Canada Biomass-Bioenergy Report

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Doug Bradley
President
Climate Change Solutions
National Team Leader- IEA Bioenergy Task 40- Biotrade

402 Third Avenue · Ottawa, Ontario · Canada K1S 2K7
phone · 613.730.1999 email · douglas.bradley@rogers.com
web site · www.climatechangesolutions.net

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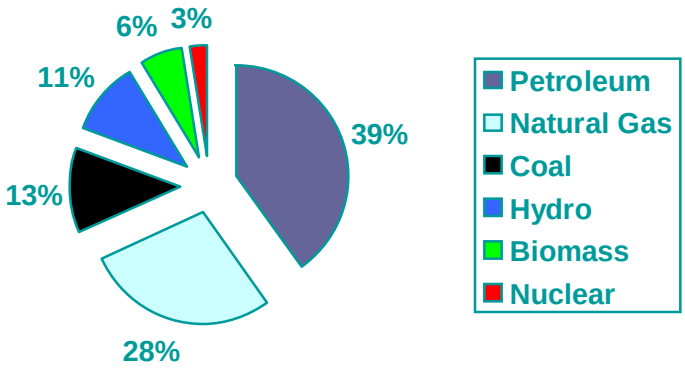
1. General Introduction

Canada is a country of 33 million people, primarily English speaking, but with French minority large enough to warrant being an officially bilingual nation. At over 9 million sq. km., it is the second largest country in the world after Russia. It stretches from the US in the south to above the Arctic Circle, and from the Pacific Ocean to the Atlantic Ocean. Canada is blessed with considerable natural resources including oil and gas, coal, hydro, minerals, and forests. Resources generally are not a federal jurisdiction but are the responsibility of the ten provinces.

Canada resembles the US in its market-oriented economic system, pattern of production, and affluent living standards. Growth of the manufacturing, mining, and service sectors has transformed the nation from a largely rural economy into an industrial, urban economy. Canada's GDP is $1.1 trillion (equivalent to €0.8 trillion).

Fig 1.1 illustrates that Canada is a nation rich in fossil fuel resources. In 2000, 39% of Canada's primary energy was from petroleum, 28% from natural gas and 13% from coal. 11% was from renewable hydropower, and only 6% from renewable biomass. Projections for the next couple of decades are for a biomass share of 6-9%[1].

Fig 1.1 Canadian Primary Energy by Source

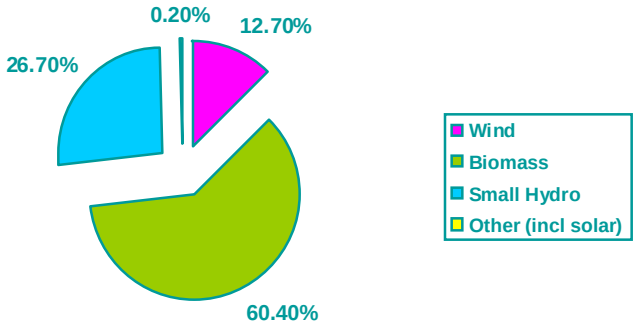


Canada has a large, well-developed forest sector and is one of the world's largest exporters of wood products. 402 million ha, or 44% of Canada's land area, is forested. 77% of forests are under provincial jurisdiction, 16% are federal, and 7% are privately owned. In 2002, 189 million M^3 of industrial roundwood was harvested on 972,000 ha, or 0.2% of total forest land[2]. The forest industry exported $39.6 billion in paper, pulp, lumber, board and other forest products in 2002, 80% to the US and 6% to the EU. The production of woody biomass is commensurate with production of forest goods.

[1] Peter Hall, Natural Resources Canada, Canadian Forest Service
[2] State of Canada's Forests 2003-04

In terms of renewable resources, as shown in Fig 1.2, over 60% of generating capacity from renewable resources is from biomass. Bioenergy production comes from a wide range of bio-based sources: combined heat and power, gasification, pyrolysis, landfill gas, ethanol from grain and cellulose.

Fig 1.2 Renewable Generating Capacity



2. Policy Setting

The energy world is changing and Canada is changing with it. The energy market now values a secure, reliable and safe supply, coupled with sustainable economic growth. The policy context has evolved as environmental awareness increased and the Kyoto Protocol influenced policy makers. Canada was one of the first countries to sign the Kyoto Protocol, in April 1998, and formal ratification came in December 2002. The government pledged that Canada would reduce its greenhouse gas emissions by 6% below 1990 levels by the 5-year commitment period of 2008-12. Canada's 2002 climate change plan committed the country to cut greenhouse gas emissions by 240 million tonnes a year by the end of 2012. It proposed a three-stage strategy to achieve that goal through a combination of incentives, regulations and tax measures.

Policy development on emissions reflects climate change, acid rain and harmful emissions. The federal government's main energy department is Natural Resources Canada, which is the primary source of public funding for bioenergy. Federal programs cover two key approaches: technology push, and market pull[3].

Technology push programs encompass basic research, applied R&D, demonstration and pre-commercialization. Funding of energy R&D is carried out in partnership with provinces, universities, the private sector and international organizations. The 2003 federal budget announced $30 million for bio-based technologies. Programs include:

- Basic Research
    - Support for BIOCAP research on bio-based products including bioenergy
    - Canadian Foundation for Innovation

[3] "Federal Climate Change Policy and Bioenergy"- Presentation by Nick Marty, Domestic Environment Policy Division, Natural Resources Canada- March 2004

- Applied R&D
    - Program of Energy Research and Development (PERD), approximately $5 million per year to support bioenergy R&D
- Demonstration
    - Sustainable Technology Development Canada- $350 million foundation focusing on climate change (includes non-biomass technologies)
- Pre-commercialization
    - RETScreen- pre-feasibility assessment tool

The federal government also has several market-pull programs in place to support utilization of bioenergy technologies. Tax related incentives include:

- Canadian Renewable and Conservation Expenses- flow through financing for early intangible project expenses
- Capital Cost Allowance 43.1- accelerated write-off for generation equipment
- Biofuels exemption from federal excise tax

Other bioenergy measures include:

- Renewable Energy Deployment Initiative (REDI)- Originally a 25% incentive toward purchase of certain biomass combustion systems, this program is being phased down to 15% and then 10% by the end of the REDI program in 2007.
- A one-time capital contribution of $78 million toward the construction of new ethanol capacity, announced in February 2004
- Incentives for industrial-scale biodiesel plants
- The Renewable Power Production Incentive (RPPI) announced in the 2005 federal budget is the newest and potentially most effective policy support for bioenergy. Designed to stimulate the installation of up to 1500 MW of renewable non-wind energy, when implemented it will pay 1¢ per KWh of production in the first 10 years of operation.

In addition, there are several initiatives for all renewable energies that encompass bioenergy. For example, a Large Final Emitters (LFE) emission trading system, pending implementation, sets target reductions for GHG emissions, which indirectly will support bioenergy. An offset trading system is being developed to complement the LFE system. The federal government has a commitment to purchase 20% of power from renewable sources. Canada now has national targets of 1.4 billion litres of ethanol and 500 million litres of renewable diesel by 2010 and this will help drive the market.

Although there are several federal programs in place to promote bioenergy as indicated above, consensus in the market place indicates that programs are directed only to small, specifically-targeted projects, and that prior to the proposed RPPI program there has been little meaningful support for commercial bioenergy capacity.

In early 2006, a new Conservative minority government was elected, ending the 12-year reign of the Liberals. In March 2006, the environment minister indicated that since ratifying Kyoto Canada's GHG emissions are up by 24%, a far cry from the commitment to achieve 6% below the 1990 levels. As such, the new government is reviewing all

policies of the former government including climate change. In the May 2 federal budget, $2 billion was earmarked for climate change, which is intended for developing new clean technologies, however the proposal have to be passed through Parliament.

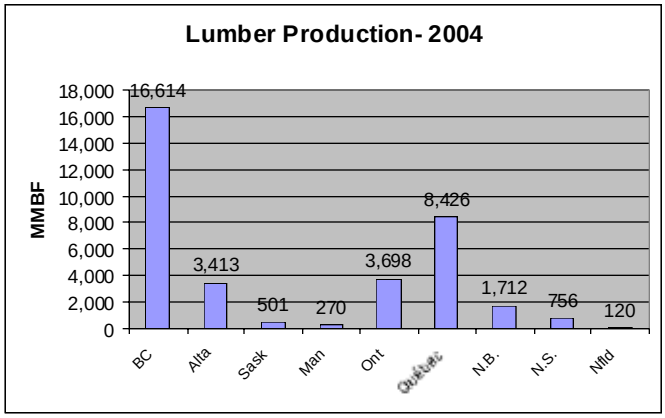
Initiatives are also happening at the provincial level. Several provinces have set Renewable Portfolio Standards (RPS) including BC, Alberta, Ontario and Nova Scotia, while New Brunswick and PEI are considering a RPS. Quebec has chosen a direct route to renewable energy by making specific requests for proposals for 1000 MW of wind power and 100 MW of biomass-based electricity. In 2006, Ontario announced that the Power Authority would purchase electricity produced by wind, biomass or small electric at a base price of 11¢/KWh. The intention is to add 1,000 MW of renewable energy over ten years.

3. Biomass Volumes

3.1. Woody Biomass

Canada is one of the world's largest pulp, paper and lumber producers. Total paper-grade wood pulp production exceeds 27 million tonnes annually. In 2004 lumber production was 35,510 million board feet (MMfbm). As shown in Fig 2.1, 16, 614 MMfbm, almost 50%, was produced in the province of British Columbia (BC), 24% was produced in Quebec and 10% in Ontario. From its pulp mills and sawmills, the forest products industry produces woody biomass as a bi-product, including bark, sawdust and shavings.

Fig. 2.1 Lumber Production in Canada- 2004



To reduce the cost of using fossil fuels, pulp mills and sawmills have increasingly been using woody biomass to produce heat for dry kilns and mill processes and power for internal usage and to feed into the grid. Independent cogeneration companies have been buying excess mill residues to produce heat for steam hosts and power for the grid. As a result, surpluses of mill residue have been declining. In June 2005 a survey was completed to determine the amount of mill surpluses, including hog fuel. The results of

this survey were combined into a single study released by sponsors Natural Resources Canada and The Forest Products Association of Canada in August 2005[4].

3.1.1. Annual Residue Production:

As shown in Table 2.1, Canadian pulp mills and sawmills produced over 21 million bone-dry tonnes (BDt, equivalent to oven dry tonnes) of bark, sawdust and shavings. Major producers were BC, Quebec, Ontario and Alberta. The table shows that at the end of 2004 there were considerable surpluses remaining in Western Canada (BC to Saskatchewan), while in Eastern Canada surpluses have mostly disappeared. Overall Canada had a surplus of 2.7 million BDt, of which 1.8 million tonnes were in BC alone.

As of May 2006, some of the BC surplus has been committed, with startup of two large cogen facilities, and the approval of a large pellet plant. The surplus is estimated to have fallen from 1.8 to 1.3 M BDt.

Table 2.1 Mill Residue Inventory

	Residue Production	Residue Surplus	Bark Piles
	000 BDt pa	000 BDt pa	000 BDt
Province			
BC	6,554	1,815	
Alberta	2,406	481	
Saskatchewan	580	164	2,900
Manitoba	225	13	
Ontario	2,602	121	6,712
Quebec	6,669	100	5,652
New Brunswick	1,373	0	257
Nova Scotia	601	13	148
PEI	24	1	0
Nfld & Labrador	195	30	19
Total	21,229	2,738	15,688

3.1.2. Existing Hog Fuel Piles:

In BC, Alberta and Manitoba the approved method of residue disposal is incineration. In the other provinces, traditionally excess hog (bark and sawdust) not used by sawmills or pulp mills is simply piled up on the mill site. Until recently, bark/hog fuel piles were considered an environmental problem, not a revenue source. Many piles were considered too contaminated, or moisture contents were considered too high for energy use. With annual residue production almost completely committed, companies are looking at hog piles with renewed interest. Some are experimenting with methods to remove contaminants, or mixing wet hog fuel with drier residues to produce a fuel with a low average moisture content.

[4] "Estimated Production, Consumption and Surplus Mill Residues in Eastern Canada- 2004" Natural Resources Canada and Forest Products Association of Canada- Authors Doug Bradley (Climate Change Solutions) and Brian McCloy (BW McCloy and Associates Inc).

As shown in Table 2.1 above, hog fuel piles identified and available for energy in Canada are estimated at 15.7 billion BDt. Some companies assessed the usable portion of bark piles at 90-100%. Other companies estimated that only 50% was usable for energy, either due to the level of deterioration, or simply to be conservative. It is quite possible that much more can be recoverable.

3.1.3. BC Pulp Chips:

BC is currently incurring a massive infestation of Mountain Pine Beetle (MPB), a pest that attacks mature pine trees that have thick bark. The MPB population has undergone an unprecedented explosion in BC, spreading from 25,000 hectares (ha) in 1994 to over 7 million ha in 2004[5]. Of this area, 26% suffered moderate mortality and 11% suffered severe mortality[6]. The estimated dead timber in 2004 as a result of the outbreak is 170 million M^3 [7]. The annual kill is projected to peak in 2008 at 70 million M^3 with over 450 million M^3 projected to be killed by this time[8]. The outbreak may last for 10 years and kill 80% of merchantable pine

In response, the BC government has increased the annual allowable cut (AAC) to allow the capture of economic value from dead trees in a way that maintains the highest environmental standards possible, speeds up regeneration, and restores the productivity of impacted forests. Without harvesting vast amounts of forest would be lost, either to fire or decay. The AAC is to increase by 27% in three north-central BC timber supply areas. The overall BC harvest is estimated to inflate from 38 million M^3 in 2000 to 50 million M^3 in 2006 and will remain at that level for 10 years. The result so far has been a 25% increase in lumber production and a glut of pulp chips on the market. The annual surplus is estimated at 500,000 M^3 and is expected to hit 1 million M^3, since pulp mills are not able to absorb the increased volumes. While the surplus chips are now being shipped to pulp manufacturers offshore, primarily to Asia, some at a heavily discounted $20/BDt, this biomass is equally available for energy domestically, creating a tremendous opportunity for manufacture of pellets or BioOil.

3.1.4. Forest Floor Biomass:

Canada also has considerable potential in forest floor biomass. The forestry industry harvests 193 million M^3 of wood annually. In Ontario, 95% of harvesting is full tree harvesting, which involves delimbing and deposit of slash at roadside. 90% of this residue is burned, both to prevent uncontrolled forest fire and also to free up more land for forest renewal. While in the past Quebec employed primarily full tree harvesting, now 40% of harvesting is cut-to-length, whereby delimbing occurs at the stump. Reasons include increased efficiency, reduced losses from skidding, and less damage to the forest floor including soils. Since there is very little of surplus mill residues, and these are projected to fall with the pending reductions the annual allowable cut (AAC) in Quebec, a new viable source of residue becomes the forest floor.

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[5] COFI Mountain Pine Beetle Task Force
[6] Beetle Information Bulletin- Government of BC website
[7] BC Ministry of Forests- Brad Stennes, Natural Resources Canada
[8] Mountain Pine Beetle Project Team, Summary of year 1 report

Trials in gathering forest floor biomass have shown costs to be relatively high, however this is not surprising as gathering of harvest slash has not been integrated into the harvest process as it has in Scandinavia. Gathering of residues should be integrated with harvest operations to minimize costs. A 2003 study[9] by BIOCAP estimated forest floor residue potential at 20 million BDt, as shown in Table 2.2. The Canadian Forest Service may be undertaking a new study in 2005-06. A massive infestation of Mountain Pine Beetle covering over 7 million hectares has caused extensive damage and mortality to trees in BC. A 2005 study[10] by BIOCAP estimated 68 million M^3 recoverable for power, or approximately 27 million BDt (at 400 kg/M^3).

Table 2.2

Unutilized Biomass Volumes

Million Bdt

Forest Floor residue	20
Mountain Pine Beetle Fibre	27
Livestock Waste	58
Agricultural Residues	18
Total	123

3.2. Agricultural Residues

Farmland occupies 67.5 M ha (million hectares) in Canada, or 6.7% of the total land base. Crops are grown on 36.4 M ha, or 54% of farmland. Agricultural activity produces millions of tonnes of biomass annually, which can be classified as: virgin biomass- grown for energy, and waste biomass- residual fraction of primary harvest, and livestock wastes. In the 2003 study[11], 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, or 309 TJ.

The same study estimated biomass from livestock waste. 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 Table 2.3, 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

[9] "A Canadian Biomass Inventory: Feedstocks for a Bio-based Economy"- 2003, Susan M. Wood and David B. Layzell, BIOCAP Canada Foundation

[10] "British Columbia's Beetle Infested Pine: Biomass Feedstocks for Producing Power-April 2005- BIOCAP Canada and the Province of British Columbia

[11] BIOCAP study as in Footnote #2.

billion M^3 pa, or heating value of 65 M GJ pa, although the energy is expected to supply on-farm requirements.

Table 2.3

Livestock Manure Production- 2001

	Production	Recoverable	Recoverable	Biogas Potential	Heating Potential
	M tonnes	%	M tonnes	Million M3/yr	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

3.3. Municipal Waste

In Canada approximately 750 kg per person of municipal solid waste (MSW) is generated annually[12]. 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.

Concerns about emission of particulates have led to a decline in support for incineration, however this reflects open incineration methods more common in small communities. Modern combustion technology shows emission of particulates to be manageable and there are obvious benefits in energy capture and reduction in need for landfills.

Despite the lack of enthusiasm for energy from incineration, there are exceptions. The City of Charlottetown in Prince Edward Island has the countries 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. State-of-the-art emissions controls were also installed at that time. A 1.2-MW turbine generates electricity to operate the plant with any surplus is exported to the grid.

4. Biomass Usage

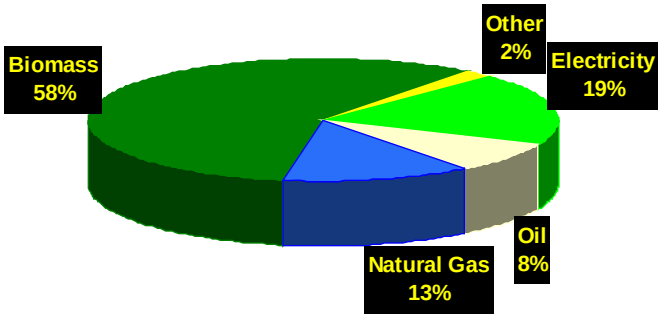
4.1. Cogeneration

To reduce the cost impact of rising fuel prices and to remain competitive, the Canadian forest industry has increasingly been substituting biomass for fossil fuel. In little more

[12] Statistics Canada, 2000

than a decade, the forest products industry has become Canada's leader in renewable energy use, with 58% of its energy coming from renewable sources by 2001—mostly wood residue and other biomass, as shown in Fig 3.1.

Fig 3.1 Energy Use – 2001 Pulp & Paper[13]



Cogeneration is making some mills net energy producers. For example:

- 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.
- Hydro-Québec intends to buy 74 KW of electricity generated by three new cogeneration projects to be based on residues (such as bark) from a sawmill and two paper mills.

Although the pulp and paper industry uses a major share of the biomass destined for heat and power, the wood products industry and major independent power producers also have significant production, as shown in Table 3.1. In 2003, combined these groups used 7.9 million BDt of biomass to produce 1,955 MW of heat and power.

Table 3.1 Canadian Wood Residue Heat & Power Generation - 2003

		Wood Residue
	MW	000 BDt
Pulp & Paper	1,436	5,992
Wood Products	46	278
Independent Producers	288	1,638
New Projects	185	
Total	1,955	7,907

[13] Forest Products Association of Canada. Biomass includes wood, bark, sawdust, and pulping liquor

4.2. Biofuels Production

4.2.1. Ethanol

In 2004, six ethanol plants in Canada produced 238 million litres of ethanol, as shown in Table 3.2. All production was from grain, except 17 million litres of wood-based ethanol from Tembec, a major forest products company.

Table 3.2 Ethanol Production 2004

	Production	Location
	Million litres	
1 Commercial Alcohols	150	Chatham, ON
2 API Grain Processors	26	Red Deer, AL
3 Commercial Alcohols	23	Tiverton, ON
4 Tembec	17	Temiscaming
5 Pound-Maker Agventures	12	Lanigan, SK
6 Mohawk Oil (Husky)	10	Minnedosa, MN
	238	

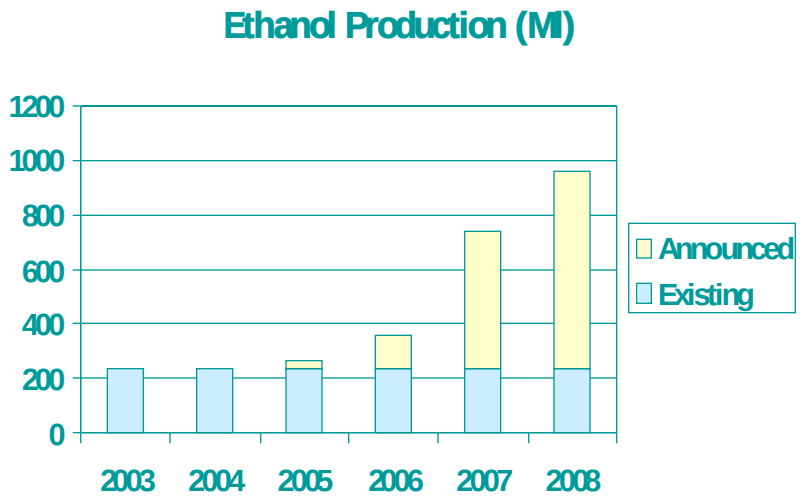
As part of a major effort to increase ethanol production, in October 2004 the federal government announced its financial support in the construction of seven new grain ethanol plants with the capacity to produce over 720 million litres p.a., as shown in Table 3.3. The expansion will bring production capacity to 1 billion litres.

Table 3.3 Announced Ethanol Expansions- Oct 2004

	New Prod'n	Subsidy		
	Million litres	$Million		
1 Suncor	200	22	Sarnia, ON	
2 Husky	130	7.8	Lloydminster, SK	350,000 tonnes grain
3 Commercial Alcohols	120	18	Varennes, QC	12 million bushels corn
4 Okanagan Biofuels	110	10	Kelowna, BC	300,000 tonnes wheat feed
5 Husky Mktg	70	6.4	Minnedosa, MN	210,000 tonnes grain
6 Noramera Bioenergy	25	3.5	Weyburn, SK	67,000 tonnes wheat
7 Seaway Grain Processors	66	10.5	Cornwall, ON	
	721	78.2		

These plants are expected to come on-stream in the next three years, shown in Fig 3.2. Policies by the provinces supporting ethanol are expected to result in additional plant capacity, which will bring production over 1 billion litres p.a.

Fig. 3.2 Projected Ethanol Production



Lignol Innovations of BC anticipates commercial production 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.

4.2.2. BioOil

BioOil from pyrolysis of wood is a brown, free-flowing liquid comprised of highly oxygenated compounds and has a density of 1.2 kg/litre. With fast pyrolysis biomass waste is rapidly heated in the absence of oxygen, vaporized, and then condensed into liquid fuel. Its heating value is 40% of diesel by weight and 55% by volume. It can be stored, pumped and transported like petroleum products and can be combusted directly in boilers, gas turbines and slow to medium speed diesels for heat and power.

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 has a patented fast-pyrolysis process that converts forest and agricultural residues into liquid BioOil. After successful production of

BioOil in its 15-tpd pilot plant, the company is moving to commercial production. In February 2005, Dynamotive began start-up of the world's largest BioOil plant in West Lorne Ontario. When fully commissioned the plant will use up to 100-tpd of wood fibre, primarily from the adjacent Erie Flooring and Wood Products plant, to produce up to 72-tpd or 26,000 tonnes p.a. of BioOil. Up to 48-tpd of BioOil can be used to fuel a gas turbine to produce up to 2.5 MW power. In June 2005, as part of the plant demonstration phase, 4.8 tonnes of BioOil were successfully fired in the Erie Flooring steam boilers.

Also in June 2005, it was announced that Magellan Aerospace, Orenda Division, and DynaMotive Energy Systems generated power in West Lorne, utilizing BioOil in Orenda's OGT2500 gas turbine. Generated power was delivered to the Ontario energy grid. The BioOil fuelled turbine successfully established comparable performance 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.

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-tpd 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 June Dynamotive announced that the international engineering firm Tecna Proyectos Y Operaciones, S.A. (Tecna) completed the conceptual design for a 200-tpd modular plant, enabling DynaMotive to commence procurement and put construction of its next plant totally within its control. The modular design will be applied to the plant being developed with Megacity Recycling and will be replicated elsewhere. The Company is currently evaluating projects of this capacity in Europe, Latin America and Asia.

In June 2005 Dynamotive announced it will ship 15 tonnes of BioOil to the research institute Forschungszentrum Karlsruhe (FZK) 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). The BioOil will be shipped from DynaMotive's facility in Vancouver to a gasifier in Freiberg, Germany and testing will be completed in September 2005. Syngas can be converted into synthetic diesel, methanol and other chemicals. Synthetic diesel, or Syndiesel, is a renewable greenhouse gas neutral fuel that can replace diesel produced from fossil crude oil, and can be used in diesel engines without modification, including automobiles, trucks, buses and industrial diesel turbines.

As a future application, DynaMotive is researching the emulsification of BioOil and hydrocarbon diesel. The goal is to allow for co-burning of BioOil/diesel mix in stationary engines without significant modification to them. As energy prices reach record levels and environmental concerns take centre stage, BioOil presents a strong potential as a

partial fuel alternative. The forest products industry anticipates that BioOil will replace oil and gas in boilers, lumber-drying kilns, and pulp-mill limekilns and to fuel cogeneration 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.

Table 3.4 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

The second major BioOil producer, Ensyn, has a mission is to develop industrial applications for its core technology, Rapid Thermal Processing, in two distinct applications- biomass (wood) processing and petroleum upgrading. In wood or other biomass operations Ensyn's process produces high yields, typically 75% by weight, of a light liquid BioOil from which natural value-added chemicals and fuels are recovered.

By 1996, there were four RTP™ plants in commercial operation. In 2001, an RTP™ biomass refining plant was built and commissioned with a capacity to produce in excess of 1.8 million kg (4 million lb) of natural resin products per year, from the existing commercial BioOil production. In 2002, Ensyn built and commissioned what was at that time its largest new RTP™ plant, with a capacity to process almost 100 green tons per day. A sixth commercial RTP™ biomass plant, designed to produce specialty chemical products, was built and put into service in 2003. Ensyn's largest RTP™ biomass refinery is presently under construction in Renfrew, Ontario. It will be completed in the summer of 2005 and will convert 160 green tons of wood per day into natural resin products, co-polymers, other chemicals, liquid fuel and green electricity. Other projects are being developed with strategic partners in Canada, the USA and Europe.

In a third BioOil development, the Ontario Ministry of Natural Resources plans to implement a small business model to improve economic fortunes in Northern Ontario, recently hit with closures of pulp & paper and lumber mills. The intent is to develop and test mobile 50-tpd BioOil units to convert harvest waste to BioOil, and implement a number of service hubs and export centres to support BioOil distribution. There is sufficient harvest slash, currently burned at roadside, to manufacture a considerable amount of BioOil, even for export. The 50-tpd plant is under construction.

4.2.3. Wood Pellets

Manufacture and export of wood pellets in Canada has grown exponentially in the past several years, primarily on the west coast. There are at least 11 pellet plants in Canada,

almost half in BC. As shown in Table 3.5, production 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.

For companies in BC, with ocean ports in close proximity, the market is primarily Europe. Similarly McTara in Nova Scotia sells largely into Europe. Companies in Alberta and Quebec export, but sell largely into the US.

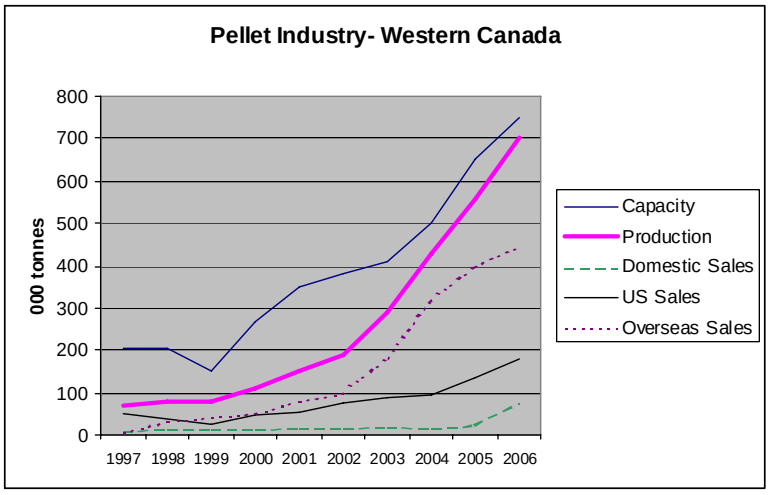
Table 3.5 Canadian Pellet Production

Pellet Production (000 tonnes pa)

Manufacturer		Capacity	Production	Exports	Key Market
Pellet Flame Inc	BC	100	60		Europe
Pinnacle Pellet	BC				Europe
Premium Pellet	BC	200	120	108	Europe
Princeton Co-Generation Corp	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 Brunswick	10	10		US
Shaw Resources	New Brunswick	20	20		
Mactara	Nova Scotia	80	80	80	Europe
Total		755	600	350	

Several new pellet mills as well as expansion of existing mills are being planned or implemented in the next year. 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. Exports to Europe in 2006 from Western Canada alone (primarily BC) are expected to exceed 450,000 tonnes as shown in Table 3.6. Production Canada-wide is estimated at 1,100,000 in 2006.

Table 3.6

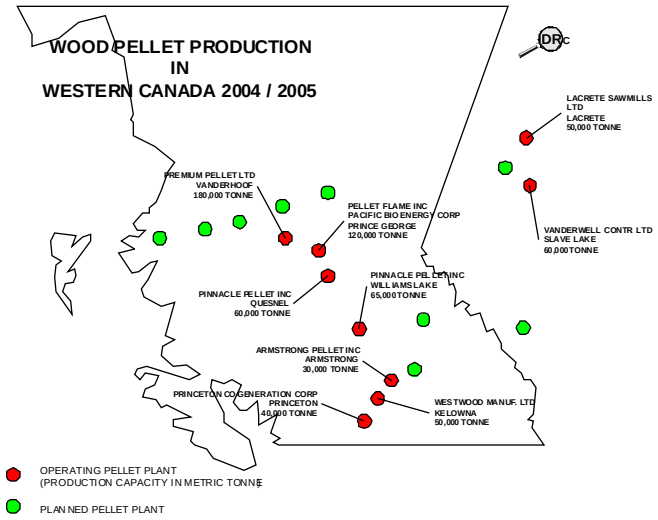


So far BC has produced only white pellets. If brown pellets becomes accepted in the market place there is a very large potential sitting in the background as a reserve.

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. Ocean freight rates escalated up to 80 % at the end of 2003, a painful experience for individual exporters. However, it did not stop export. Freight rates are now back at the mid 2003 level, however a lower cost structure for ocean shipping has to be maintained. Infrastructural changes in the shipping industry as well as in the Chinese industrial policy of more domestic raw material supply will hopefully keep the ocean rates lower. Some suppliers are locked-in to rates from mid 2003 and have been somewhat immune to the price roller coaster. To handle the sharp increases in capacity, more cost-efficient vessel loading facilities need to be put in place. A new dedicated pellet loading facility is being erected in Port of Vancouver and should be in operation in October 2005. This terminal will handle 1,000,000 tonnes per year and could be expanded to handle twice that volume over time. Construction of a new loading terminal in Port of Prince Rupert to replace the one just closed is being pursued and could be a reality in two years.

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

Fig. 3.3 Pellet Production Locations in BC



5. Imports and Exports

5.1. Ethanol

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.

5.2. Bio-oil

The European market offers significant incentives for the use of renewable energy sources. While DynaMotive hopes to develop a large domestic market for BioOil, It anticipates major exports to Europe in the early stages. Exports could be in the area of 400,000 tonnes in 2008 and double that within four years.

5.3. Wood Pellets

The greatest opportunity for pellet exports from Canada is in BC. Capacity in central Canada is not near ocean ports and thus production is largely destined for the US market. The East Coast has little mill residue available for additional pellet capacity and the province is not currently predisposed to use harvest waste. In Quebec, reduced wood harvesting will put pressure on the demand for mill residues, however there is an opportunity to manufacture pellets from unutilized forest slash. Quebec plants would also be near the port of Montreal. However, the use of harvest waste is still an environmental question and is not yet supported. The Canadian Bioenergy Association held a workshop in Quebec City in Sept 2005 on opportunities from harvest waste. It was widely attended, suggesting considerable interest in this new source.

In BC, pellet export potential is almost limitless. The annual surplus of mill residues is still 1.3 million BDt, and the surplus pulp chips is estimated to reach 400,000 BDt, sufficient to build nine 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 be used for cogeneration, there is considerable interest by the forest industry to enter new markets, such as pellets.

6. Barriers to Increased Production and Trade:

6.1. Domestic

The Canadian bioenergy industry has been faced with a number of domestic economic, social and infrastructural barriers to production and export, including:

1. Until recently, the **availability and low cost of energy,** including fossil fuels and grid electricity, compared with much of the rest of the world. Now, sharply higher thermal energy and electricity prices in Canada will likely induce the production and use of biomass locally.

2. **Awareness** of biomass energy as an option. With the exception of forestry and energy companies, the populace is largely unaware of biomass as an option for

heating or power. Solar and wind power options are perceived by the public as cleaner for the environment.

3. **Lack of capital** financing. Many remote communities have entertained the use of biomass to reduce fossil fuel costs, but lack the capital to convert.

4. **High capital costs** for installation.

5. **Small**, **widely separated biomass sources**. In many regions, forestry and energy companies have absorbed the larger pools of residue from pulp mills and sawmills for cogen. Now forest floor and other sources are being considered to enhance supply options.

6. **Availability and cost of biomass.** – With traditional sources of biomass largely dried up and increasing demand for biomass, this commodity formerly hauled away at no charge now demands a price.

7. **Undeveloped supply chains** for biomass. Forest floor biomass harvesting is only at the trial stage, and cost-effective supply chains have not been developed.

8. **2-year payback** requirements for energy investments by the forest industry. Heavy offshore competition and an uncertain future for pulp mills and sawmills dampen willingness to spend capital on non-core business, such as energy. Most forestry companies have had a 2-year payback requirement for over 20 years.

9. **Lack of domestic markets** for pellets, BioOil and ethanol. Markets do exist for pellets and ethanol in Canada, but they are small. Increased pellet capacity requires export markets, and the same is thought to be true of BioOil initially. The domestic market for ethanol is anticipated to absorb production increases.

10. **Lack of access to the grid** for power production. The bureaucracy created for provincial power utilities has been slow to change and allow new power into the grid at a fair price, however this is beginning to change.

11. **M**arginal and **complex domestic government incentive programs**. Most programs have been targeted at small installations and have caps that make them ineffective for large projects. Often the administrative effort to get an incentive is not worth the effort to apply for it.

12. **NGO misinformation on bioenergy**. The populace and NGOs have not been supportive of bioenergy projects because of long-held beliefs on particulate emissions common in outdated bioenergy installations. For example, the Greater Vancouver Regional District prohibits the use of biomass unless emissions are less than the natural gas option, without taking into account GHG emissions considerations. Ontario does not permit combustion of municipal waste.

13. **No national standards for pellets**. Canada has no national standard for wood pellets, however the BC Pellet Fuel Manufacturers Association is attempting to establish such a standard based on the Swedish, Austrian and other standards.

14. **Risk of change in Kyoto carbon accounting.** While biomass neutrality is expected to be maintained for Kyoto accounting, it is unclear what impact adding the managed forest, including slash, will have on carbon crediting.

15. **I**mplementation **Climate Change Initiatives**. Implementation of the Large Final Emitter System and of the associated Offset Trading System will tend to promote domestic use of biomass.

6.2. Offshore

While pellet trade with Europe is in full swing, there are many barriers to enhanced trade in pellets and other biofuels, including:

1. **Indirect trade barriers** for import in certain areas of Europe. For example, the UK is promoting domestic supply of biomass and restricts subsidies if the imports exceed certain limits, resulting in almost no trading of pellets into the UK. Consequently, no receiving facilities exist for Panamax size vessels, a requirement for BC producers. UK utilities continually request millions of tonnes of pellets, but none are able or willing to invest in receiving facilities due to government subsidy policies.

2. **No common standard for pellets.** Some countries in Europe have pellet standards, some have none, and even those that have are different. A common standard is preferred, and it is understood that this initiative is underway.

3. **High Freight Costs.** A sharp increase in shipping costs in 2003 made trade between Canada and Europe difficult. Biomass power facilities require an uninterrupted supply of feedstock, and Canada was often considered a supplier of last resort due to supply uncertainties. It is important to establish a supply chain with consistent freight costs.

4. **BioOil an unknown product.** Research has been underway on applications and there are many proven uses in research, but there is not enough production of BioOil yet and it needs to be tested commercially. BioOil is now being produced and tested commercially in a combustion gas turbine at the Ontario plant.

5. **Special Freight Conditions.** Unlike other fuels, BioOil has a density of >1 and a low PH , and therefore may need specific transportation requirements.