Europe
Premium Pellet	BC	200	120	108	Europe
Princeton Co-Generation Co	BC	75	60	6	Europe
expansion May 2005			30		
Armstrong	BC	50	50		Europe
Pacific Bioenergy Corp	BC	140	130	124	Europe
Dansons-Vanderwell	Alberta	80	40	32	US
Energex	Quebec				
Advanced Wood	New Brunswic	10	10		US
Shaw Resources	New Brunswic	20	20		
Mactara	Nova Scotia	80	80	80	Europe
Total		755	600	350	

From: *Biomass in Canada - Development and Trade Options, Business Forum on Sustainable Biomass Production for the World Market, Campinas, Brazil- Dec 1, 2005, Doug Bradley*
http://www.bioenergytrade.org/downloads/bradleynovdec05.pdf

Manufacture and export of wood pellets in Canada has grown exponentially in the past several years, primarily on the west coast. Almost half of the pellet plants in Canada are in BC. The production of wood pellets in BC has **reached 600,000 tonnes**, but recent capacity expansions will allow production to reach **755,000 tonnes** in short order. **Princeton** has recently upgraded to 75,000 tonnes and **Armstrong** to 50,000 tonnes. These plants are being built to take advantage not only of the surplus mill residue situation in BC, but also the huge potential wood supply from Mountain Pine Beetle affected stands.

Several new pellet mills as well as expansion of existing mills are in the planning stage and are likely to be announced within the next year. In 2004, the government of Canada announced that over $6 million would be invested in B.C. communities affected by softwood dispute. With funding from the Softwood Industry Community Economic Adjustment Initiative (SICEAI), **Premium Pellet Ltd**. in **Vanderhoof, BC**, installed a new, proprietary technology to permit 100% utilization of wood fiber in manufacturing wood pellets. The expansion of Premium Pellet Ltd. makes it the largest wood pellet plant in the world, positioning Canada as a world leader in the production of high quality, renewable energy. Also, **Cariboo Gold Pellets** received $2,000,000 in repayable funding to establish a wood pellet manufacturing plant in **Williams Lake, BC**. The total cost of the project is $8,400,000. The new plant will produce wood pellets from the abundant wood waste material that is otherwise discarded by local sawmills.[47]

In October 2005 the BC government announced that four industrial wood pellet plants will be constructed in the Interior to process beetle-killed trees. Timber cutting rights to 4.7 million cubic metres of pine in the **Prince George and Quesnel forest districts** is only the first stage of a plan that will see another 21 million cubic metres licenced "in the near future," said Forests and Range Minister Rich Coleman. North Vancouver-based **C.H. Anderson and two Swedish partners** agreed to spend $110 million for the plants, expected to create about 600 new jobs. The pellets are to be sold to power plants in Europe as a substitute for coal.[48]

The production capacity in **BC** could reach **1,000,000 tonnes within 2 years and 1,500,000 tonnes within 3 years.** However, overseas contracts will have to be concluded as the expansion progresses. It was expected that the export to Europe in 2005 would exceed 400,000 tonnes from Western Canada alone.[49]

3.2.6.2 Switchgrass Pellets Industry

Switchgrass pellets can be converted into usable heat at 82-84% efficiency in a close coupled gasifier pellet stove designed to handle moderately high ash fuels. Relative to oil and natural gas systems, switchgrass pellets have the potential to reduce fuel heating costs and greenhouse gas emissions in eastern Canada by approximately 30% and 90%, respectively. Compared to all other biofuel production and energy transformation pathways currently proposed, switchgrass pellet heating offers the highest net energy yield per hectare, the highest energy output to input ratio, the greatest economic advantage over fossil fuels, and the most significant potential to offset greenhouse gases.

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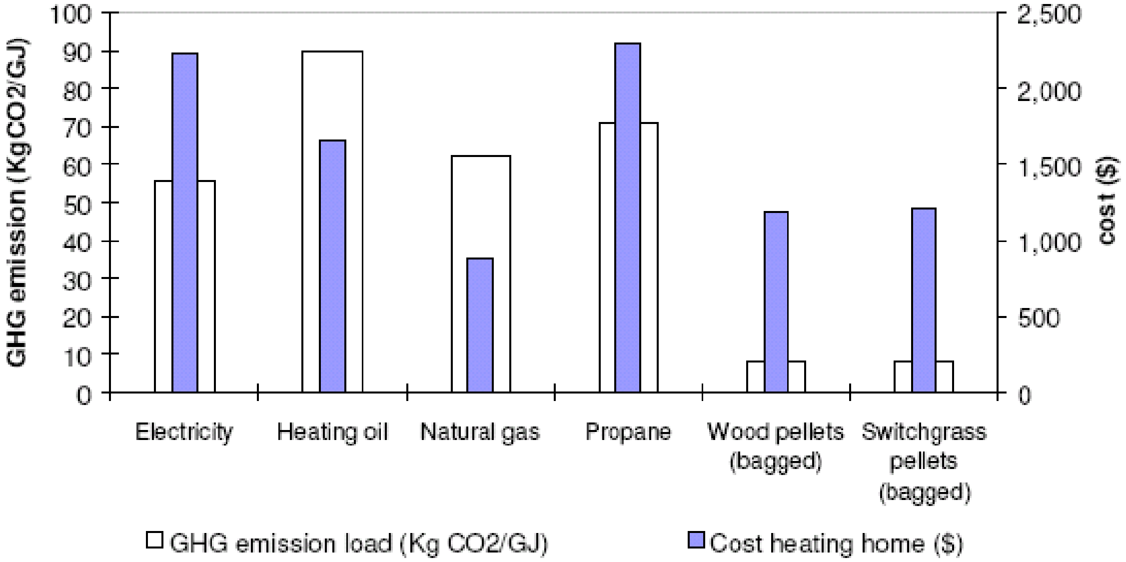
[47] *Government of Canada Invests Over $6 Million in B.C. Communities Affected by Softwood Dispute, May 2004*, http://www.wd.gc.ca/mediacentre/2004/may05-01a_e.asp

[48] *Wood energy emerging as key forest strategy, October 2005,* http://www.ecobc.org/NewsToday/2005/10/TodaysNews1464/index.cfm

[49] *Canada Biomass-Bioenergy Report,* 2005, http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

Heating costs and C02 emissions in Ontario according to fuel types



From: *Switchgrass Fuel Pellet Production In Eastern Ontario: A Market Study, December 2001*, http://www.reap-canada.com/online_library/Reports%20and%20Newsletters/Bioenergy/9%20Switchgrass%20Fuel.PDF

Switchgrass fuel production in Eastern Canada is positioned for the early stages of commercialization. Production methods are well established and plantations are established in **Ontario, Quebec**, and, more recently, in **Manitoba.** One pellet plant in **southwest Quebec** is currently processing small quantities of pellets, and several alfalfa dehydrators in Ontario have expressed interest. Production of multi-fuel pellet stoves (grass pellets, wood pellets, corn) by **Dell-Point Technologies** is about to undergo a major expansion. The establishment of a pellet fuel industry will probably proceed incrementally as alternative heat markets and production capability evolve. A major constraint to pellet production is accessing pelletizing infrastructure close to switchgrass production zones. Currently pelleting capability exists at alfalfa or wood pellet plants, but these are not always located in the most favorable regions (areas with marginal soils, low land rents) for switchgrass production. Plants in eastern Canada have relatively low outputs of approximately 10,000 tonnes/yr. New plants with a 100,000 tonne capacity could considerably reduce production costs.[50]

Roger Samson, Executive Director of Resource Efficient Agricultural Production-Canada (R.E.A.P.) sees the provinces of Manitoba, Ontario and Quebec as the most promising regions to develop a grass pellet fuel industry because of low costs of hay production—generally indicated by low land rents—and high heating costs—due to a long winter heating period and high fossil fuel costs.[51]

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[50] *Changing the energy climate: clean and green heat from grass biofuel pellets, October 2001,* http://www.cns-snc.ca/events/CCEO/graphics/2a_jannasch_paper.pdf

[51] *The Potential for Grass Biofuel Pellets, February 2006,* http://www.fcpp.org/pdf/FB039ThePotentialforGrassBiofuelPelletsJan2706.pdf

3.2.7. Biofuels Industry Targets for 2010

	Biofuels Targets
Annual revenue growth	15%
Market priorities	penetration of North American transportation fuels (ethanol 10% and biodiesel 5%)
Commercial targets	• full-scale implementation of Iogen technology for ethanol from straw • designing cellulose ethanol production facilities to ferment sugar into ethanol and platform chemicals • industrial-scale demonstration of BIOX and Rothsay biodiesel technologies
Annual R&D targets	• new technologies to maximize conversion of carbon to ethanol and to extract ethanol from fermentation liquid, without distillation (reduce energy cost by 30%) • new high-efficiency technology (e.g., semi-permeable membranes) to separate high-value biochemicals from biofuel feedstock and bio-oil • development of pyrolysis/gasification technology for production of hydrogen from biomass via value capture from coproducts so net cost is competitive with hydrogen derived from natural gas
Market share	• domestic: high penetration of domestic market (>90%) • international: access to U.S. market for excess Canadian regional capacity

From: *Innovation Roadmap on Biobased Feedstocks, Fuels and Industrial Products,* 2004, http://www.bio-productscanada.org/pdf/en_roadmap_book.pdf

4. Biofuels Market in Canada

Biofuels are strategically important to Canada. There are several successful Canadian companies actively engaged in this field. Canada is in an excellent position to benefit with its resource base, expertise and developing community-based eco-industrial clusters. The biomass opportunity will provide new revenue streams for the traditional agricultural, forestry and marine resource sectors and communities.

Major benefits can be derived from Canada's exceptionally large biomass resource — Canada's Natural Advantage. For instance, the BIOCAP Foundation estimates that our standing forests have an energy content that is equal to 69 years of Canada's current energy demand now being met by fossil fuels. [52]

Due to a highly unstable global energy market as well as large spikes in oil and natural gas prices, Canada is at a tipping point regarding future fuel developments. Action must be taken now. Substantial biofuel opportunities both now and in the near-term future can get lost despite Canada's abundant biomass resources and strong competitive advantages, especially in the

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[52] *Innovation Roadmap on Biobased Feedstocks, Fuels and Industrial Products,*2004, http://www.bio-productscanada.org/pdf/en_roadmap_book.pdf

physical, chemical and thermal conversion of primary and residual biomass to bio-based energy and industrial products.

Canada's potential for producing fuels and generating energy from biomass is both very large and underutilized. However, the feasibility of using biomass as a source of fuel for cars, factories and electricity generation depends on the availability of appropriate technologies and the harvesting of sometimes remote biomass resources.

4.1. Market Potential of Ethanol in Canada

The report "*Non-Food/Non-Feed Industrial Uses for Agricultural Products,"*[53] prepared by Canadian Agricultural New Uses Council in 2004, analyses issues affecting the ethanol market in Canada. Several issues are central to assessing the future market potential of ethanol in Canada, including: feedstock availability; production cost structures for both grain and lignocellulosic-to-ethanol technologies; potential new markets; possibilities for increasing revenues from co-product streams; and the prospect of producing higher value-added biochemicals.

In general, Canada has a rich resource base that could be used for the production of ethanol. But despite this apparent wealth in biomass feedstocks, caution against excessive optimism is adviced. One concern is that most of Canada's grains are targeted at higher value food markets. Even in the case of less expensive feed grains, only relatively small amounts of surplus feed grain are available for ethanol use. Other feedstocks, such as crop residues, are only economically viable in a handful of locations where volumes are sufficient to justify investments in large-scale, capital-intensive, lignocellulosic-to-ethanol operations. Of the 97 million tones per year of forestry waste, only about 5.4 million tonnes per year of saw mill residues are easily and economically accessible. The economics of collecting the other sources of forestry residue are questionable. In contrast, biomass feedstock availability south of the border, particularly in the United States Midwest corn belt, is about 10 times greater than Canada's. For some large investors, locating ethanol plants close to these US feedstocks could provide a competitive advantage, compared to locating in Canada. The greater willingness, and capability, of the US government to invest heavily in R&D and assist in plant scale-up further reinforces this feedstock advantage.

A second concern is that while the dry mill grain-to-ethanol technology is well established, much can still be done to improve the economics of production: increase crop yields, using traditional crop breeding programs, and plant biotechnology; develop more efficient grain and crop residue harvesting equipment; improve the productivity of ethanol processing (e.g., by preprocessing grains, using high gravity fermentation, etc.); and improve the value and range of existing co-products and animal feed markets (e.g., upgrading distillers dry grain (DDG) for poultry, swine, and dairy markets).

According to recent research, the pretreatment/enzymatic technology for converting lignocellulosics to ethanol is the preferred technology at the moment because of its future cost reduction potential and ability to provide a flexible engine for biorefining fuels, chemicals, and energy. However, experts are divided over the market potential of lignocellulosic ethanol in Canada.

On the more pessimistic side:

- The minimum size of an economically viable lignocellulosic ethanol plant is thought to be about 225 million litres, which would require 600,000 to 750,000 tonnes per year in corn stover feedstocks, or about 20-25% of the corn stover harvestable in Ontario. There are

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[53] *Non-Food/Non-Feed Industrial Uses for Agricultural Products, Phase 2 and 3 Summary,* 2004, http://www.agr.gc.ca/misb/spec/bio/pdf/non2_e.pdf

efforts now in the US to scale up the **feedstock collection infrastructure** to as much as 4-10 million tonnes per year, per refinery, so that it can reach a scale comparable to the petroleum refining industry. If this scale is technically and environmentally sustainable (and it may not be), it would certainly rule out Ontario as a potential site, and would probably present a significant challenge even for Western Canada. The US Midwest corn belt might be the only location that could meet these feedstock requirements.
- **Corn stover yields per acre** in the US are higher than corn stover yields in Eastern Canada which are in turn higher than wheat straw yields per acre in Western Canada.
- **Total yields from Canadian wheat** and corn have decreased over the last three years due to drought and other crop stresses.
- **High capital costs**. Feedstock supply is not the major barrier to the commercialization of this technology - market access, market size, capital costs, and government incentives in other jurisdictions will present higher hurdles than feedstock availability and price. The largest barrier to the new technology could be the cost of capital plant construction for first plants, which may be as much as 2-3 times higher than the $175 million figure currently being discussed. This would represent a huge risk for early movers.
- The ability of cellulosic feedstocks to **compete with grain based ethanol** may also be too optimistic, and based on unrealistic assumptions about genetically engineered feedstocks. Grain-based ethanol production will also continue to become more cost effective, and will likely dominate markets and capital investment because it is a more mature technology with proven success.

On a more optimistic note:
- Although wheat straw may provide lower yields, there may be technical reasons why **it could make a better feedstock** (e.g., it is easier to collect and transport than corn stover). Case-New Holland (CNH) is now developing a one pass wheat harvest that breaks the straw and leaves the lignin, ash, and nodes in the field for cover while collecting the stems for baling or in bulk. A one pass system for the harvest of corn would appear to be of real benefit to Ontario and Quebec farmers due to the short harvest window
- Wheat producers could shift to **genotypes that leave more straw** in areas where there is sufficient moisture.
- Notwithstanding the fact there is 10 times as much corn stover in the US as wheat straw in Canada, PFRA data indicate that there are **at least four sites in Western Canada with yields over a million tonnes of straw** in an 80 kilometre draw after discounting for soil husbandry, livestock, and other uses.
- The cost estimates for **cereal residue in Western Canada are about $50 per tonne** CDN, with the breakdown as follows: collection - $15.86; profit - $13.83; loading - $3.12; transport - $11.43; and nutrient - $5.76. This is close to the $30-35 per tonne US cost for stover.
- The **potential feedstock base could be expanded** - there is currently a sufficient area of unused land in Canada that could be used to grow dedicated cellulosic feedstocks such as **switchgrass**. Other dedicated crops could include **reed canary grass, poplar, and hemp**. There could be up to 10 potential sites in Western Canada and one each in Ontario and Québec.
- There is strong and continuing **support from the federal government** for cellulosic ethanol.

There appears to be a consensus that **cellulosic ethanol has limited market opportunities in Canada before 2010**. The technology will likely be developed elsewhere, and it will take at least until 2010 or beyond to drive down production costs and make it competitive. Government subsidies required to support the first “prototypes” could cost up to $1 billion. This is not likely to happen in Canada given current market barriers. The most likely **window of opportunity for Canada would be the 2010-2020 time frame.**

Another concern is that Canada typically invests in early stage R&D and tends to be reluctant to invest in risky commercial ventures. Unless these policies are changed, innovative Canadian companies will be forced to go south to scale-up production. The hurdle in Canada is not a lack of R&D, but the inability of companies to scale-up commercial production. These risks could be minimized by joining international consortia that are focused on developing technology platforms and forming public-private sector cost-sharing agreements to help scale-up production. For example, the sugar and yeast technology platforms established by the US Department of Energy have drawn together companies from across North America to jointly share the risks and rewards from developing ethanol and other biochemicals from lignocellulosic feedstocks. Participating in these international collaborations would help reduce government research, development, and demonstration costs as well as risks.

4.1.1. Market Potential of Ethanol as a Transportation Fuel

The report *Ethanol and other Chemicals from Sugars*[54] analyses the market potential of ethanol as a transportation fuel as follows:

- **E10**

E10 (or 10% ethanol, 90% gasoline) is the focus of current market efforts. All cars built since the mid-1970s can run on E10 without modification. In most provinces, E10 sells for about the same price as regular gasoline. In Ontario, for example, the 300 Sunoco, UPI, and Pioneer gas stations sell E10 for the same price as regular gasoline sold at competing stations. If every gas station in Canada sold E10, it would consume all of Canada's surplus grain as well as the crop and forest residues that are easily accessible.
Canada has only begun to exploit the E10 market.

- **E85**

E85 (or 85% ethanol, 15% gasoline) has a very positive environmental profile (reduces harmful emissions). E85 requires specially-equipped vehicles. The big three auto manufacturers have embraced E85 and have developed E85 flex fuel vehicles (FFV) which can run on either 100% gasoline, or any blend of ethanol up to 85%. There are now about 3 million E85 flex fuel vehicles in operation in North America.

The market for E85 fuel in Canada is also being driven by government procurement. *The Alternative Fuels Act*, 1997, which has a seven year phase-in period, requires that 75% of the vehicles purchased by the Canadian federal government must be alternative-fueled vehicles (AFVs), where cost-effective (i.e., there are savings over the life of the vehicle) and operationally feasible (i.e., vehicle operation is not curtailed by the fuel system and availability). AFVs include ethanol, methanol, natural gas, propane, hydrogen, and electrical (where the latter is the only fuel source). The vehicles covered by the Act include automobiles as well as passenger vans, light and medium duty trucks, and buses.

The June 2001 *Federal House in Order Initiative* established the goal of building seven new E85 fueling sites to serve government vehicles by 2005. **Natural Resources Canada (NRCan**) built the first E85 depot in Ottawa (and shares it with other departments like **Environment and National Defence). Agriculture and Agri-Food Canada** has built an E85 site in Ottawa at the Central Experimental Farm and at five other regional sites in the west. **Correctional Services Canada** is also establishing E85 fuel depots. NRCan provides a $5,000 incentive under the *Federal Housein Order Initiative* to other federal departments who install an on-site E85 fuelling facility. They (NRCan) also provide a $0.20 per litre incentive to departments that use E85.

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[54] *Ethanol and Other Chemicals from Sugars, 2003,* http://www.agr.gc.ca/misb/spec/bio/pdf/ethanol2_e.pdf

In summary, the E85 market is largely created by US and Canadian federal government procurement policies that have been shaped by regulations requiring government departments to acquire alternative fueled vehicles. North American car manufacturers also support E85 because the Corporate Average Fuel Economy (CAFÉ) program credits they receive from the manufacture of E85 FFVs allow them to offset the environmental costs of producing larger, less fuel efficient vans, trucks and SUVs.

Ethanol blends such as E85, could further boost market demand. However, the existing feedstock supply in Canada is not capable of sustaining this market segment if it becomes widespread.. A more practical blend, from a feedstock supply perspective, would be an E20 or E25 blend.

- **E-Diesel (Oxy-Diesel)**

Oxy-diesel involves a 7.7% blend of ethanol with No.2 diesel fuel using a 1% co-solvent to keep the ethanol and diesel in phase. It offers very good smog reduction benefits, using the existing ethanol infrastructure, and may not require further government subsidies.

The following pilots have been conducted in Canada:

- Winnipeg Transit (Winnipeg, MB): Oct. 2001 - Aug. 2002 (20 buses)
- OCTranspo (Ottawa, ON): Starts first quarter of 2003 (20 urban buses)

- **Ethanol Fuel Cells**

Ethanol has several advantages as a hydrogen fuel.
Ethanol as a hydrogen fuel has three potential markets:

- hydrogen fueling stations
- a hydrogen fuel for on-board vehicle reforming.
- stationary power -- a partnership has been formed between **Nuvera (a PEM fuel cell maker), Caterpiller, and Williams Bio-Energy (an ethanol producer)**

4.1.2. Ethanol Export Opportunites

Although production of grain ethanol will reach more than 1 billion tonnes by 2008, and anticipated additional capacity announcements will raise this projection, it is not expected that a meaningful amount will be available for export initially. Ontario has instituted a renewable fuels policy requiring an average of 5% ethanol in all gas sold in Ontario by 2007. Saskatchewan and Manitoba also have standards for ethanol use. It is expected that the Canadian market will absorb most of the ethanol produced to 2008. Saskatchewan, an agricultural province, has plans to develop a major ethanol industry capable of export, however the market is expected to be the US.[55]

4.2. Biodiesel Market Potential in Canada

The government of Canada set a target of producing 500 million litres by 2010. Alberta, Saskatchewan and Ontario are the provinces with the biggest production capacity.

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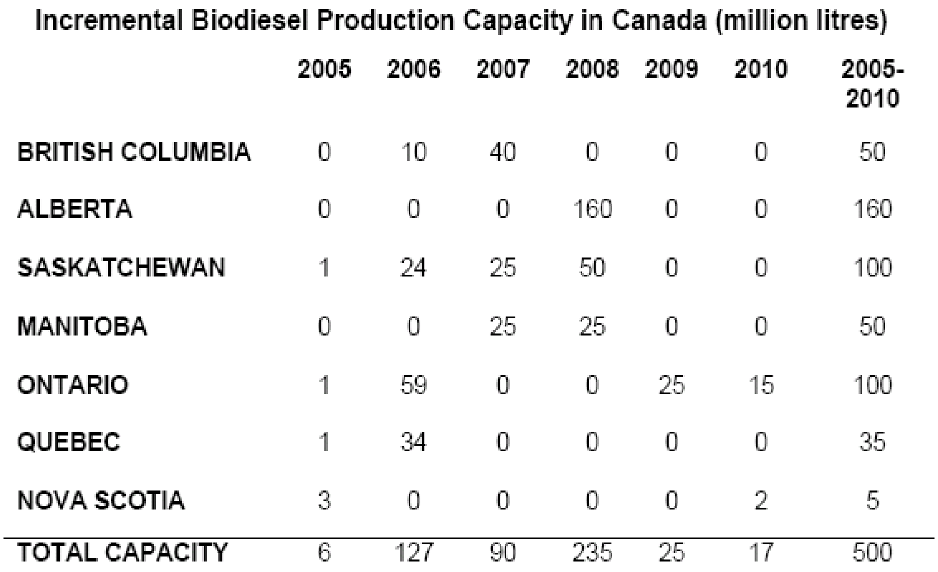
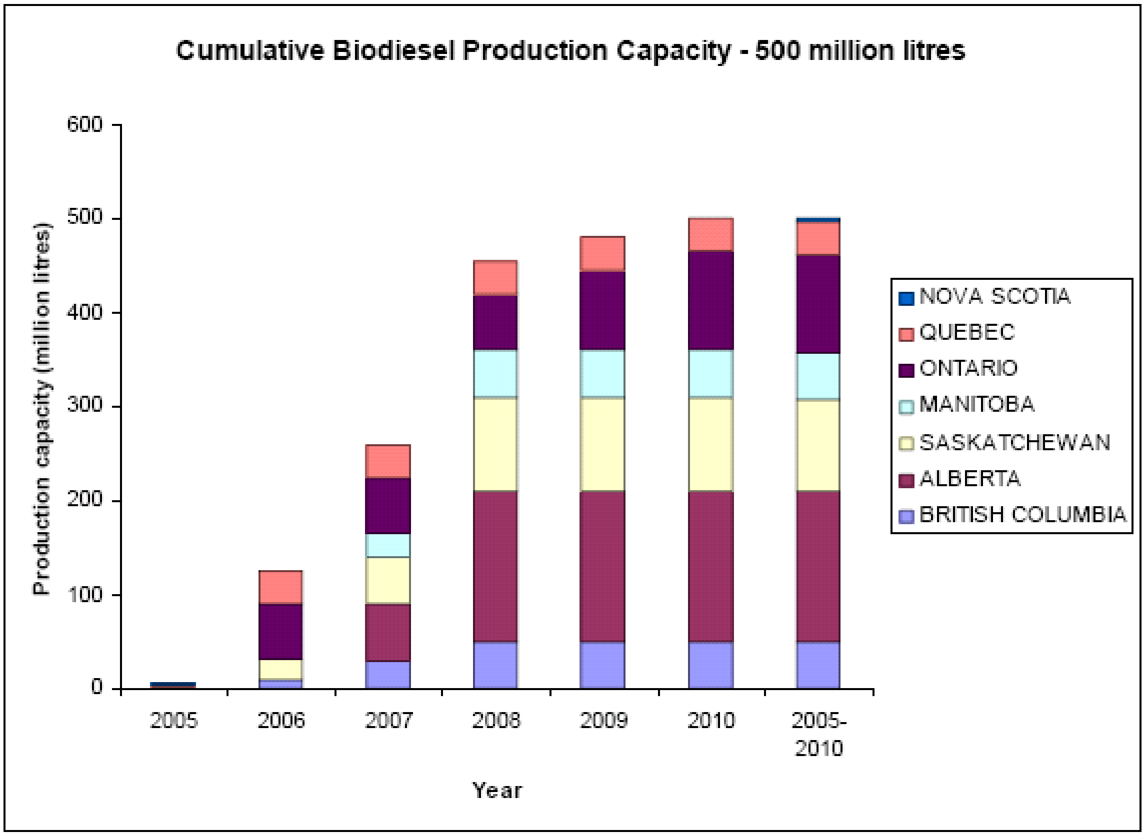
[55] *Canada Biomass-Bioenergy Report, 2005*
http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf



Incremental Biodiesel Production Capacity in Canada (million litres)

	2005	2006	2007	2008	2009	2010	2005-2010
BRITISH COLUMBIA	0	10	40	0	0	0	50
ALBERTA	0	0	0	160	0	0	160
SASKATCHEWAN	1	24	25	50	0	0	100
MANITOBA	0	0	25	25	0	0	50
ONTARIO	1	59	0	0	25	15	100
QUEBEC	1	34	0	0	0	0	35
NOVA SCOTIA	3	0	0	0	0	2	5
TOTAL CAPACITY	6	127	90	235	25	17	500

From Developing a Canadian Biodiesel Industry: Policy Submission, November 2005
http://www.canadianbioenergy.com/Resources/DEVELOPING_A_CANADIAN_BIODIESEL_INDUSTRY.pdf



From Developing a Canadian Biodiesel Industry: Policy Submission, November 2005
http://www.canadianbioenergy.com/Resources/DEVELOPING_A_CANADIAN_BIODIESEL_INDUSTRY.pdf

As of 2001, the diesel fuel market in North America was 245.5 billion litres (United States – 222.9 billion litres; Canada – 22.6 billion litres). The market has been growing steadily, with most of the growth occurring in on-highway consumption, which represents 56% of the market in the US and 43% in Canada. Other significant market segments in Canada include commercial and institutional use (15%), industrial (14%), agriculture (11%), railways (9%), and marine (5%)[56].

Several issues are key to assessing the future market potential of biodiesel, including: biodiesel feedstock availability; feedstock and production cost structures; fuel performance issues; competing products and technologies; potential niche markets; and possibilities for increasing revenue streams from the production of higher value-added products.

Feedstock availability and cost are the two major barriers to the commercialization of biodiesel. Biodiesel feedstocks, such as surplus vegetable oils, animal fats, and recycled cooking oils, can only provide about 3% of the diesel fuel market in North America. In 2002, Canadian diesel wholesale prices were 20–30 cents per litre compared to a projected cost of 36 cents per litre for biodiesel made from animal fats and 63 cents per litre for biodiesel made from vegetable oils. Feedstock costs account for 75% or more of biodiesel production costs. With the possible exception of converting animal fats to biodiesel, there is limited potential for improvements in biodiesel production technologies to reduce production costs.

Research suggests that the biodiesel industry should pursue the following key strategies:

- Focus on using **low levels of biodiesel (B2) as a lubricity additive** in low sulphur diesel fuels. Laboratory scale and field demonstrations suggest that biodiesel additives can improve fuel economy in light vehicles by up to 6% and reduce engine wear by 50%, and provide the consumer with a net economic return when life cycle costs are considered. Low level biodiesel lubricity additives are also price competitive with other after-market lubricity additives. Additional field research is required to ensure that these findings can be applied to the trucking industry and other market applications.
- Focus on a **B5 biodiesel blend using animal fats**. These feedstocks are lower priced than vegetable oils. A new and more efficient production technology developed in Canada promises to further reduce the costs of converting these feedstocks into biodiesel. A recent **biodiesel demonstration project in Montréal** involving mass transit buses also indicates that a B5 blend using animal fats can significantly reduce smog-forming emissions. Animal fats also have lower NOx emissions than either vegetable or recycled cooking oils and can improve the cetane rating of diesel fuels.
- In the longer term, develop **dedicated biodiesel feedstocks**, such as industrial mustard, which could be produced for under 10 cents US per pound, provided biopesticide markets can be developed for the meal co-product. At this price, biodiesel could compete with petroleum diesel without government tax support.
- The economics of biodiesel production could also be further improved by supporting R&D efforts focused on **developing other higher value-added products for methyl esters**. Methyl ester solvents and biolubricants are two areas that look promising. Finding other value-added uses for glycerol and meal co-products would also serve to increase revenues or at least mitigate the impact of declining prices, which may occur as increasing biodiesel production inevitably drives up glycerol and meal supplies beyond market demand.

4.2.1. Market Sectors for Biodiesel in Canada

The transportation sector is an important initial target for use of biodiesel due to its high diesel consumption, established infrastructure for marketing and delivery and high fuel inventory

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[56] *Canada Biomass-Bioenergy Report, 2005*
http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

turnover. However, biodiesel use is otherwise appropriate for other stationary and off-road diesel applications, representing additional future potential approximately equal to that achievable in the transportation sector alone.

Niche markets like government fleets, underground mines, and recreational marine use have been targeted over the past decade in the US and elsewhere, but these markets tend to be small, fragmented, and subject to competition from other technologies.

The most serious challenges come from:

- competing fuel additives, e.g., Sunoco's Soy Gold
- competing alternative fuels, e.g., compressed natural gas, liquid natural gas, and propane
- competing technologies and systems, e.g., diesel-electric hybrid vehicles; thermal depolymerization and chemical reforming of organic waste into clean energy; and new pollution control technologies.

The *Biodiesel and Other Chemicals from Vegetable Oils and Animal Fats* report described the potential of biodiesel in the niche markets in Canada as follows: [57]

- **Government Fleet Vehicles**

We do not have diesel fuel consumption by the Canadian federal and provincial government fleets. Assuming the Canadian government fleet market is 1/10 of the US, the most aggressive scenario would result in Canadian biodiesel sales to federal and provincial fleets of 14 million litres. Assuming biodiesel sold at $3.00 US per gallon, the revenue would be only $11.1 US million per year.

These data do not paint a very optimistic picture. Assuming that 57 million litre, stand-alone, biodiesel plant is required to reach economies of scale; even an aggressive marketing scenario for biodiesel on-road use by government fleets would rise within 6 years to 14 million litres—not enough to keep a single 57 million litre biodiesel plant running at anywhere near capacity. Although Canadian federal and provincial government fleets, by themselves, do not offer a market large enough to sustain a biodiesel plant, they can demonstrate leadership by providing a highly visible public example of biodiesel use.

- **Mass Transit**

One of the largest biodiesel demonstrations in North America was conducted by the ***Société de Transport de Montréal*** **(STM) in Montréal.** The $1.3 million project evaluated the economic and environmental impacts of using about 500,000 litres of B5 and B20 biodiesel blends in 155 mass transit buses using vegetable oil (B5), animal fats (B20), and recycled cooking oil (B20) as feedstock sources. The demonstration, called BIOBUS, was carried out between March 2002 and March 2003. Partners in the demonstration included the **Canadian Renewable Fuels Association, *Fédération des producteurs de cultures commerciales du Québec* (FPCCQ), STM, Rothsay/Laurenco (member of Maple Leaf Foods Group), Natural Resources Canada, Environment Canada, Environment Québec, and Transports Québec.**
In general, the demonstration was considered successful, but the recent decision by the Québec government not to remove the 16.4 cent per litre tax on biodiesel could negatively impact the economics of biodiesel purchases and may stop the program from expanding to include the full 1,600-bus fleet.

Other Canadian biodiesel demonstrations include:
< The **City of Brampton** runs all of its 137 transit buses on B20. It is the first municipality in Canada to commit to using biodiesel.

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[57] *Biodiesel and Other Chemicals from Vegetable Oils and Animal Fats*, 2004, http://www.agr.gc.ca/misb/spec/bio/pdf/diesel2_e.pdf

< The **City of Vaughan** has started a pilot project using biodiesel blends in selected City and Hydro fleet vehicles with the intention of converting the entire fleet in the future.
< The **City of Saskatoon** has initiated a BioBus pilot project. Over the next two years, two transit buses will use a 5% blend of canola biodiesel.
< Five Lower Mainland municipalities in BC **(Burnaby, Delta, the City of North Vancouver, Richmond, Vancouver)** and the resort municipality of **Whistler** will be testing biodiesel in a dozen heavy-duty vehicles, such as garbage trucks.

The demand for biodiesel blends within the Canadian municipal mass transit market will likely continue to expand and provide an important market. The market might be bigger in southwestern Ontario where summer smog levels are having serious health impacts.

- **Marine Vessels**

The higher cost of biodiesel will be a major market barrier for commercial vessels where fuel costs represent a major portion of total operating costs. Commercial boaters are not willing to pay even a few cents more per gallon for biodiesel.

Recreational vessels represent the best market opportunity for biodiesel blends but in Canada, they would provide a market for only 757,000 litres.

Given the dispersed location of recreational users and the difficulties in distribution, the marine market provides limited opportunities for biodiesel.

- **Railroad Use**

In 2001, **Canadian railways** consumed 2.13 billion litres of diesel fuel, or 9.5% of the total diesel market. This significant niche market has the potential to be more important in the Canadian context than it might be in the US, where it represents only 5% of the total diesel market. If Canadian railways used a B20 blend, it would create a market for about 400 million litres of neat biodiesel.

Urban commuter rail operations are likely to be near term market opportunities, including:

- the **AMT service in Montreal**, which operates 15 locomotives and uses 2.56 million litres of diesel fuel annually
- the **GO train service in Toronto**, which operates 45 locomotives and uses 21.6 million litres annually
- the **West Coast Express (WCE) in Vancouver**, which operates 6 locomotives and uses 1 million litres per year.

Intercity passenger operations could also be considered for demonstrations including the **VIA Rail Quebec-Windsor Corridor** service, which operates 35 locomotives and consumes 30 million litres of diesel annually.

Freight switching operations could be another opportunity for demonstrating biodiesel because they typically use older engines where warranty issues are not as critical. As well, the duty cycle of switching locomotives is such that fuel consumption concerns would also be minimized.111 There are 643 switching locomotives in Canada, which consume about 5% of Canadian railway diesel fuel.

In general, there are currently a number of barriers to using biodiesel in railway locomotives, such as: cost, higher NOx emissions, few greenhouse gas (GHG) incentives for railway use, lack of field testing, no warranty protection for engines, and security of supply.

- **On-Farm Use**

On-farm use of biodiesel is another large potential niche market.
In 2001, Canadian agriculture consumed 2.5 billion litres or 11% of the total market for diesel fuel in Canada.

If a B2 blend was used throughout Canadian agriculture, it would create a market for 50 million litres of neat biodiesel. Biodiesel blends may offer farmers several benefits that outweigh paying just a few cents more per gallon than petroleum diesel

- **Residential and Commercial Heating Oil**

In Canada, commercial and institutional diesel use accounts for 3.3 billion litres, or 15% of the total diesel market in Canada. Research results indicate that biodiesel blends can be used as a premium home heating fuel.

Biodiesel made from waste fish oil should also be studied further. In Canada, Ocean Nutrition (Mulgave, Nova Scotia) has signed a 10-year deal with Wilson Fuels Inc. for 5 million litres of biodiesel per year. Wilson Fuels intends to sell a biodiesel blend for home heating.

- **Underground Mines**

A Canadian study conducted in 1997 at the INCO metal mine in Sudbury found 21% lower total carbon emissions when a diesel-powered scooptram equipped with diesel oxide catalysts used a blend of 58% soy-based biodiesel and low-sulphur No. 2 diesel, compared to low-sulphur No. 2 diesel used alone. The results, however, were lower than the researchers initially expected. Biodiesel fuel costs would have to be significantly lower for it to be a viable particulate emissions control option for underground metal mines in Canada.

- **Parks and Other Environmentally Sensitive Areas**

Assuming that the Canadian market for biodiesel in parks and environmentally sensitive areas is about 1/10th the US market, this niche market could provide a projected demand for about 1.1 million litres of biodiesel, excluding fuels used by the Canadian Coast Guard. This is a small market that is relatively fragmented by types and uses of diesel equipment, making efforts to communicate and organize change difficult, though not impossible.

4.3. Market Potential of BioOil in Canada

DynaMotive, the major player in the BioOil market, forecasts a growing market based on high oil costs, growing demand for renewables, increased environmental concerns and inexpensive, abundant feedstock available for BioOil (2 billion tones of forestry and agricultural waste available annually = 4.4. billion BOE). The company hopes to develop a large domestic market for BioOil. But it anticipates major exports to Europe in the early states (in the area of 400,000 tonnes in 2008 and double that within four years.)[58]

Customers for BioOil fuels could potentially include local, regional and international producers and electrical utilities (fuel substitution in large scale power plants and fuel for district heating), fuel distributors, forest companies (natural gas substitute in limekilns and boilers), oil and gas producers (steam production for extraction) and manufacturing companies (process heat) including sawmills, pulp mills and greenhouses.

4.4. Market Potential for Biomethanol in Canada

An important opportunity for Canada seems to exist in terms of the large amounts of black liquor produced in the pulp & paper sector, which could also be used to make methanol. From presently

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[58] *Canada Biomass-Bioenergy Report, 2005*
http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf

4 million tonnes of black liquor generated annually in Canada methanol could be produced in the same order of magnitude as current ethanol production in Canada.[59]
It is estimated that the biomethanol production potential in Canada is 7 million tons. With the reported consumption of petrol and diesel fuel oil for road transport the calculated potential replacement is 7.2%, which is of course substantial and, not before noticed, offers great help in the commitment to the Kyoto protocol cut down on use of fossil fuels.[60]

Methanol can be used in pure form as a gasoline substitute, or in gasoline blends such as M85 (85% methanol and 15% gasoline). Pure methanol can be used in existing vehicles; however, engine modifications are required to facilitate cold starts and to replace materials that can be corroded by methanol and M85. Methanol has a higher octane rating than gasoline, which helps reduce engine "knock." It can also deliver greater fuel efficiency if the engine's compression ratio is properly adjusted. Because methanol carries more hydrogen by weight than liquefied hydrogen, it is also seen as a possible synthetic fuel for fuel cells.

Methanol is being considered as a storage fuel for hydrogen fuel cell cars. Nevertheless, during the past 20 years, no significant market has developed for methanol as fuel, although it is often used as an additive and can be blended with biodiesel to enhance cold weather properties. Methanol has only half the energy content of gasoline; it has a lower vapor pressure than gasoline; it can attack fuel and engine components; and it is toxic. Although these obstacles could be overcome, together with the lack of a methanol vehicle fueling infrastructure, they have limited the potential of this fuel.

4.5. Pellets Market Potential in Canada

4.5.1. Wood Pellets Market Potential

Due to escalating home heating oil and natural gas prices the demand for wood pellets grew in the recent years and wood pellets made from compressed wood shavings and sawdust became a hot, but scarce commodity. According to Bruce Lisle, president of the Pellet Fuels Institute, 76,000 pellet-burning stoves were sold in Canada in the first nine months of 2005, a 98% increase over the same period in 2004. Pellet sales rose 96% in B.C. and 30% in Quebec and the Maritimes.[61]

John Swaan, head of the Wood Pellet Association of Canada, said rising oil prices after Hurricane Katrina had caused a knee-jerk reaction to a perceived shortage of pellets in the east. This had led to panic buying and hoarding of fuel supplies, putting additional pressure on what was already a growing market.[62]

The situation has been compounded by a reduction of harvesting permits in Quebec, where pellet production has fallen due to the softwood lumber dispute. As a result, pellets from B.C. are being transported by rail to packaging plants in Quebec, which has pushed prices up further in the east.

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[59] *Identifying Environmetally Preferrable Usees for Biomass Resources. Stage 1 Report: Identification of Feedstock-to-Product Threads, 2004,*
http://www.cec.org/files/pdf/ECONOMY/Biomass-StageI_en.pdf

[60] *Technical and Commercial Feasibility Study of Black Liquor Gasification with Methanol/DME Production as Motor Fuels for Automotive Uses – BLGMF, December 2003*
http://www.nykomb.se/pdf/BLGMF.pdf

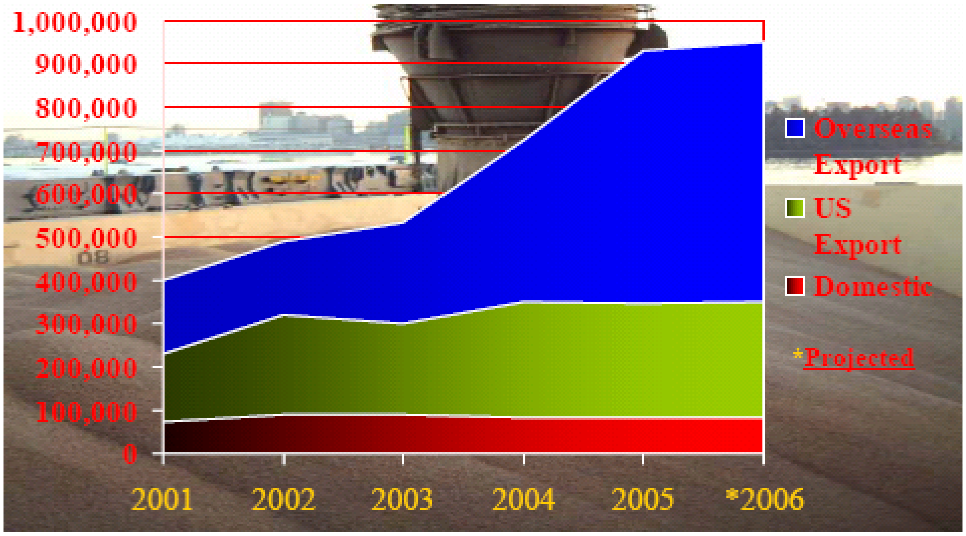
[61] *North American Pellets Market Heating Up As Oil Prices Soar, January 09, 2006,*
http://www.forestweb.com/iiFeed/clients/canfor/feed.taf?nID=578153568&feed=xTranet

[62] Ibid

[62] *Pellet-Burning Stove Owners Have a Problem: No Pellets, December 2005,*
http://www.consumeraffairs.com/news04/2005/cpb_pellets.html

Compounding the problem, leading pellet manufacturers in Canada are in the midst of long-term contracts with buyers in Europe. Those contracts were signed when the demand for wood pellets was low during the mild winters of 1998 and 1999. Pellet fuel manufacturers indicate that they have made plans to meet future demand by significantly increasing production. In a recent survey, PFI member companies state the industry plans to ship over 350,000 additional tons next year, a 35% increase. In addition, the North American industry anticipates new pellet mills being added in 2006 that could generate an additional 120,000 tons of pellet fuel for next winter.[63]

Canadian Wood Pellets Production and Consumption
Domestic – US Export – Overseas Export



From: *BC's Role in the Global Wood Pellet Industry, November 2005,*
http://www.bcbioproducts.ca/29-11-05%20Laurel%20Point/PelletFlame%20-%20BCBPA%20Nov%2029%2005.pdf

The greatest opportunity for pellet exports from Canada is in BC. For companies in BC, with ocean ports in close proximity, the market is primarily Europe. Productive capacity in central Canada is not near ocean ports and thus production is largely destined for the US market. Nova Scotia on the East Coast has very little mill residue available for additional pellet capacity and the province is not currently predisposed to use forest floor waste. In Quebec, reduced wood harvesting will put pressure on the current demand for mill residues, however there is an opportunity to manufacture pellets from the large amount of unutilized forest slash. Quebec plants would also be near the port of Montreal. However, the use of forest floor biomass is still an environmental question and is not yet supported.

In BC, pellet export potential is almost limitless. The annual surplus of mill residues is 1.8 million BDt, equivalent to twelve new 150,000-tonne pellet plants. Domestic use is growing only marginally, so most would be exported. Similarly, the wood available for energy from the mountain pine beetle infestation is estimated at 27 million tonnes, which will be usable for perhaps 12-15 years. There is pressure to utilize this wood for energy before it burns from natural forest fires. While some of the wood will find its way to cogeneration, there is considerable interest on the part of the forest industry to enter new markets, such as pellets.[64]

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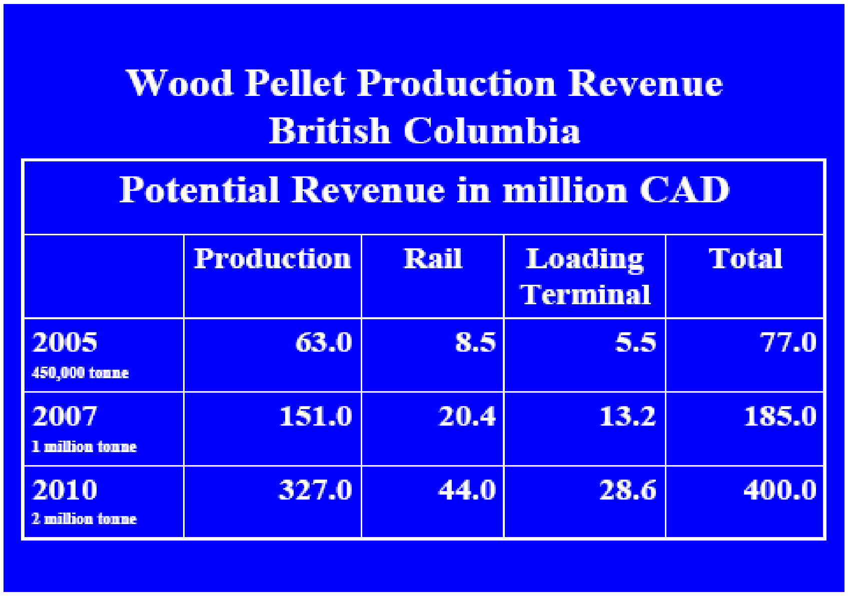
[64] *Canada Biomass-Bioenergy Report,* 2005, http://www.bioenergytrade.org/downloads/douglascanadacountryreport.pdf



Wood Pellet Production Revenue
British Columbia

Potential Revenue in million CAD

	Production	Rail	Loading Terminal	Total
2005 450,000 tonne	63.0	8.5	5.5	77.0
2007 1 million tonne	151.0	20.4	13.2	185.0
2010 2 million tonne	327.0	44.0	28.6	400.0

From: *BC's Role in the Global Wood Pellet Industry, November 2005,*
http://www.bcbioproducts.ca/29-11-05%20Laurel%20Point/PelletFlame%20-%20BCBPA%20Nov%2029%2005.pdf

The rate of pellet industry expansion in BC and Alberta is hinging on a number of key factors including: licenses to use pine beetle infested wood at a reasonable price, lower costs for railing pellets to the coast, sustained low ocean freight rates, and new loading facilities. In order to make pine beetle infested forests a viable fibre source the provincial governments have to license its use at an acceptable stumpage fee. To be competitive in world markets, a lower cost structure for railing pellets to port is needed. A consolidation of railing for all mills is in the final stage of negotiation. To handle the sharp increases in capacity, more cost-efficient vessel loading facilities have been erected. A new dedicated pellet loading facility has been erected in Port of Vancouver. This terminal will handle 1,000,000 tonnes per year and could be expanded to handle twice that volume over time. Construction of an intermodal container port in Prince Rupert is scheduled to begin in September 2005, with operations commencing in the first quarter of 2007.

A recent trend is for the large forest companies to consider building a combination of cogeneration and pellet mills with the pellets being exported.

4.5.2. Grass Pellets Market Potential

Roger Samson, *Executive* Director of Resource Efficient Agricultural Production Canada (REAP), makes the case that the easiest way to move biomass energy ahead in North America in the future is to focus on the development of pelletized grass biofuels as an ecological substitute for high-grade energy forms such as oil, natural gas and electricity in heat-related energy applications. North American energy markets could be profoundly transformed by the development of a large-scale, pelletized grass biofuel industry. As prices continue to rise for high-grade energy forms, low-priced farm-derived biofuel pellets will increasingly become the heating fuel of choice for many North American energy consumers.

He sees the main market opportunities for energy grasses and crop milling residue fuels as follows[65]:

- Residential stoves and boilers 9-25 kw (though not quite as fuel friendly as bigger units)
- Small commercial boilers 100-300kw (few combustion limitations, most units now with ability to burn most higher ash fuels due to advancing technology)
- Industrial boiler biofuel markets, few technical problems but will greatly benefit from carbon credits especially in western Canada

5. Global Market Forecast for Biomass Energy

It is estimated that the global market for biofuels and bioenergy will grow from 2-5 billion $US in 2003 to 150 billion $US in 2050, and that by 2050 biomass will provide 30% of the global needs for fuels and chemicals.[66] Bio-energy will need to be up to 50% share of total worldwide energy demand in 2050 (today 1-2%) to meet the growing demand of energy.[67]

The *World Biomass Report, 2004-2013*, by Douglas Westwood Ltd, predicts that in the next ten years the global biomass market will grow to $18 billion US, 12 GW.[68] The improved competitive position of biomass as a power source will result from higher energy prices, as oil shortages and growing demand increase the costs of fossil energy and the desire for security of energy supplies.

Because of their economic status, West Europe and North America are the most important regions for all biomass systems but Asia has the most potential for both crop-based and livestock wood and agricultural materials.

5.1. Global Biomass Market by Conversion Processes

The authors of the *World Biomass Report, 2004-2013,* divide the biomass market into three core sectors based on the conversion process used to extract energy: thermal, landfill gas and anaerobic digestion.

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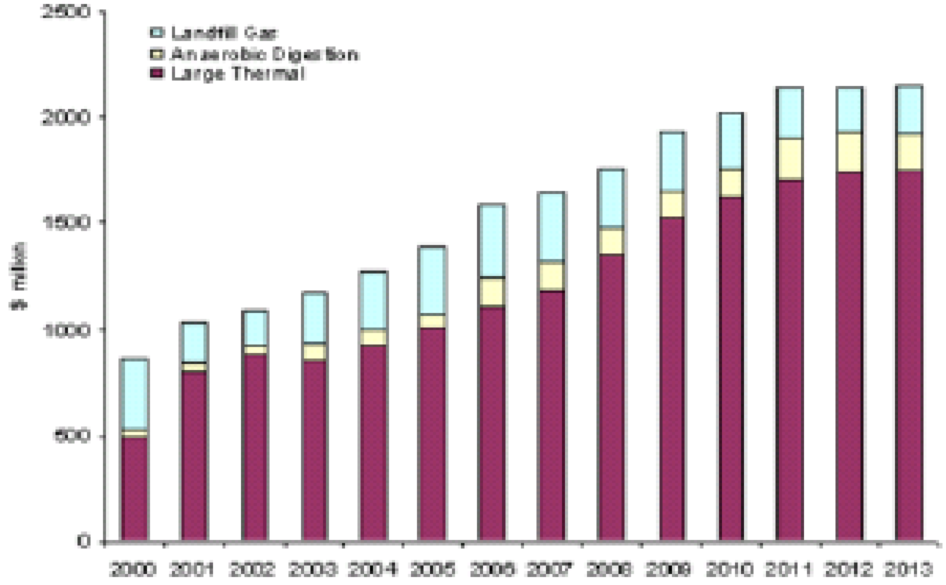
[65] *The Potential for Grass Biofuel Pellets, by Roger Samson, February 2006,* http://www.fcpp.org/pdf/FB039ThePotentialforGrassBiofuelPelletsJan2706.pdf

[66] *The Canadian Bioproducts Community* - Capturing Canada's Natural Advantage Together... A BioProducts Canada presentation (2005). http://www.bio-productscanada.org/pdf/BPC-Industry%2BCommunity-Presentation2005.ppt

[67] *European Perspective on Bio-Energy, 2004* http://www.bioalberta.com/ims/client/upload/European%20Perspective%20on%20Bioenergy.pdf

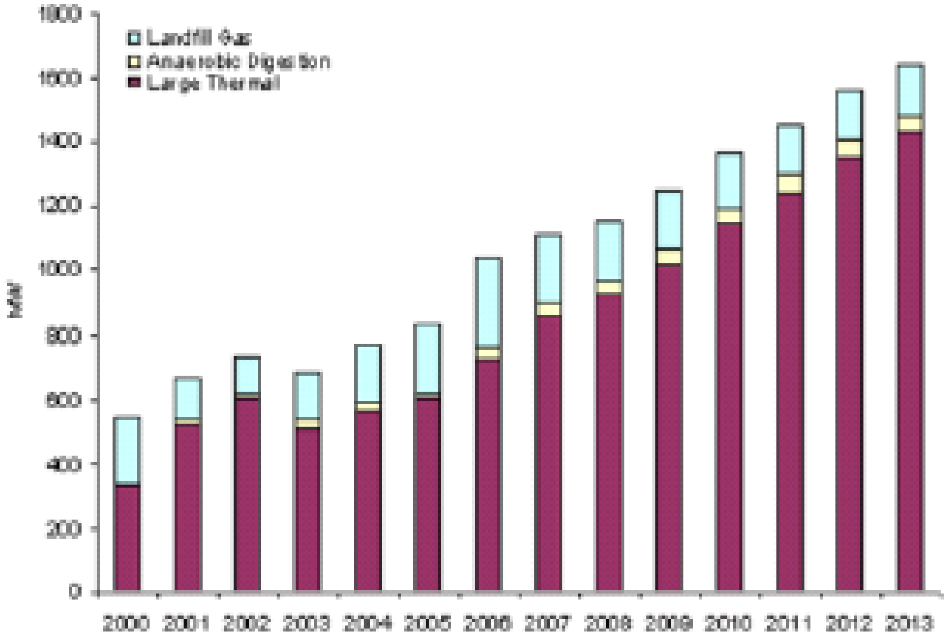
[68] *The World Biomass Report,2004-2013, December 2004,* http://www.bioenergy.org.nz/documents/newsletters/Newsletter%201204.pdf

Biomass Plant Capital Expenditure 2000-2013 ($ million)



From: *The World Biomass Report,2004-2013, December 2004,*
http://www.bioenergy.org.nz/documents/newsletters/Newsletter%201204.pdf

Biomass – Annual Installed Capacity by Sector 2000-2013



From: *The World Biomass Report,2004-2013, December 2004,*
http://www.bioenergy.org.nz/documents/newsletters/Newsletter%201204.pdf

The biomass market attracted an annual expenditure of $863 million in 2000. This will rise to $1,276 million by the end of 2004, and to $2,145 million by the end of 2013. Over the next decade the authors forecast that some $18 billion of capital investment will be made. The thermal sector will attract the largest capital expenditure due to average plant sizes having greater capacity than the other two sectors. In addition, thermal plants will see average plant size grow considerably over the period. Landfill gas and anaerobic digestion are important markets, but small in comparison to thermal.

A total of 12,172 MW is forecast for installation between 2004 and 2013 worldwide. Large thermal biomass plants represent the bulk of this capacity, with 9,868 MW being installed in the next ten years. Landfill gas is the second largest sector, with 1,887 MW of installations forecast. The anaerobic digestion market will grow, but it is a smaller sector than either large thermal or landfill, with only 417 MW of new capacity forecast over the next ten years.

Total annually installed capacity has grown each year since 2000 and is forecast to grow throughout the period. However, the landfill gas sector will peak in 2006, from which point installation rates fall quickly. The strong large thermal sector is responsible for the overall growth rate more than making up for the declining landfill market.

5.1.1. Large-Scale Thermal Plants

A total capacity of 9,868 MW is forecast to be brought online from large-scale thermal plants over the ten-year period. While Europe and North America will continue to develop, with 2.4 GW and 4.4 GW forecast for installation over the next ten years respectively, it is other regions where the most dramatic rates of growth will be found. Asia and Latin America will see the highest growth as these regions have held massive potential for a long period which is now beginning to be exploited. Small scale thermal is already well established, and the move to large-scale developments is being encouraged.

Large-scale thermal development will attract a total Capex over the future ten-year period of $13,908 million. Western Europe is the largest market with $5.6 billion of expenditure forecast. While North America is the second most valuable market with $3.4 billion of expenditure over the next ten years, it is Asia that is the most interesting region – the rapid growth here means the market is worth a substantial $2.1 billion between 2004 and 2013.

The Capex growth rate decreases towards the end of the period. This pattern is the most pronounced in the already well-developed markets of Western Europe and North America. This is indicative of reducing costs and greater efficiency and experience in designing and building thermal plants. By building larger plants, costs per MW are generally reduced.

5.1.2. Anaerobic Digestion

Although slightly erratic, the market trend for anaerobic digestion is clearly growing. The annually installed capacity peaks in 2011 with close to 60 MW being installed that year. The total installed capacity increases more than three-fold over the ten-year period from 2004-2013, growing from 185 MW in 2004 to 575 MW in 2013.

Western Europe dominates with forecasts to install 203 MW in the future ten-year period.

The capacity added per year in Western Europe decreases after 2007, fluctuating between 15 and 25 MW of new installations per year. By 2013, however, the region will have four times the installed anaerobic digestion capacity of the next largest region, North America.

North America installs 68 MW of anaerobic capacity in the ten-year period. The annual capacity in North America is projected to increase each year, one of only two regions where it does so (the other being Eastern Europe).

Australasia had significant anaerobic digestion increases, installing 46 MW over the period, but this area is also the most erratic. The potential is large, but stronger market mechanisms and proven technologies are necessary to attract investment.

Although every region has growth forecast, some, such as Africa and the Middle East, will only make limited progress over the next ten years. Growth in other regions such as Asia and Australasia is ongoing, but is not as rapid as market-leader Western Europe, or North America – which develops well from a small base, becoming the second largest region by the end of the period.

A total spend of $1.6 billion is forecast for the anaerobic digestion sector between 2004 and 2013. Capex increases from $85 million in 2004 to a peak of $246 million in 2011. Western Europe will see the bulk of this expenditure, some 52%, with a market worth $846 million over the next ten years. North America and Eastern Europe are the next largest regions with 17% and 12% market share respectively. Compared with the other sectors, Africa is forecast to have a significant level of expenditure. Total spending for 2004-2013 is $81 million – higher than that of the Middle East, Asia, and Latin America. Costs per MW here are several times greater than in other regions.

5.1.3. Landfill Gas

A total of 1,680 MW will be installed worldwide over the ten year period 2004-2013. From a strong position in 2000, when over 200 MW of capacity was installed, landfill gas installations slumped by half within two years to little over 100 MW in 2002. From 2003 through to 2006, growth picks up reaching a high of 272 MW of new installations per year, before decreasing through to 2012.

The reason for this pattern is largely the declining installation rates in the two largest markets, Europe and North America. These have 70% of future installations and therefore a big effect on global annually installed capacity levels. In North America, 160 MW of landfill gas capacity was installed in 2000. This falls to 110 MW in 2004, and slumps massively to just 10 MW in 2013. Although there is growth until 2006 in Western Europe, from this point on, the installation rate plateaus before decreasing from 2011. Other regions such as Australasia and Latin America will experience stable installation rates. Although Africa and Asia show signs of long term growth, no region is forecast year-on-year growth in the landfill gas sector.

North America is forecast to install 400 MW of new capacity between 2004 and 2013. Western Europe’s higher installation rate means that by the end of the period it is only narrowly behind North America in terms of total installed capacity. North America will experience a 31% increase in installed capacity over the next ten years, whereas Western Europe has a much higher 85% rise in prospect. Midway through the next decade, Western Europe will be the market leader with $1.2 billion of expenditure or 44% market share between 2004 and 2013.

North America is the second largest market at $766 million forecasted; a 28% market share. The North America market slumps dramatically from 2005 and does not recover by the end of the period. This has a major impact on the global picture.

Asia is the fastest growing market, achieving more than ten-fold growth in ten years, albeit from a lower base level. From 2008, the region brings more capacity online each year than the larger North American market. Asia has the potential to spend $309 million; an 11% market share which is likely to increase over the next decade.

The large decrease in spending after 2000 has only recently been reversed. From the present until 2006, expenditure increases each year. However, from 2007 it begins to fall until to 2012. The last year of the period shows a slight increase. Overall, significantly more investment is forecast in the first half of the period than in the second. Capex over the 2004-2013 period is forecast at $2.7 billion.

5.2. Biomass Energy Market by Sectors

Market opportunities for biomass energy are in the heating and power and in the transportation sectors.

5.2.1. Global Biopower and Waste-to-Energy Market

Since 1995, the global Waste-to-Energy (WTE) industry increased by more than 16 million tonnes of municipal solid wastes (MSW). Currently, there are WTE facilities in 35 nations, including large countries such as China and small ones such as Bermuda. Some of the newest plants are located in Asia. In 2003, about 130 million tonnes of municipal solid waste (MSW) are combusted annually in over 600 WTE facilities that produce electricity and steam for district heating and recovered metals for recycling. [69]

According to Frost & Sullivan's report, *European Waste to Energy Plants Markets,*[70] a number of European countries have embraced waste-to-energy, with approximately 340 plants up-and-running dealing with around 50 million tonnes of municipal solid waste each year in 2002. Given current estimates showing each household discards around a tonne of waste each year, current projections suggest that by 2020 twice the current number of waste management facilities will be required. Waste-to-energy plants are well positioned to address this problem and by overcoming distinct challenges that oppose waste-to-energy solutions, the market promises to show good returns for active competitors.

Frost & Sullivan analysts comment that the period 1999 to 2002 has seen some good growth in the total European waste-to-energy plant market, with 1999 especially posting strong growth. The period saw approximately 75 plants coming online with a treatment capacity of nearly 12 million tonnes/year. In later years, with a number of landfill bans and pieces of new legislation expected to take effect, growth is expected to recover and demand accelerate. Frost & Sullivan has estimated that between 2003 and 2009 166 plants will be commissioned across Europe. This includes a wide variety of plant sizes and types and will be largely stimulated by the healthy growth expected from the emerging pyrolysis and gasification plants market.

In terms of competitive environment, the European market for waste-to-energy plants currently contains around 40 companies, ranging from huge multinational turnkey power plant suppliers to smaller, more dedicated waste-to-energy equipment suppliers.

At first glance, the European market for waste-to-energy plants appears somewhat sporadic in nature, and it might appear that the growth in the market has peaked. However, on closer scrutiny, a number of very

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[69] *An Overview of the Global Waste-to-Energy Industry, August 2003,* http://www.seas.columbia.edu/earth/papers/global_waste_to_energy.html

[64] *European Waste to Energy Plants Markets, 2003,* http://www.the-infoshop.com/study/fs22505_energy_plants.html

important issues have been highlighted, thus showing that the market has both appealing and unappealing characteristics.

The key market characteristics that Frost & Sullivan has highlighted include:

- Although regions such as Germany, Scandinavia and the Alpine region are somewhat more mature, growth in Iberia the UK and Italy will offset this.
- The slowing yet ongoing consolidation of the market as a result of merger and acquisition activities
- The sporadic and inconsistent nature of demand, frequently causing problems relating to fixed costs for technology suppliers that rely on this industry for revenues
- Growing acceptance of and investment in fluidised bed and pyrolysis & gasification plants
- Restricted opportunities for price increases because of the fierce nature of competition in the marketplace, combined with problems of oversupply
- The Europe-wide shift away from landfill disposal in favour of the higher value-added segments of the waste management industry, including thermal treatment

Frost & Sullivan therefore believes that, in spite of the seemingly limited growth potential of the market, significant opportunities exist for companies that can target and exploit specific pockets of growth. Indeed, the waste-to-energy plants market in Europe has been driven by the imposition of a range of environmental legislation at the national and international level.

There has been a general movement away from using landfill sites as a means of waste disposal without pre-treatment and the development of policy measures to facilitate this. Opportunities are expected to intensify competition and spur market diversification. Suppliers are expected to seek to expand the range of technologies offered in respect to waste-to-energy plants, encompass more of the vertical supply chain and move into new geographical markets.

The United States is responsible for 23% of the global municipal waste-to-energy market. American plants tend to be larger than their European counterparts, with many units in the Northeast and Florida able to process over 1 million tons per year. [71]

There are 89 waste-to-energy plants operating in 27 states managing about 13 percent of America's trash, or about 95,000 tons each day. Waste-to-energy facilities generate about 2,500 megawatts of electricity to meet the power needs of nearly 2.3 million homes, and the facilities serve the trash disposal needs of more than 36 million people. The $10 billion waste-to-energy industry employs more than 6,000 American workers with annual wages in excess of $400 million. [72]

In North America, biomass and waste-to-energy plants are expected to grow by 18 to 26 percent in the next ten years in terms of newly-installed electricity capacity alone, despite the high initial investments and difficulties in securing finance. Frost & Sullivan analysts say, "Competition will be limited during the first five years, as the primary focus of market participants will be to install their first commercial plant and prove reliability and generate economies of scale". There will be a gradual increase in competition as different technologies are accepted and established in the market. Companies that are able to offer a one-stop shop solution from design to installation, maintenance, and financing have a better chance to capture substantial market share.[73]

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[71] *Global WTE Facts,*
http://wte.cbll.net/about/

[72] *About Waste-to-Energy:Clean, Reliable, Renewable Power,*
http://www.wte.org/waste.html

[73] *North American Biomass and Waste-to-Energy Markets,*
http://www.marketresearch.com/map/prod/896666.h6ml

5.2.2. Global Biofuels Market

Encouraged by policy measures, global production and consumption of biofuels around the world continues to grow rapidly. Nevertheless, biofuels production is now estimated to be over 35 billion liters compared to about 1,200 billion liters of gasoline production worldwide.[74]

Brazil and the United States each produced about 4 billion gallons in 2005. Brazil, the world's largest sugar producer, makes its ethanol from sugarcane. The United States, the world's largest grower of corn, uses corn as the primary feedstock for its ethanol production. China is a distant third in ethanol production, at just under 1 million gallons in 2004. European nations traditionally use more diesel fuel than gasoline. Bio-diesel made from crops such as rapeseed is growing fast. The European Union hopes that by 2010, all diesel vehicles sold in the EU will contain a blend of 5.75 percent bio-fuels.[75]

There is considerable scope for biofuels such as ethanol and biodiesel to replace oil in the transport sector. Government policies may boost the share of biofuels in worldwide road transport fuel consumption to around 4% in 2030. The rate of increase will vary greatly among countries, reflecting different degrees of interest in biofuels. In OECD countries, biofuel consumption may reach 55 Mtoe in 2030. In the developing countries, biofuels remain important in Brazil and start to play a significant role in India.[76]

The recent sustained increase in international oil prices has spotlighted the potential for biofuels to supplement fossil fuels for transport. Another impetus is the rising dependence on oil imports in many countries. Net oil import dependency is expected to rise in all OECD regions and in China and India, and oil exports from the Middle East will represent more than two-thirds of global fossil trade in 2030. In most countries, however, oil imports have not crowded out domestic production. Just as indigenous industry coexists with imported oil, a global biofuels market could be created alongside protected domestic markets.
Given the wide range of biofuels production costs worldwide and the wide range in production potential among countries, there are substantial potential benefits from international trade in biofuels. These benefits include lower energy costs, energy supply diversification and economic development. Ethanol from sugar cane, produced mainly in developing countries with warm climates, is generally much cheaper to produce than ethanol from grain or sugar beets in IEA countries. For example, production costs of Brazilian ethanol from sugar cane are one-quarter of production costs in the EU and US. In countries where sugar cane is produced in substantial volumes, sugar cane-based ethanol is becoming an increasingly cost-effective alternative to petroleum fuels. A global biofuels markets would enable a wide variety of feedstocks to be planted worldwide, enhancing rural and agricultural markets in developing countries, Actions to diversify energy supply often means more subsidies, but trade would enhance the benefits of diversification by offering alternative, cheaper fuel sources.[77]

The main biofuels available in the U.S. transportation sector are ethanol and biodiesel. In 2004 alternative fuels accounted for 1.2 percent (2,111 thousand gasoline-equivalent gallons) of the total market for transportation fuels (177,562 thousand gasoline-equivalent gallons). Although relatively small, biofuels consumption has increased rapidly in recent years. In 1994, biofuels

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[74] *Renewables 2005 – Global Status Report,*
http://www.worldwatch.org/brain/media/pdf/pubs/ren21/ren21-2.pdf

[75] *Ethanol Gets a Push, but Road Ahead Fraught with Challenge, January 19, 2006,*
http://www.contracostatimes.com/mld/cctimes/news/nation/13664431.htm

[76] *Renewable Energy Markets: Past and Future Trends*
http://www.iea.org/Textbase/work/2005/Biofuels/Biofuels_Sellers_Paper.pdf

[77] ibid

consumption stood at 846 thousand gasoline-equivalent gallons or 0.6 percent of the transportation (140,719 thousand gasoline-equivalent gallons) fuels market. Fueling stations which provide bio-based fuels are increasing due to public education and awareness. Federal and state incentives also encourage the use of alternative fuel or flex-fuel cars.[78]

According to European Union (EU) plans, the proportion of biofuels is set to almost treble, rising from roughly 2% currently to 5.75% by 2010. As a result, EU-wide demand for fuels made from renewable resources will increase from under 5-million mt now to just below 14 million mt per year.[79] Global demand for biodiesel is expected to touch 10.5 million tonnes in the next few years.

About 5 percent of the road fuels used in the United States and the European Union are expected to be bio-derived within the next five years. The U.S. Department of Energy aims to replace 30 percent of the liquid petroleum transportation fuel with biofuels by 2025. Studies show that with such technology developments, biofuels could supply some 30 percent of global fuel demand in an environmentally responsible manner, according to Koonin.[80]

5.2.2.1 Global Ethanol Industry and Market

Global consumption of ethanol is rising rapidly. In 2005, the world made about 36 billion liters of ethanol fuel, an increase of nearly 20 percent from the year before. Main production regions of ethanol are Brazil and North America (United States and Canada). The share of bioethanol in world motor gasoline use amounted to 2,8% (US/Canda: 2,3%)[81] But consumption is rising rapidly. According to *Renewables 2005 – Global Status Report*[82] demand for ethanol fuels, compared to gasoline, was very strong in 2005. In recent years, significant global trade in fuel ethanol has emerged, with Brazil being the leading exporter. World ethanol trade volume hit a record level in 2004, reaching nearly 4.9 billion liters, compared with 3.7 billion liters in 2003. Brazil's 2.5 billion liters of ethanol exports accounted for more than half of global trade in 2004. Japan and the U.S. were the largest importers, with India close behind.

However, Brazilian ethanol prices during 2004 were near historic lows, fuelling trade, and higher ethanol prices likely during 2005 could slow or even reverse this trend, at least in the short term. There was also considerable biofuels trade (of both ethanol and biodiesel) within the EU (between various member countries), and growth in intra-EU trade appears likely to continue with the 10 new members beginning to play an active role.

India has been examining for quite some time the supply of ethanol-blended petrol in the country. In order to ascertain financial and operational aspects of blending 5% ethanol with petrol, the government had launched three pilot projects in different states during 2001 and these pilot projects were supplying 5% ethanol-doped-petrol only to the retail outlets under their respective supply areas. The Society for Indian Automobile Manufacturers (SIAM) has confirmed the acceptance for use of 5% ethanol-blended petrol in vehicles.

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[78] *Ethanol and Biodiesel Fuels in The U.S., January 09, 2006,* http://www.bioproducts-bioenergy.gov/news/DisplayRecentArticle.asp?idarticle=227

[79] *Lurgi to Implement World's Largest Biodiesel Project, January 25, 2006,* http://www.manufacturing.net/ct/article/CA6301888?spacedesc=latestNews

[80] *Ethanol More Energy Efficient Than Thought, Study Says, January 26, 2006,* http://news.nationalgeographic.com/news/2006/01/0126_060126_ethanol.html

[81] *Drivers for an International Biofuel Market, December 2005,* http://www.clingendael.nl/publications/2005/20051209_ciep_misc_biofuelsmarket.pdf

[82] *Renewables 2005 – Global Status Report,* http://www.worldwatch.org/brain/media/pdf/pubs/ren21/ren21-2.pdf

State governments of major sugar producing states and representatives of sugar/distillery industries have confirmed availability/capacity to produce ethanol. An expert group established by the government recommended blending of ethanol with petrol at supply locations (terminals/depots) of oil companies. In 2003, the government resolved that 5% ethanol-blended petrol would be supplied in the nine states and four union territories.[83]

The United States is the world's second-largest consumer and producer of fuel ethanol. Fuel ethanol production in the United States has grown substantially in recent years, both in volume and in number of participants. In 2004, the U.S. ethanol industry produced 3.4 billion gallons of fuel ethanol, more than double the volume produced in 2000. More than 75 different firms operate more than 90 fuel ethanol production facilities in the United States, with a current capacity of more than 4.1 billion gallons per year. This contrasts with 43 firms and just under 2 billion gallons per year of capacity in late 2000. The largest producer's share of capacity is currently around 25 percent, down from over 40 percent in 2000. The industry continues to expand, as incumbent producers are currently expanding existing plants and 18 new entrants are constructing new plants. As a result, an additional 1.3 billion gallons per year of ethanol capacity are expected to be operational within the next year.[84]

By 2005, there were nearly 400 fueling stations (mostly in the upper Midwest) that sold E85, an 85-percent ethanol/15-percent gasoline blend, and many more selling gasohol (E10). By 2005, about 3 percent of the 140 billion gallons of vehicle fuel (non-diesel) consumed annually in the U.S. was ethanol. In addition, 30 percent of all gasoline sold in the United States was being blended with ethanol (E10) as a substitute oxygenator for MTBE (methyl tertiary-butyl ether), which more and more states were requiring be discontinued. [85] Currently, there are 95 ethanol plants across 20 states with 33 new ones under construction and eight expanding. These 41 construction projects should add 2 billion gallons of annual production of straight ethanol to the nation's existing 4.4 billion gallons per year.[86] Corn-based ethanol is poised to make up 6 percent of US gasoline consumption by 2012, about double the current level.

This US market growth is expected to continue to accelerate, because of the economic benefits of ethanol, because of the Renewable Fuel Standard created in the Energy Policy Act of 2005, and because ethanol is replacing the other major oxygenate, MTBE (methyl tertiary butyl ether), in many markets. MTBE was found to have contaminated underground water supplies and, as of August 2005, its use has been banned or restricted in 25 states, including California, Illinois and New York.

The Energy Policy Act of 2005 includes major incentives to use cellulosic biomass ethanol, authorizes significant grants and loan guaranties for building cellulosic biomass ethanol production facilities and for technology development, and mandates an increase in the use of ethanol to 7.5 billion gallons in 2012 (the Renewable Fuel Standard). Augmenting the existing and growing production of ethanol from grains with that from cellulosic biomass will enable the substantial increase of ethanol production in the U.S. that has become a national security and economic imperative.

Other countries producing fuel ethanol include Australia, Canada, China, Columbia, the Dominican Republic, France, Germany, India, Jamaica, Malawi, Poland, South Africa, Spain, Sweden, Thailand, and Zambia.

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[83] *Renewables 2005 – Global Status Report,* http://www.worldwatch.org/brain/media/pdf/pubs/ren21/ren21-2.pdf

[84] *Report on Ethanol Market Concentration, December 2005,* http://www.ftc.gov/reports/ethonal05/20051202ethanolmarket.pdf

[85] *Renewables 2005 – Global Status Report,* http://www.worldwatch.org/brain/media/pdf/pubs/ren21/ren21-2.pdf

[86] *Presidential Push Spurs Ethanol Market, February 9, 2006*, http://www.upi.com/Energy/view.php?StoryID=20060209-010634-2950r

5.2.2.2 Global Biodiesel Industry and Market

Biodiesel was not produced in significant quantities anywhere in the world prior to 1996. The EU is the world's leading region for the production and consumption of biodiesel. By 2004, biodiesel markets had developed in seven primary countries (Austria, Belgium, France, Germany, Italy, Indonesia, and Malaysia). Germany has been the biggest biodiesel producer, with about 2 billion liters capacity on line or under construction. Biodiesel production grew by 50 percent in Germany in 2004, bringing total world production to more than 2 billion liters. Pure biodiesel (B100) in Germany enjoys a 100- percent fuel-tax exemption, and the country now has over 1,500 fueling stations selling B100. Other primary biodiesel producers are France and Italy, with several other countries producing smaller amounts, including Austria, Belgium, the Czech Republic, Denmark, Indonesia, Malaysia, and the United States.[87] Around the world, many other countries have now launched biodiesel programmes, using a wide range of different feedstocks, from cassava to used cooking oil.

There were only about 75 million gallons of biodiesel produced in 2005 in the United States, just a tiny fraction of the 38 billion gallons of diesel produced and compared with the 67 billion gallons of diesel fuel consumed annually in the United States. Still, that was three times the biodiesel produced in 2004 and the production is expected to at least double again this year. There are presently more than fifty-three companies that have invested millions of dollars into the development of biodiesel manufacturing plants and are actively marketing biodiesel in the United States. The question of available biodiesel production capacity must be answered in two parts. First, there is dedicated production capacity, which relates to the capacity of U.S. plants that produce nothing but biodiesel. In addition to dedicated production capacity, there is available production capacity for biodiesel within the oleochemical industry. Current dedicated and oleochemical production capacity is estimated to be 354 million gallons per year. Thirty-five companies have reported that their plants are currently under construction (January 2006) and are scheduled to be completed within the next 18 months. Their combined capacity, if realized, would result in another 278 million gallons per year of biodiesel production.[88] A federal tax incentive, state legislation and a diesel shortage are all contributing to a rise in demand.

In Brazil a 2% biodiesel blend will become mandatory in 2008. In addition to developing soya, investments are also being made to develop production from castorseed, in particular in the poorer semiarid north-east of the country.

Malaysia, the world's biggest producer of palm oil, is developing a biodiesel industry, as are Indonesia and the Philippines. The first two countries will also supply palm oil to new plants in Singapore, from where biodiesel will be exported. The obligation in India to mix 5% biodiesel with normal diesel is expected to create an immediate demand of 2.5 million tones of biodiesel, which may increase to 16 million tonnes if the mix is to achieve the target of 20% in 2020. Fiji is keen to replace 10% of its diesel fuel imports with coconut oil from local copra production.[89]

Developing countries such as Malaysia, Indonesia and the Philippines, that currently produce biodiesel for their domestic markets, could well develop export potential.

In 2003, share of biodiesel in world motor gasoline use amounted to 0.2% (EU:1%).[90]

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[87] *Renewables 2005 – Global Status Report,*
http://www.worldwatch.org/brain/media/pdf/pubs/ren21/ren21-2.pdf

[88] *U.S. Biodiesel Production Capacity*
http://www.biodiesel.org/pdf_files/fuelfactsheets/Production_Capacity.pdf

[89] *An EU Strategy for Biofuels, 2006,*
http://europa.eu.int/comm/agriculture/biomass/biofuel/com2006_34_en.pdf

[90] *Drivers for an International Biofuel Market, December 2005,*
http://www.clingendael.nl/publications/2005/20051209_ciep_misc_biofuelsmarket.pdf

5.2.2.3 Global Biomethanol Developments and Market Potential

Methanol, also known as wood alcohol, can be used to fuel flexible fuel vehicles, and since it is rich in hydrogen and has physical characteristics similar to gasoline, can also be used as a hydrogen carrier fuel to power fuel cell vehicles.

According to the American Methanol Institute[91], biomass production of methanol may begin where the cost of producing the fuel is offset by other benefits. Municipal solid waste disposal and sewage disposal both meet the criteria. Landfill methane and sewage processing accounts for about 11% of all methane released by the United States into the atmosphere. Currently most landfill methane is vented into the air. If landfill materials were processed through methanol manufacturing facilities, then this contribution to global warming would stop.

Methanol can also be made by gasifying dried sewage sludge. Such a facility is already being operated in Berlin by the SVZ subsidiary (Sekundarrohstoff -Verwertungszentrum) of Berliner Wasser Betriebe, German's largest water supply and sewage disposal company.

Gasification of municipal solid waste offers the same kind of opportunity, and also has been under active development. This has a wide variety of potential applications, of which processing landfilled waste into fuel is one. The Hynol process for methanol production has been tested at the University of California at Riverside. Biomass processing tests included local energy crops, municipal wastes, sewage sludge, landfill gas, and waste wood.

Recent technology developments are making renewable methanol a more economically attractive alternative. In Columbus, Ohio, a methanol production plant is being built on a landfill using landfill methane gas. In Southern Utah hog manure is run through a digester to produce methane gas for methanol production. A company in Frederick, Maryland, has developed a process to produce methanol from sugar beets. In Japan, a power company is collecting driftwood to produce methanol, and another company is using rice straw in a pilot methanol plant. In Sweden, black liquor from a paper mill is gasified to make methanol. And in Germany, 1.5 tons of mark notes are shredded each day and turned into methanol.[92]

A study of a patented Swedish technology[93] concluded that the alcohol fuel methanol can be produced from biomass via black liquor gasification at a cost competitive with that of gasoline and diesel.

The world production of black liquor comprises some 600 TWh/year, however a few countries dominate the production – USA, Canada, Japan, Brazil and in Europe, Finland and Sweden. These countries have a substantial potential for possible biomass-based methanol or DME production to be utilised at the mills. Although ready available, however today with considerable capital already invested in existing recovery boilers. Nevertheless, the market potential is ample and credible as the pulp & paper industry is capital-strong and structured around large concentrated plants simplifying logistics and gaining scale-economics. Economically, the industry comprises mainly nationally-based companies although with a merger trend for internationalisation and globalisation as new markets appear. Technically, in principle, all plants could be fitted with a BLGMF plant when the process technology has become successfully demonstrated and commercially available.[94]

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[91] *The Promise of Methanol Fuel Cell Vehicles,*
http://www.methanol.org/pdfFrame.cfm?pdf=amipromise.pdf

[92] *Methanol Transportation Fuels: A Look Back and a Look Forward, September 2005,*
http://www.methanol.org/pdfFrame.cfm?pdf=MIPaperforISAF.pdf

[93] *Technical and Commercial Feasibility Study of Black Liquor Gasification with Methanol/DME Production as Motor Fuels for Automotive Uses – BLGMF, December 2003*
http://www.nykomb.se/pdf/BLGMF.pdf

[94] ibid

For the whole European Union as much as 61 TWh or some 11 million tonnes of methanol could be produced each year. This may be compared with current total consumption of motor fuels for the road transport sector and a calculated maximum replacement percentage (on energy basis) for each country. Finland could replace more than 50% of all transport fuels consumed, Sweden and Portugal nearly 30% and 10% respectively.
In absolute terms, Sweden and Finland could produce about 4 million tonnes each, a substantial amount. Thus, the production potential in the European Union is concentrated to a few countries, which have a large potential and for Sweden and Finland extremely high replacement potential.[95]

USA has the world's largest methanol potential by amount, but not with replacement percentage. Potentially, a staggering 28 million tonnes of methanol could be produced. Astonishingly, this already equals today's world methanol production from mainly natural gas based plants, which are all commercial and can be of 5000 t/d or more. However, just the US national petrol consumption totals the equivalent of 1000 million tonnes of methanol or 21 500 PJ. The resulting possible potential replacement is about 2.2% if also the diesel fuel oil consumption would be accounted for.[96]

In a report titled *Looking Beyond the Internal Combustion Engine: The Promise of Methanol Fuel Cell Vehicles,*[97] the Methanol Institute estimated that by 2020, the worldwide fleet of fuel cell vehicles could reach 35 million cars and buses, creating a demand for 15.4 billion gallons of methanol annually (roughly 135% of current world capacity).

6. International Opportunities for Canadian Biomass Companies

The Canadian Trade Commissioner Service website and Industry Canada Strategis website offer market briefs on international market opportunities for Canadian companies. The following reports are dealing with opportunities in the bioenergy and biofuels sectors in different countries.

6.1. Asia & Australia

Renewable Energy – India, 08/29/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr119847e.html

Sub-sectors of bioenergy that continue to show a high growth rate and are expected to drive the RE market are briefly discussed below:

Biomass Energy and Cogeneration: Conservative estimates indicate that even with the present utilization pattern of crop and plantation residues and by using only the surplus biomass materials, estimated at about 150 million tons, about 17,000 MW of distributed power could be generated.

India is the largest producer of cane sugar and the energy potential from cogeneration is estimated at 19,500 MW, which comprises around 3,500 MW of surplus power from bagasse-based cogeneration, and 16,000 MW of grid quality power from surplus biomass material. Notable initiatives for acceleration of the biomass power generation program include granting

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[95] *Technical and Commercial Feasibility Study of Black Liquor Gasification with Methanol/DME Production as Motor Fuels for Automotive Uses – BLGMF, December 2003*
http://www.nykomb.se/pdf/BLGMF.pdf

[96] ibid

[97] *Looking Beyond the Internal Combustion Engine: The Promise of Methanol Fuel Cell Vehicles,*
http://www.methanol.org/pdfFrame.cfm?pdf=amipromise.pdf

interest subsidy, concessional customs duties, exemptions from excise duty and sales tax, 100 percent corporate income tax holidays, accelerated depreciation, and soft loans for commercial biomass-fired power projects.

Energy from Wastes: Good potential exists for generating approximately 15,000 MW of power from urban and municipal wastes and approximately 100 MW from industrial wastes in India.

Biofuels: the government requires blending of fuel ethanol in diesel through out India causing a significant demand for ethanol. This demand growth creates a tremendous manufacturing opportunity for the U.S. fuel ethanol industry seeking to expand its investments internationally. A substantial import of fuel ethanol will be necessary to supply the product required to meet the burgeoning demand created by the currently effective GOI mandate.

Other potential biomass-derived liquid fuels produced and used in India consist of edible and non-edible oils such as Jatropha Curcas, Karanje and Honge. The enormous potential of bio-diesel, on the other hand, is yet to be realized in India but there is already excitement in the air. Indian railways will initially employ around 5%, with this figure rising to 20% throughout the year. Indian Railways is the second largest rail operator in the world, with over 4000 locomotives. Therefore, there is enormous opportunity for U.S. biodiesel suppliers to explore the Indian market.

There are many business opportunities in different environmental market segments for foreign companies. In particular, many of the Indian companies are seeking joint ventures and licensing arrangements with foreign companies. The estimated number of foreign collaborations in the environment goods sector is about 200.

Biomass Industries Profile – Japan, January 2005
http://www.infoexport.gc.ca/vtc/DisplayDocument.jsp?showDocsForAllCountries=&showDocsForAllPreselectedCountries=&showDocsForAllWorldCountries=true&did=50961

Japan requires a number of sophisticated and cost-effective methods to fully develop its biomass capacity. Both large-scale and small-scale technologies are needed in both the private and public sectors.

According to market research organization International Business Strategies, opportunities exist to supply the following:

- energy-efficient technology to produce methane gas from livestock waste through fermentation,
- energy-efficient technology to produce bio-diesel fuel from cooking oil waste through esterification,
- gasification of biomass materials for power generation or liquid fuel production,
- production of ethanol from starch, and
- production of ethanol from wood-product waste or unused wood products through saccharification

see also: Biomass Energy– Japan, 10/01/2003,
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr109628e.html

Japan: Biomass Market Overview and Opportunities – July 2005, U.S. Commercial Service
http://www.export.gov/comm_svc/market_research/market_research_japan.html

Best Prospects

There are a number of examples of biomass technology imports from European countries which have long used biomass energy ago, particularly in the field of methane fermentation, methane refining and power generation with biomass gasification, etc. However, Japan does not need heat for district heat supply systems in Japan, as compared to European countries. Consequently, Japan needs more energy-efficient power generation systems, such as gasifie power generation systems that are high in electric energy efficiency even when used in small scale systems, such as co-firing of biomass and coal, or liquefied biomass fuel. These technologies would need to be developed and demonstrated for years to come. U.S. companies with expertise for these technologies will have good opportunities for participating in the Japanese biomass energy market.

Environmental Industries Sector Profile - Malaysia, March 2005
http://www.infoexport.gc.ca/vtc/DisplayDocument.jsp?showDocsForAllCountries=&showDocsForAllPreselectedCountries=true&showDocsForAllWorldCountries=&did=27354

Opportunities for Canadian firms exist in projects or plans to:

- develop biomass as a renewable source of energy, mostly using oil palm waste;
- supply recycling and incineration technologies for municipal solid waste;

Given the tremendous potential in the conversion of biomass waste to energy, opportunities in this sector come from equipment related to direct combustion (i.e. incineration), which is the simplest and the most common method of releasing the energy contained within biomass. Boilers and furnaces, steam turbines and generators are the typical requirements in conventional power generation plants, along with fuel storage, handling equipment, and environmental control systems.

In addition, the treatment of palm oil mill effluent (POME) can bring about biogas and sludge that can be used as alternative fuel and fertilizer, respectively. Equipment that is related to such treatment is in demand, and includes closed tank anaerobic digesters, pressure vessels, gas compressors, and scrubbers.

Aside from the palm oil sector, the timber and rubber manufacturing sectors would be likely end-users for biomass waste-to-energy projects.

New and Renewable Energy – South Korea, January 2006
http://www.infoexport.gc.ca/vtc/DisplayDocument.jsp?showDocsForAllCountries=&showDocsForAllPreselectedCountries=true&showDocsForAllWorldCountries=&did=61559

South Korea imports most of its new and renewable energy (NRE) related equipment. With the Renewable Portofolio Agreement (RPA) in effect, financial support for the construction of additional NRE facilities will increase which will result in more opportunities for Canadian suppliers of NRE equipment and services.

Green Electricity Market – Australia, 08/05/2002
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr112064e.html

There is some local production for the equipment used for biomass projects. However, the majority is imported for projects like sugar mill bagasse conversion to electricity. Equipment is also imported for the Green Power developed from sewage waste from biomass, which is converted into electricity at landfill sites.
The majority of equipment used to generate Green Power in Australia is imported from the UK, the U.S., Denmark, Sweden, Canada, Japan, Korea, Germany, and the Netherlands.

6.2. North America

Renewable Energy and Alternative Fuels Technology in Mexico, August 2005
http://www.infoexport.gc.ca/vtc/DisplayDocument.jsp?showDocsForAllCountries=&showDocsForAllPreselectedCountries=true&showDocsForAllWorldCountries=&did=57774

Renewable energy (biomass, biogas, solar, water and wind) and alternative fuels (electricity, ethanol and biodiesel) technologies could be worth $2.6 billion by 2015.
The most prominent opportunities for exporters of equipment to generate renewable energy and alternative fuels come from small-scale hydroelectric projects, solar-photovoltaic (PV) systems, wind power, and waste-to-energy systems (biogas, biomass and biodiesel)
The Mexican market for renewable energy and alternative fuels offers substantial opportunity for the export of Canadian environmental technologies, as well as Canadian foreign direct investment.

Opportunites in the Waste-To-Energy sector:

- Canadian firms may find opportunities to sell their biogas/landfill gas technologies to Mexican municipalities or Mexican firms
- Canadian gasification and Liquification technologies may find a large market for the efficient and cost-effective production of biogas for electricity.
- large-scale Canadian fermentation technologies for the production of ethanol from bagasse and surplus corn crops might find a welcome market. At least two, 60 million gallon ethanol plants are scheduled to be constructed in the next two to three years: one in Guadalajara and another in the state of Hildalgo, near Mexico City.
- Canadian firms may find opportunities to export technologies to convert waste bio-oils originating from Mexico’s restaurant and food industries into biodiesel for use in the modified personal and transport vehicles.
- The North American Development Bank (NADB)’s Project Development Program provides grants to Canadian, Mexican and U.S. firms that establish environmental infrastructure projects. Projects, such as small-scale biomass and biogas production facilities, that develop alternative fuels and renewable energies along the Mexican-U.S. border are an important priority for the NADB, and may receive project funding.

6.3. Europe

Renewables in Russia - From Opportunity to Reality - IEA, 2003
http://www.iea.org/textbase/nppdf/free/2000/renewrus_2003.pdf

The use of biomass and waste for combined electricity and heat generation is commercially viable in many Russian regions. Agricultural, municipal and industrial wastes are currently underused for energy production. Economically exploiting these resources using currently available modern technologies could bring numerous economic benefits to industries and municipalities. It would solve the problem of waste treatment and would improve energy efficiency. Using wood to produce energy is particularly attractive in the north and north-west of the European part of Russia.

In Russia's north-west regions, the forestry and pulp and paper industries are very important. The northwest produces 60% of the country's paper. Forestry and pulp and paper industries are large potential suppliers of biomass wastes to power generation companies and to local utilities. They are also big potential users of biofuels for their own energy purposes. The pulp and paper industry in Russia relies on biofuels to meet only some 20-30% of its energy needs. In Europe, the pulp and paper industry relies on biofuels for 52%.16 Increasing the share of biofuels would increase the reliability of electricity and heat supply to the pulp and paper industry. It could also reduce costs.

Conversion of coal- or oil-fired district heating boilers to burn biomass fuels (especially wood wastes) is another costeffective application, especially in cases where Russian consumers face unsubsidized heavy fuel oil and coal prices. Small and medium-sized boilers have already been converted to biomass use in Estonia, Latvia, Lithuania and some regions of Russia. Simple payback time for these conversions has been around 3-5 years, and positive financial returns have been demonstrated. The most favorable regions for this market are Leningrad, Karelia, Vologda, Novgorod, Maritime and Khabarovsk.

Most rural settlements in Russia have no centralized heat supply, so some 12.6 million houses are heated by burning wood, peat or coal. Families spend a significant part of their income and/or their time to provide fuel for winter. In-door burning of wood is often inefficient and harmful to human health and the environment. These rural areas represent a vast potential market for modern technologies for small-scale (individual) heat and hot water production from biomass (agricultural and municipal wastes and wood) and also for individual solar collectors.

Biofuels – Poland, 05/05/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr109822e.html

Currently the best prospects in Poland are for companies offering technology and expertise in the production of bio-ethanol, (dehydrated alcohol made of grain, patatoes, malt), as well as of plant oils (rapeseed). Companies offering complete solutions and assistance in obtaining favorable credit lines will enjoy a competitive advantage.

Ukraine Ethanol Market Potential and Demand for Molecular Sieve Technology, 08/15/2002
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr107372e.html

There is growing demand for ethanol as a renewable fuel, both for sale in Ukraine's domestic market and for export to European countries. To improve efficiency, producers need to retrofit with molecular sieve technology

Renewable Energy – Hungary, 07/31/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr110227e.html

The market for development of renewable energy sources should grow strongly in coming years, which should create good opportunities for the US equipment manufacturers and service providers as well as investors in this industry. According to the Hungarian energy office, the forms of renewable energy production with the best prospects for success are wind and biomass fuels.

Waste to Energy Equipment and Projects – Hungary, 03/05/2004
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr118875e.html

In the area of renewable energy, Hungary has committed to double its reliance on renewable energy sources from the current 3.6% to 7.2% of total energy usage by 2010. The two areas with the highest growth potential in the waste-to-energy sector are biomass and municipal/hazardous waste.

Czech Republic: Waste-To-Energy and Renewable Energy, 02/18/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr110087e.html

As the Czech Republic moves toward EU accession, it is also paying closer attention to the diversity and security of their energy resources. As a result, it is relying less on imported oil and gas, while seeking more efficient utilization of its energy resources. Most electric power end-users will also be able to purchase the power from third parties. These market pressures combined with low labor costs are aiding the development and creation of a waste-to- energy and renewable energy industry that is expected to become an important player in each country and the region as a whole.

This new energy industry includes the development of a new biomass resource supply chain that incorporates the production of energy crops and a new fuel processing industry. The fuel processing system includes the production of biogas, liquid biofuel, biomass pellets, and new technologies for clean electric power and heat generation. Technologies are also needed for converting biomass to biodiesel and other transportation fuels or additives. An open issue is whether allowances will be provided for combustion of fuel produced from waste

Physical, thermal, chemical, and biological waste to energy technologies are the best prospects over the next few years, especially process that reduce the volume and/or hazardous nature of waste. Technologies that also facilitate waste handling and/or enhance its recovery will also be in demand. This is a change from the past when the focus was on simple landfilling.

Environmental Technologies: Renewable Energy – Czech Republic, 06/12/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr115019e.html

In the EU wind and biomass are expected to be the largest sources of renewable energy. In the Czech Republic biomass has best prospects. Czech Republic is at the beginning with biomass use. Phytofuel market has not been developed in all areas yet. On the other hand biomass is the most perspective alternate energy source in the Czech Republic (see table 1). There are various sources of biomass: wood processing industry, growing agricultural plants, agricultural waste, industrial and municipal activities. Environmental impacts and the use of waste materials make biomass even more interesting.

Recently state has started to support energetic use of biomass through grants but those are still very low compared to EU countries. Farmers may receive $200/1 ha per year if they grow energetic plant on 5% - 10% of their land.

The price of the installation of boiler rooms is the biggest obstacle for biomass use expansion. Most of already installed biomass boiler rooms received grants and state support

Renewable Energy Generation, Transmission and Distribution Upgrade Opportunities – Slovakia, 09/11/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr109396e.html

Combined Power and Heat
The possibility for combined power and heat (CPH) production is an important advantage of district heating. Gradual liberalization of the market significantly change the conditions of energy supply. Fuel and energy represent substantial costs in the energy sector. The importance of low cost energy sources with low environmental impacts is vital. Main barriers of CHP are a distortion of natural gas prices, thus providing an advantage to individual gas boilers in comparison to district heating and CHP plants. District heating and CHP are the most efficient energy source with the lowest prices for consumers. The total installed capacity of large CHP plants for industrial companies represents 8300 MW thermal and 750 MW electric output. In 2000 approx. 3,200 GWh of electricity was produced and more than 70PJ of heat was supplied to district heating systems.

In 2000 more than 33 small cogeneration units were in operation with a total electric capacity of more than 16.9 MW in Slovakia. This produced approximately 59.15 GWh (it is 0.24 percent of total annual electricity consumption - 28.3 TWh). Seventy percent of electricity output covers own consumption with the rest supplied to the grid. In 2010, the potential for 320 MW in households and service sectors and 480 MW in industry is a possibility. Combined Power and Heat (CPH) in district heating plants can be optimally used for electricity production during the winter months. There is still potential to increase the use of biofuel for CPH in municipal systems.

CPU is mostly used by large companies that have their own high-energy consumption. U.S. energy companies to deliver the knowledge and services needed to transform this waste energy for Slovak users.

Waste to Energy
The annual volume of communal waste is approximately 316 kg per capita, which makes the total annual volume of 1,7 million tons of waste. 58 percent of the communal waste contains organic waste, wastes from paper and fabric and plastic wrapper which can be used as fuel. One ton of communal waste produces about of 1,7 - 1,9 MWh in the form of warm water or steam. In 2000 Slovakia burned 204,290 ton of communal waste for energy purposes. That represents12 percent of the total municipal waste.

Currently in operation there are two municipal waste incineration plants with a total capacity of 220,000 ton / year which is equivalent to 1,145 TJ.

Both plants are highly profitable and there are good opportunities for U.S. companies to export equipment and services in this sector.

Biomass
Presently, only 11,491 TJ (3,192 GWh) / year is used from biomass. Biomass represents the largest potential of renewable energy in the world. In Slovakia, available biomass energy compromises a volume of 48,967 TJ (13,602GWh) /year. It is comprised of materials of plant and animal origin fit for energy uses. Biomass is considered to be a CO2 neutral fuel, as only as much CO2 is released for its burning as by the plant during its growth. Low cost biomasses available are forest biomass (firewood, branches, stumps, roots, bark, saw dust), agricultural biomass (cereal and rape straw, hemp, animal excreta, wastes), wood working industry wastes (trim, chips, saw dust) and municipal refuse (solid combustible waste, landfill gas, sludge gas). Despite the extensive use of forestry wastes for energy production, it is estimated that only 10 percent of this resource is currently being used. Significant amounts of forestry biomass could potentially be used to generate electricity on a large scale, or supply heat for residential and industrial needs. The continued growth of biomass use is closely connected with the future of nuclear power in Slovakia. A continued phase-out of nuclear power will require a broad introduction of natural gas

into Slovakia in order to generate sufficient quantities of both electricity and heat. Biofuels do not currently have the potential to generate electricity on a such large scale at competitive prices. Expansion of natural gas use would decrease investments in biofuel equipment, primarily in the district heating sector.

Currently, a biogas-based power plant located in the municipality of Batka runs on farm animal excrement. Several waste treatment plants in Banska Bystrica use sludge gas to generate electricity. Presently only Slovenske elektrarne a.s., www.seas.sk along with research institute VUJE Trnava, a.s, www.vuje.sk suppors t the research into the use of biomass for cogeneration. Receivable will be the implementation of a model source in a selected site close to biomass energy resource.

The biomass shows good potential for U.S. exporters of technology that process biomass and for consultancy services offering this service to Slovak companies.

Guide to the Bulgarian Energy Market, 08/30/2004

http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr126512e.html

According to the PHARE Project Report data, the renewable energy sources (RES) potential is evaluated to 14387 J/year for geothermal energy; 77156,7 J/year for solid agricultural waste; 478,4 J/year – biomass from paper waste; 9605,2 J/year –biomass from wood for heating; 79,8 J/year –biomass from natural fibers; 11381,83 J/year –liquid agricultural waste; 25766 GWh/year – big and small HPS; 1450-1500 kWh/m year – solar radiation. The geothermal and wind energy sector's potential is considered the highest, while larger-scale utilization of solar and biomass energy may also be attractive as soon as the government develops its subsidy program and conventional energy prices continue to increase.

The national program on RES in Bulgaria for 2002-2010 includes best prospects for the following bioenergy equipment.

Biomass installations	374.3 USD million
Biogas and Natural Gas installations	244.3 USD million

The applications for biomass can be grouped into the following main market segments:

A) substitution of part of the fossil fuels in existing district heating schemes (wood chips),
B) enhanced uses of biomass as industrial fuels (wood chips and logs as industrial fuel for steam or hot water boilers) instead of oil,
C) improved uses of biomass for new district heating schemes for small towns and villages near the resources, in the countryside, where the population has no access to central co-generation or gas supply,
D) uses of straw and other agricultural by-products in appropriate biomass boilers for heat supply of farms and small villages (in the medium term).

Renewable Energy – Sweden, 01/30/2003

http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr113837e.html

Due to the strong forest industry, Sweden is one of the top EU countries when it comes to using wood fuels. The main users for wood fuels are forest industry and the Combined Power and Heat plants in District Heating. The forest industry uses its own by-products such as black liquor and refuse, while the wood fuels used in DH include even processed fuels like pellets and briquettes. Commercial import of biofuels has increased in the recent years, and according to industry sources, consist today of wood fuels, salvaged wood, unrefined tall oil and peat, and processed

wood fuels such as briquettes and pellets. U.S. exports only small amounts of processed wood fuels to Sweden.
If the current conditions favoring biofuels remain, consumption could double during the next 20 years, whereby biofuels would constitute 35-40 percent of the total energy supply. The growth would come primarily from the conversion of heating systems.

Biofuels play an increasingly important role in the Swedish energy system. They now contribute almost a fifth of the overall energy supply, and their expanded use is a cornerstone in the government's plan for a sustainable energy system. Sweden has, with its large forest industry and rich farmlands, a large supply of residual biomass-products that can be processed into biofuels. The government is also faced with a set of environmental goals that essentially require an expanded use of biofuels. The phase-out of nuclear power has begun and Sweden has committed itself to lower its emissions of greenhouse gases. The renewable and carbon dioxide-neutral biofuels have thus emerged as a promising alternative source of energy.

Energy Brief – Sweden, 02/25/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr114453e.html

The share of biofuels in the overall energy supply in Sweden is 15 percent, which is higher than in any other EU country. The factors contributing to the high use of biofuels are good availability of forests, an efficient forest products industry and wide existence of district heating systems. In 2001, over 97 TWh was consumed in the following sectors: the forest products industry (51 TWh), district heating (31 TWh), the single-family house sector (10 TWh) and electricity production (5 TWh). If the current conditions favoring biofuels remain, consumption could double during the next 20 years, whereby biofuels would constitute 35-40 percent of the total energy supply. The growth will come primarily from the conversion of heating systems.

The biofuels used in Sweden can be grouped into five categories:

- digester liquors from pulp mills (e.g. crude tall oil)
- wood fuels (logs, bark, sawdust and energy plantations)
- refuse
- peat
- field fuels (straw and energy grasses)

Most of the biofuels used in the forest products industry (including the cellulose and sawmill industries) are by-products from various manufacturing processes and are used for economic reasons to produce heat and electricity. Subsequently, these fuels never reach the market but are consumed within the industries.

The second largest users for biofuels are the district heating plants. The use of wood fuels has more than quadrupled since 1990, and consumption can reach 38 TWh by 2010. The expanded use of district heating is a major target in the government's electricity conservation plan outlined in the Sustainable Energy Supply proposition.

The district heating sector is the principal consumer of imported biofuels, and 28 percent of the total supply comes from import. Processed wood fuels such as wood pellet and briquettes dominate, and a total of 270,000 tons of pellets are imported annually. Because many of the boilers in the district heating plants are converted coal or oil boilers, they require the more expensive processed wood fuels. The use of unprocessed and cheaper wood fuels such as chips are likely to increase as plants install new boilers adapted for such fuels.

The single-family home sector is the third largest biofuel user, with consumption totaling 10 TWh. The consumers are still mainly farms and rural houses using firewood. The use of biofuel in the residential sector is expected to increase, and move towards more processed forms of biofuel, such as wood pellets and briquettes.

In 2001, the Swedish Energy Agency initiated a project called 'Safe Heat from Pellets for Single-Family Houses', aiming to increase the use of biofuels by informing consumers of the environmental and financial advantages of biofuel use, and making it easier to install the necessary equipment for pellet heating. Currently there are three Swedish regions involved in the project.

The continued growth of biofuel use is, however, intimately connected with the future of nuclear power in Sweden. A continued phase-out will require a broad introduction of natural gas into Sweden in order to generate sufficient quantities of both electricity and heat. Biofuels do not currently have the potential to generate electricity on a large scale at competitive prices. An expansion of natural gas networks would thus sideline investments in biofuel equipment, primarily in the district-heating sector.

Renewable Energy Markets – Portugal, 08/14/2002
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr112000e.html

New technologies related to non-polluting energies and also renewable energies, among others, are leading the increase in demand. These innovations should be considered a best prospect for both domestic and international companies. Key sectors include: solar energy, wind energy, biomass, and even geo-thermal from ocean wave activity.

Overview of the Spanish Environmental Market, 07/08/2004
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr118766e.html

Biomass is one of the basic necessities that needs to be developed in Spain. The Renewable Energy National Plan requires that this type of energy be used within a short period of time, given that it is extremely important for the energy development of the country. It is expected to reach 1,800 MW, although current trends will not reach 500 MW

It is necessary to note that the government requires companies to deal with their waste, which creates a strong potential market for those that use waste to produce energy.

The city councils and authorities have encouraged the use of this type of energy. An example is the Cuellar plant, in which agriculture waste (wooden containers, pineapple rind, bark) creates energy with a budget of 1.6 million dollars. Furthermore, this project has had strong funding from the autonomous community of Castilla y León.

Renewable Energy Resources – France, 03/17/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr111886e.html

The implementation of a plan called “*Bois-Energie 2000-2006*” demonstrates France’s recognition of wood biomass as an essential power supply. This program established a wood energy goal of 20 MW over 7 years, which equates to 700kW per year per department in France, with the expectation that the number of currently installed wood burners in homes and offices would have to be doubled.

French government authorities have decided to completely eliminate waste stations that until now had been used to store urban and household waste. Around 60 percent of this household waste is combustible and can be processed to generate electricity (the incineration of one ton of waste can produce between 300 to 500kWh), or even to directly produce household heating. The recycling of urban waste is one of EDF's development policies, in order to produce not only electricity, but also steam and methane. Through its specialized subsidiaries, EDF provides municipalities with its services in the elimination of household wastes. In 1999, TIRU (Industrial Treatment of Urban Wastes) had already generated 165 GWh and 4 million tons of steam by incinerating the household wastes of the Paris region.

Biogas is the gas produced in landfills by the fermentation of household waste. It is essentially a mixture of methane (45 percent to 65 percent), carbon dioxide (20 percent to 35 percent), and nitrogen. The necessary fermentation to produce biogas only takes between one and three weeks, and on average 500 m3 of methane are produced per ton of degraded matter. Additionally, the carbon dioxide released during the combustion of methane does not add to the "greenhouse effect". Although biogas is a valuable supply of energy, in terms of reaching the 21 percent required by the European Renewable Energy Directive, increasing biogas production is not a major trend for France. Nevertheless, actions have been taken to exploit this renewable energy source. In 1999, after issuing a call for tenders, EDF selected five installations to recover energy from biogas on the landfills at Hussigny (Meurthe-et-Moselle), Le Cannet (Alpes-Martimes), Ferrolles-Atilly (Seine-et-Marne), Sonzay (Indre-et-Loire) and Hersin-Coupigny (Pas-de-Calais). Despite these initiatives, 2001 statistics illustrate the minimal role played by biogas; of the 83 TWh produced that year, only 2.4 percent was obtained from urban waste biogas.

Renewable Energy – UK, 09/22/2003
http://strategis.ic.gc.ca/epic/internet/inimr-ri.nsf/en/gr110109e.html

Biofuels and Wastes:
Landfill gas is now recognized as an important resource (rather than simply as a potential hazard) and is being used to provide heat and electricity. The banning of dumping of sewage at sea has prompted investigation into other forms of sewage processing and disposal. Schemes are being set up in which sewage products can be processed to produce gases or liquids as fuels.
The EU Landfill Directive is restricting the amount of waste sent to landfills and increasing attention is being given to incineration with energy recovery. There is scope to develop environmentally acceptable incineration or other plant to obtain recoverable energy from the public waste stream. It is important that developments convince the public that incineration plants present absolutely minimal risk to human health or to the environment
Other projects, such as biomass installations, also have a variety of project developers and operators. Waste management companies, including Biffa Waste Management Services and United Utilities, produce energy from landfill gas schemes. Specialist developers of biomass projects use a variety of energy sources. In rural areas, schemes may use straw from cereal crops, farm slurry in dairy farming areas, poultry litter from chicken farms, short rotation coppiced woods (such as willow) and wood pellets from saw mills.