CLIMATE CHANGE SOLUTIONS
"Consulting in strategy, business investment, bioenergy, policy and climate change issues"

Canada Report on Bioenergy 2010

Sept 15, 2010

Sponsors:
Canadian Bioenergy Association
Natural Resources Canada- Canadian Wood Fibre Centre
Wood Pellet Association of Canada

Douglas Bradley
President, Climate Change Solutions
President and Executive Director, Canadian Bioenergy Association
NTL- IEA Bioenergy Task 40- Biotrade

(with help from Kendal Bradburn)

402 Third Avenue ·Ottawa, Ontario ·Canada K1S 2K7
phone · 613.321.2303 email ·douglas.bradley@rogers.com
web site · www.climatechangesolutions.net

Table of Contents

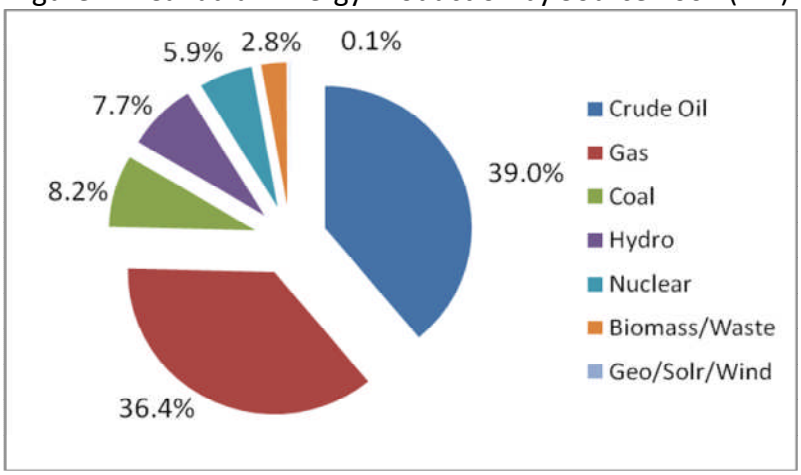
1. General Introduction

Canada is a country of over 34 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.

Canada resembles the US in its market-oriented economic system, 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 in 2009 was 14th in the world at ~$1.29 trillion (€1 trillion).

Figure 1.1 illustrates that Canada is a nation rich in fossil fuel resources. In 2007, 39% of Canada's energy was from oil, 36% from natural gas and 8% from coal. 7.7% was from hydropower, and 2.8% was from renewable biomass and waste[1]. Biomass energy fell from almost 5% in 2006 due to pulp mill cogen shutdowns and a shortage of mill residue from sawmills. Projections for the next 10-20 years are for a biomass share of 6-9%[2].

Figure 1.1 Canadian Energy Production by Source 2007 (IEA)

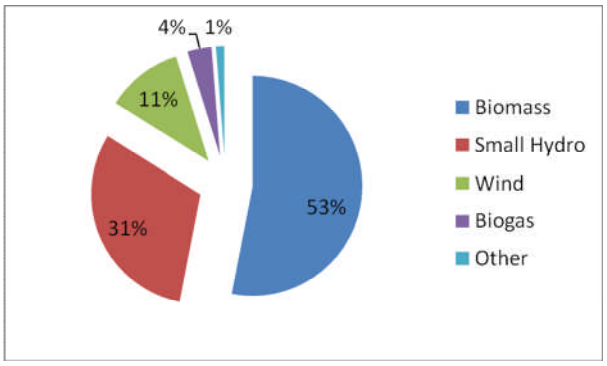


Canada has a large, well-developed forest sector and has historically been one of the world's largest exporters of wood products. 402 million ha, 41% of Canada's land area, is forested of which 27.6 million ha, or 6.9%, are national parks. 77% of forests are under provincial jurisdiction, 16% are federal, and 7% are privately owned. In 2008, 137 million m^3 of industrial roundwood was harvested on 678,700 ha, or 0.17% of total forest land[3]. Harvest is only 61% of 2005 harvest due to falling demand for wood products in the US. Nonetheless, Canada has vast biomass potential.

[1] OECD/IEA 2009
[2] Peter Hall, Natural Resources Canada, Canadian Forest Service
[3] State of Canada's Forests 2009

Major initiatives are underway to produce power from renewable sources. Incentives resulted in a major increase in wind power capacity 2006-10, reaching 3,472 MW in June 2010[4]. But governments are realizing that wind capacity does not mean power production. Wind supplies power at 30% efficiency, only when wind blows. Biomass has an advantage in producing both renewable heat and power, and on demand. Fig 1.2 illustrates renewable energy production (not including large hydro) in 2008; 53% from biomass, 31% from small hydro, only 11% from wind, and 4% from biogas.

Fig 1.2 New Renewable Heat and Power Production 2008 (TWh)

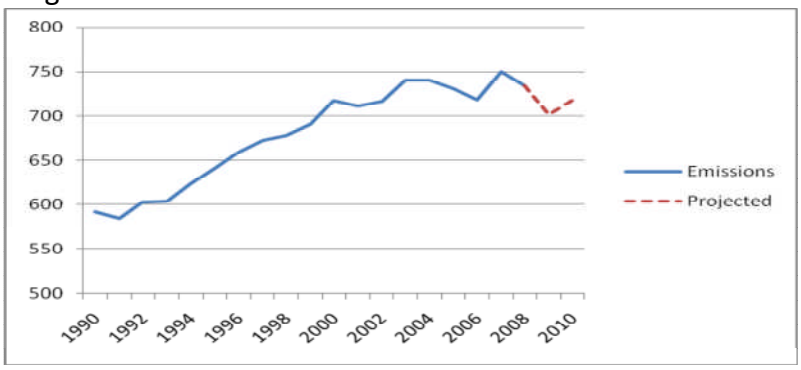


2. Policy

2.1. Climate Change Policy

In 2008 Canadians emitted 734.4 million tonnes (MT) GHGs, 24% higher than 1990 but continuing a downward trend begun in 2004, shown in Fig 2.1[5]. Emissions spiked 32 MT in 2007; 8.3 MT due to increased power generation from coal necessitated by nuclear outages, and 14.7 MT from oil & gas production and refining as a result of increased demand by the US, our major trading partner. A decline in emissions in 2008 is partly due to the economic downturn, but also increased hydro power as a result of higher water levels. GHGs are projected to decline in 2009-10 due to federal GHG policies.

Figure 2.1- Canada GHG Emission Performance 1990-2008

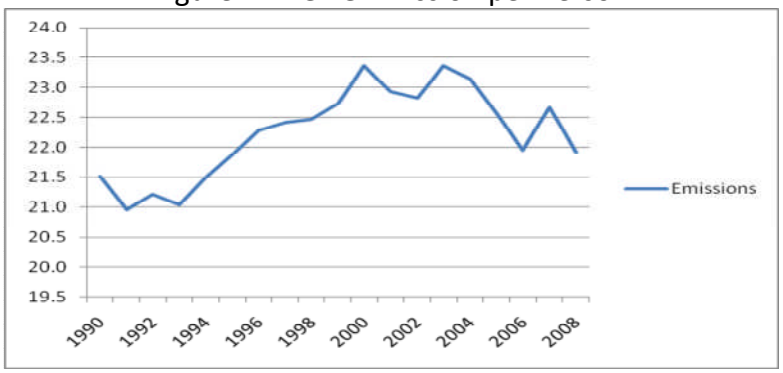


[4] CanWea

[5] Environment Canada 2007- http://www.ec.gc.ca/pdb/ghg/inventory_report/2005_report/som-sum_eng.cfm#s1

In the past Canada was ranked below other industrialized countries on climate change progress. However, our population grew more quickly than other countries, 23% in 1990-2009, versus 11% for France and 10% for the Netherlands, for example. Figure 2.2 illustrates that GHG emissions per person in 2008 were less than 1.9% higher than 1990.

Figure 2.2- GHG Emission per Person



The Canadian Government is committed to reducing greenhouse gases. Since 2006 the government has deployed a range of instruments to combat climate change; investing in renewable energy, incentives to develop green technologies, and regulations to reduce emissions. In 2010 Canada inscribed in the Copenhagen Accord its 2020 target of 17% GHG emission reductions from 2005. Canada will work closely with the US to align policies to preserve competitiveness of Canadian firms. A Clean Energy Dialogue with the US will focus on clean energy research and development, deploying clean energy technology, and building a more efficient grid based on renewable generation. This approach better reflects Canada's trade and population situation than the Kyoto Accord.

Several programs have been ongoing since April 2007, and new programs and policies were funded as of May 1, 2010[6]. Examples include;
- **Energy Efficiency**: Amendments to the Energy Efficiency Act allow for energy efficiency standards for products that affect energy consumption, such as windows, doors and thermostats. ENERGY STAR labeling leads consumers to the most efficient equipment.
- **ecoEnergy for Technology Initiative**: $239 million invested 2007-12 in research, development and demonstration of clean energy technologies, now fully subscribed.
- **ecoEnergy for Buildings and Houses**: $60 million in 2007-10 to encourage construction of energy-efficient buildings and houses, resulting in 4000 people trained in energy management and 400 commercial buildings receiving energy labels.
-**ecoENERGY Retrofit Program**: $805 over 5 years to provide energy efficiency improvements in homes and medium-sized organizations, including property grants of up to $5000 for energy efficiency improvements.

[6] A Climate Change Plan for the Purposes of the Kyoto Protocol- Environment Canada, May 2010

Canadian provinces are also committed. In Feb 2008, **BC** announced North America's first carbon tax on all fossil fuels, starting at \$10/tCO_2e (6.7€), or 2.41¢/l (1.6€) at the pump, and increasing at \$5 (3.3€) per year for four years. The tax hit \$20/tCO_2e in 2010. While initially welcomed by households because proceeds were used as a low-income credit, the magnitude of the tax in 2010 combined with a new HST (Harmonized Services Tax) made taxes hit low incomes harder than high incomes. BC also set a target of 33% emission reductions from 2007 to 2020. In Oct of 2007, **Quebec** instituted a carbon tax on energy companies of 0.8¢/l gasoline and 0.9¢/l diesel. In 2009 Quebec committed to a 20% reduction in GHGs 1990 to 2020. Quebec adopted the same standard as California for GHG emissions from transportation vehicles, set targets for emissions by aluminum companies, implemented a number energy efficiency programs and has even implemented innovative incentives to convert heavy and light oil use in building heat to biomass. Quebec joined BC, **Ontario, Manitoba** and 7 US States in the Western Climate Initiative, that will implement a cap-and-trade system to reduce GHGs. **Alberta**, a climate change leader since 1992, implemented a carbon emission trading system in June 2007 that required companies with large GHG emissions to reduce emissions by 12% from July 1 to Dec 31 of 2007. Firms could achieve targets by trading verified emission reductions, buying offsets, or investing in a technology fund. Few trades took place, and most targets were achieved by pumping money into the technology fund that had no positive GHG impact. Alberta now is focusing on energy efficiency and carbon capture that enhances oil recovery while storing CO_2 in underground aquifers.

2.2. Renewable Fuels Policy

Policy incentives to promote biofuel use, such as a federal excise tax exemption in the 1990's, had little impact in developing a biofuels industry. In 2006 the government announced a new biofuel strategy to increase ethanol production, a mandate legally requiring annual renewable content of 5% ethanol by volume in all gasoline for ground transportation by 2010, and 2% in diesel for ground transportation and heating by 2012. Including diesel in the renewable fuel standards (RFS) is in response to a lobby by oil seed producers. Canada is the world's 3rd largest producer of canola after China and the EU, at 12.6 MT in 2008-09 and Canada is the largest net exporter of canola oil. Adding new demand for canola to produce of bio-diesel will enhance farm incomes.

In March of 2007 the federal excise tax incentive was dropped and replaced with producer incentives. This is shown in Table 2.1, where a maximum 10¢/litre (6.8$€_c$/l) was initially paid for ethanol in gasoline and 20¢/litre (13.5$€_c$ /l) for biodiesel.

Table 2.1

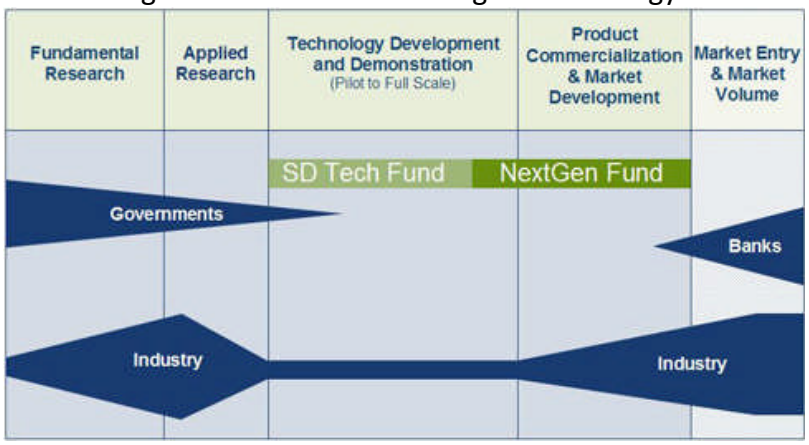
Maximum Incentive Rates for Renewable Fuels (currency per/l) April 1- March 31

	2008	2009	2010	2011	2012	2013	2014	2015	2016
In Gasoline (\$Cdn)	0.10	0.10	0.10	0.08	0.07	0.06	0.05	0.04	0.04
In Gasoline (€)	0.067	0.067	0.06	0.054	0.047	0.040	0.034	0.027	0.027
In Diesel (\$Cdn)	0.20	0.20	0.20	0.16	0.14	0.12	0.10	0.08	0.06
In Diesel (€)	0.13	0.13	0.13	0.11	0.09	0.08	0.07	0.05	0.04

These incentives were established to encourage biofuel production in Canada, rather than importing biofuels. $1.5Cdn billion (1€billion) in funding was budgeted to establish a volume limit of 2 billion litres of renewables (ethanol) in gasoline and 500 million litres of biodiesel. The incentive is calculated to ensure a 20% pre-tax return to manufacturers, even before considering any provincial incentives. By April 2010, 21 contribution agreements were signed; $765M to Ethanol and $201M to Biodiesel.

Federal policies are being put in place to go beyond increasing biofuel production to establishing a sustainable bio-based economy. Support programs include: a $145 million (98€million) Agricultural Bio-products Innovation Program (ABIP) to mobilize research networks to develop effective technologies for conversion of agricultural biomass; and a $134 million (90€million) Agri-Opportunities Program over 5 years to accelerate commercialization of agricultural products. SDTC (Sustainable Development Technology Canada) in 2007 announced a $500 million (336€million) NextGen Biofuels Fund to pay up to 40% of project costs to establish first-of-a-kind large demonstration-scale facilities producing next-generation biofuels from many feedstocks such as wheat straw, corn stover, wood residue and switch grass. The NextGen Fund is a departure from the norm where government traditionally supported research only, leaving an investment gap at the commercial demonstration stage, shown in Fig 2.3. By May 2010, the NextGen Fund had not yet been fully subscribed, partly because it does not fund 2nd of a kind plants, a definite roadblock to progress.

Fig 2.3 Government Funding of Technology[7]



Many provinces have mandated renewable fuel content in fuels, as shown in Table 2.2, and some have announced infrastructure grants. While some provinces now have renewable targets, each is implementing its own complex, unharmonized tax exemptions. Inconsistencies in threshold levels, timeframes and feedstocks have hindered intra-provincial biofuel trade. For example, ethanol produced in Alberta is exempted from Alberta's gas tax, but not ethanol produced in neighbouring BC or Saskatchewan. Although Quebec announced its intention to mandate a 5% biofuel

[7] SDTC web site

content, leading to the construction of a 200 million litre corn ethanol plant at Verennes, in November 2007 Quebec announced that no other corn ethanol plants would be built in Quebec, owing to findings about environmental impacts of intensive corn cultivation and market price impacts of corn to ethanol seen in the US. However, the province anticipates building next generation ethanol plants from cellulosic ethanol using technology from Quebec-based Enerkem.

Table 2.2- Provincial Renewable Fuel Incentives (1¢=.68€$_c$)

	Mandate	Incentive
BC	5% ethanol, 5% biodiesel-Jan 2010	14.5¢/l for ethanol
		0.09¢/l for biodiesel, tax exemption, BC fuel only
Alberta	5%ethanol. 2%biodiesel-Apr, 2011	9¢/l tax exemption, producer incentive, Alb fuel only
Saskatchewan	7.5% ethanol in Gas	10¢/l for ethanol
		20¢/l for biodiesel, tax exemption. Sask fuel only
Manitoba	8.5%, of Gas*	20¢/l producer incentive 2008-09, Man only
	10% in ethanol	15¢/l producer credit 2010-12, Man only
	2% in Biodiesel-Nov 1, 2009	10¢/l 2013-15, Man only
Ontario	5% ethanol in gas 2007	20¢/l producer incentive
	10% ethanol in gas 2010	
Quebec	5% ethanol in gas-2012	producer incentive
Nova Scotia		15¢/l for biodiesel produced in N.S.

2.3. Renewable Biomass Heat and Power Policy

While government policies and incentives have been very supportive of biofuels, supported by a strong industry lobby, support for biomass heat and power has been lean and less effective by comparison. Federally programs typically focus on basic research, applied R&D, demonstration and pre-commercialization. For example, the $550 million (407€million) SD Tech Fund™ supports late-stage development and pre-commercial demonstration of products and processes that contribute to clean air, clean water and clean land, that address climate change and improve the productivity and the global competitiveness of the Canadian industry. However, there is little federal support for anything after the pre-commercialization stage.

A generous, successful ecoENERGY Renewable Power program provided $1.48 billion to increase renewable power through a 1¢/kWh (.74€c/kWh) incentive. By March 2010, 99 contribution agreements were signed totaling $1.4 billion. By April 2010 52 projects were in operation with capacity 2500 MW. However, less renewable electricity was actually produced than expected due to a large majority of projects being wind power. The program ends March 2011. An ecoENERGY Renewable Heat Initiative provided only $36 million, a fraction of that committed to power, and most of this went to solar projects. This program also ends March 2011, with application deadline of Oct 2010. In 2009, the government announced a $1 billion package to improve environmental performance of pulp mills to counter a similar program in the US. It will provide

16¢/litre of black liquor produced in 2009, a renewable fuel which pulp mills use to power their boilers. The subsidy must be used to increase energy efficiency. The government has provided many successful programs, but they clearly favour energy efficiency, biofuels like ethanol and biodiesel, and renewable power, with almost no recognition given to equally valuable bio-heat.

With forestry industries in distress, and mill closures rampant, the provinces now see bioenergy as a viable socio-economic alternative to traditional forest products.

BC has the largest forest industry in Canada. In 2008 BC became the first jurisdiction in Canada to release a Bioenergy Strategy which included: $25 million (17€million) to establish a bioenergy network, a target of at least 10 community energy projects by 2020, a commitment to establish a comprehensive biomass inventory, and a 2-part call for power. The first call-for-power by BC Hydro was targeted at projects that were already well along in planning, and proponents had to "bid" a power price. 20 proposals were received from 13 proponents to provide 6,000 GWh with bid prices of 10.7-30.0¢/KWh (7.9-22.2€c). Only four projects were chosen, to provide 579 GWh (60MW) at 9.7-10.7¢/KWh (7.2- 7.9€c). The second call for power released May 2010, targeted to acquire 1000 GWh, yielded 19 proposals to produce up to 650 GWh capacity. In 2010 BC became the first province to eliminate the need for ASME certification and allow EU-certified bioenergy equipment in BC. BC has committed to; develop legislation to phase in requirements for methane gas capture, streamline the permitting process, legislate elimination of beehive burners, promote wood pellet production and facilitate pellet market development, improve access to wood fibre feedstocks for generation of heat and power, and develop new fine particulate standards.

In Quebec, the second largest forest industry in Canada is reeling due to cut backs in annual allowable cut of wood, the rising Canadian dollar, and the falling demand for lumber by the US. Quebec issued a "Green Paper" to begin restructuring the forest regime to ensure equitable management and allocation of timber resources. A 2007 call for 100MW of biomass power by Hydro Quebec was unsuccessful due to the inadequate time allowed to prepare proposals; only two cogen projects at pulp and paper mills were submitted. There are no incentives for small power. However, Quebec remains committed and in 2008 launched a program for wood bioenergy, taking an innovative approach to wood allocation unique in Canada; allowing 17 regional economic development Boards, CREs (Conseil régionale de l'environnmente) to examine bioenergy proposals and recommend 5-year wood allocation contracts. Several regions are moving quickly to garner forest biomass for small community heating systems. In 2008, Quebec allocated $150 million (€93 million) over three years to convert heavy oil heating systems to woody biomass. In 2009 it announced a program aimed at 4500 institutional buildings to convert from light oil to biomass, paying either (1) an amount to bring the payback to 4 years, or (2) $40/tonne CO2e, or (3) 50% of project costs, or(4) $500,000. The province projects over 1600 GWh in conversions from oil to biomass will occur.

Ontario set GHG reduction targets of 6% below 1990 levels by 2014, 15% below by 2020. Much of these reductions will be achieved by phasing out coal for electricity generation, mandated by 2014. The province set two renewable targets in 2004: 5% of generating capacity from renewable sources by 2007 (1350 MW), 10% by 2010 (2700 MW). In an effort to move forward meaningfully with renewable power, the Ontario Power Authority announced the Standard Offer Program in 2007, paying 11¢/KWh (7.4€$_c$/KWh) for renewable power over 20 years for projects under 10 MW. By Jan 2008, 262 contracts for power were executed; 69 for wind power, 158 for solar power, 15 for water power, and only 20 for biomass. Of the biomass projects 13 were landfill gas, 3 were biofuels, and only 4 out of 262 were biomass heat and power, partly due to economics, but partly due to lack of time given to prepare biomass supply. The Green Energy Act was passed in 2009. Recognizing from European experience that feed-in-tariffs were the most effective incentive for renewable energy, a second program was initiated in 2009 providing 13.8¢/KWh for biomass plants under 10MW and 13¢/KWh for larger facilities. Wind received 13.5¢/KWh and solar 80.2¢/KWh. By April 2010 184 projects had been approved; 77 solar, 48 wind, and again only 2 biomass.

Despite efforts to move forward with bioenergy, a key barrier has been the inability of projects to confirm wood supply from the Crown. Accordingly, Ontario began to streamline the process to gain access to an estimated 22 million m^3 of biofibre[8], including harvest tops and branches, unused allowable harvest, and unmerchantable timber. In 2009 a call for expressions of interest drew 130 applications for 143 facilities to use biofibre, of which 84 were for the manufacture of pellets. The province is expected to start signing wood supply agreements late in 2010. In Aug 2010, the province issued the Ontario Power Authority a directive to negotiate a power purchase agreements for biomass electricity at the Atikokan generating station, a huge step to enabling biomass power generation.

A major barrier to bioenergy has been antiquated legacy legislation by the Ministry of the Environment; conflicting air quality permits, onerous permitting process, and poor definitions that lump woody biomass together with municipal waste. New legislation in the Green Energy Act is aimed at streamlining approvals for renewable energy projects.

One of the major shortfalls of Canadian policy is the fixation with power rather than heat. This focus has led to a significant increase in power capacity building, largely wind turbines, but the result has been a realization that wind power capacity translates to production only 30% of the time. Now additional gas cogeneration is contemplated to meet peak power needs. Production of renewable energy that includes power and heat is one of bioenergy's great advantages. The Canadian Bioenergy Association (CanBio) is promoting equal incentives for both power AND heat, both to improve the economics of biomass energy projects and to enable the constant power required by grids.

[8] Jo Maure, Ontario Ministry of Natural Resources, Sherbrooke presentation, June 2009

23% of **New Brunswick's** energy comes from renewable energy sources such as conventional hydro and wood. The government would like to increase renewable power by 10% by 2016. In 2008 the NB government announced a Biomass Policy whereby harvest residues would be made available for bioenergy projects, and in early 2009 it requested submissions for up to 1 million ODT annually of this fibre. 16 projects were submitted and eight projects from four companies were accepted;
1. AV Group- 272,000m^3 for a new bioenergy project at Atholville, and 221,000 m^3 for a new cogen unit at Nackawic, where the company already operates a 20+MW cogen.
2. JD Irving-493,000 m^3 for four projects including; 139,000m^3 for a new biomass boiler at the Lake Utopia mill, 138,000m^3 for a cogen unit at the St. John paper mill, 60,000m^3 for the Grand Lake Sawmill. The federal government provided a grant of $22 million for Lake Utopia, and NB provided a $10.8 million repayable loan.
3. Twin River Papers- The 40 MW cogen plant formerly owned by Fraser Papers and now with $40 million in ownership by the province, will utilize 308,000 m^3 forest wood to replace shortfalls of mill residue.
4. Groupe Savoie- 62,000 m^3 wood to supplement feedstock for its new pellet plant[9].
Despite the generous release of new fibre for renewable energy, the biomass assignments benefited industry but left nothing for community heat projects.

For decades **Nova Scotia's** prime energy supply came from imported coal (80%). However, with rising costs and mine closures coal is no longer a reliable, low-cost source of electricity, it is not a dependable provider of jobs for residents, and it is becoming environmentally unacceptable. Renewable energy has a greater potential to create jobs and keep investments local. Renewable Energy Standards came into effect in 2007 to produce 18.5% of the provinces electricity from renewable sources by 2013. NS aims to generate 25% renewable electricity by 2015 and 40% by 2020. Electricity from co-firing biomass will help meet the 2015 target, however this strategy will be pursued with caution[10]. Although, the Department of Natural Resources found that 750,000 ODt new forest biomass could be sustainably harvested to generate electricity, the plan caps forest biomass used for power at 150,000 ODt (150 GWh), to ensure sustainability pending the release of the Natural Resource Strategy. Also, while New Brunswick has allocated harvest residues for energy, Nova Scotia does not allow any use of residues, only stem wood, despite CFS studies that show using harvest residues in the province is sustainable. Environmental activists, with little knowledge of forest dynamics and influenced by questionable studies, have argued for reduced wood supply, which industry argues will crush a $billion industry with all its socioeconomic benefits. The government searches for middle ground. Other renewable energy initiatives have been introduced such as: Community–based projects eligible for a Feed-In Tariff (COMFIT), limited to non-for profit and First Nations; and Community Economic Development Investment Funds (CEDIFs). NS will be launching a Cleaner Energy Strategy (summer/fall release) that will address other energy sources for heat and water.

---

[9] The Biomass Sweepstakes- Atlantic Forestry July 2010, David Palmer
[10] REP 2010

What can we learn from other jurisdictions that have excelled in bioenergy?

New England US federal renewable energy policy has focused on: transportation fuels, primarily to reduce dependence on Middle East Oil and enhance farm incomes; and electricity, from hydro, wind, solar etc. Biomass for heat and power has been largely overlooked. Since New England relied on expensive oil for energy, it is these states that spawned leadership in US bioenergy policy.During the 1980's the price of oil was both high and volatile, so Vermont set a goal to reduce energy costs and improve the market for low-grade wood. In a 'Fuels for Schools' program 20 schools converted to biomass, getting federal and state aid for up to 30% of capital costs. In 2001, state aid increased to 50% of capital costs, and in 2003 up to 90%, causing a flood of conversions to biomass. Municipalities usually issued long term bonds to cover the rest of the capital cost rather than raise property taxes, and in some cases even issued short term bonds to start the project,s knowing the State funds were pending. To confirm project viability, each school had to do a life cycle analysis on the project economics. The 2007 financial crisis temporarily ended the market appetite for bonds, but by then 43 schools had converted to biomass, saving 51% of total heating cost, enough for each school to afford two additional teachers. Over 1/3 of the State's student population now attends a wood heated school. What did Vermont learn that is applicable to Canada? State aid worked, bio-heat saved municipalities money, bond issues were a good way to finance a portion of the costs, and all invested funds were kept in the local economy rather than being squandered to middle east oil barons. Were there any mistakes? Yes. 90% support proved to be too high, causing an unwanted flood of projects, many of which were rushed and done poorly. Also a "buy American" policy in some cases resulted in poor technology being adopted, when superior European equipment was available. As a way to reach renewable objectives, Canadian Provinces should try a program with 65-70% capital support for conversion from oil heat to biomass, municipalities should issue bonds to cover the rest, and all technologies should be allowed, including from Europe.

Finland is a world leader in use of renewable energy sources, particularly bioenergy. It's forests, 70% privately owned, cover more than 86% of its land area. Finland has no fossil fuel resources and therefore uses its wood resource for energy. 6 Mm^3 of wood chips are used annually in thermal and other power plants and Finland aims to increase to 13.5 Mm^3 by 2020. District heating (DH) provides 50% of total space heating, supplying 2.6 million people from DH plants. Finland has achieved such success out of necessity, and with progressive bioenergy policies. How did these policies evolve? The EU Renewable Energy Directive sets national targets for renewable energy and requires each member state to produce a National Renewable Energy Action Plan. Finland must reach 38% by 2020, from 25%. Finland is focusing on renewable electricity, heating and cooling, and transport fuels, and has a number of programs to achieve these targets;

- a small wood chipping subsidy up to 36M€
- support of 18€/Mwhe (10€/t CO_2) and 41€/Mwhe (23€/t CO_2) for electricity production from wood chips

- feed-in tariffs for new small scale CHP plants of up to 36M€
- In 2011 a tax increase for oil, electricity and coal of 0.16€/l
- Capital subsidies

The Eno community used these benefits to develop district heating projects, maintain a small carbon foot-print, and build and support the local economy. After 3 years of discussions, the Eno Energy Co-operative was founded by 12 private forest owners in 1999. Today there are 51 members. There is an entrance fee of $15-20,000Cdn and membership fee of 200€ ($250Cdn). Financial supports for district heating projects receive up to 40% of the investment costs, as shown in Table 2.3

Table 2.3 Capital Cost- Eno Heat Projects ($Cdn)

	Ylakylä .8 MW	Uimaharju 2 MW	Alakylä 2 MW
Centre	561.0	438.8	952.0
Network	307.5	429.0	432.0
Total	868.5	867.8	1384.0
Subsidies	235.5	72.8	319.0
Net Cost	633.0	795.0	1065.0
% Subsidies	27%	8%	23%

In 2000-04 Eno built three plants that supplied heat to municipal office buildings, health centres, high schools, fire station, housing for the elderly, business premises, houses etc. The Alakylä heat plant cost the Euro equivalent of $952,000, the piping network $432,000, and they received subsidies of $319,000 or 23%. Almost all capital investment stayed within the municipality. Supplying the plants with local wood chips, peat and pellets developed a proper market for an existing wood supply and increased employment. The projects saved the local economy 1,000,000€ by replacing 1.6 million liters of oil every year. Forest owner members are ensured better prices for their wood. Thus a small government grant enabled huge local socioeconomic benefits. Canadian communities would benefit greatly if they had similar government support.

3. Biomass Resources

Historically, the chief feedstock for bioenergy was mill residue from forest products operations and the primary use was generation of heat and power by pulp and paper mills, sawmills, and independent power plants. In 1989, Ensyn began using sawmill residue to make Pyrolysis Oil, and in 2005 Dynamotive Energy began to use post-industrial wood to make Pyrolysis Oil. Corn and wheat have increasingly been used to make ethanol, and a small amount of biodiesel, and agricultural wastes are used to heat greenhouses. Now several different streams of biomass are used to make all kinds of energy, from lignocellulosic fibre to ethanol to wood waste for syngas.

3.1. Woody Biomass

Forest biomass can be broadly separated into three categories; mill residue (bark, sawdust and shavings primarily from pulp mill and sawmill operations), forest residue (tops, branches and leaves from harvest and thinning operations that are left in the forest or at roadside after delimbing), and standing timber (Mountain Pine Beetle Wood and unmerchantable wood for example).

3.1.1. Annual Residue Production:

In 2004, Canadian sawmills produced 83.5 million m^3 of lumber. However, the financial crisis in the US that led to a worldwide recession changed the situation entirely. Millions of unsold homes in the US drastically reduced home building and subsequently the demand for Canadian lumber. Production fell every year reaching 45.1 million m^3 in 2009, shown in Fig. 3.1. However, production is projected to reverse the slide and increase to 52 million m^3 in 2010, based on monthly growth Dec 2009-Jun 2010.

Figure 3.1

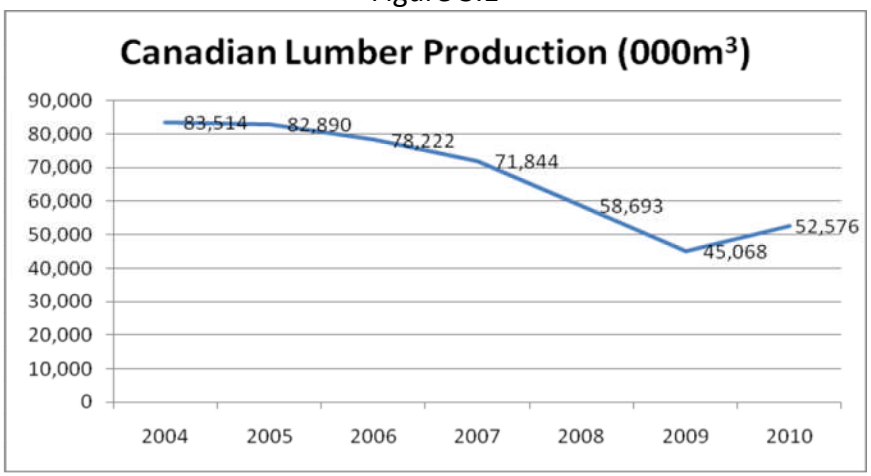


Table 3.1 shows that the decline in sawmill production has hit all provinces, with Ontario, Quebec and Nova Scotia being particularly hard hit.

Table 3.1- Sawmill Production in Canada by Province[11] ($000m^3$)

	2004	2005	2006	2007	2008	2009	2010 LE
BC	39,205	41,014	41,050	36,677	28,192	22,975	26,758
Alberta	8,053	7,362	6,782	7,853	7,358	6,644	7,386
Sask	1,184	749	479	200	0		0
Manitoba	637	700	459	200	0		0
Ontario	8,728	9,104	8,493	7,753	5,509	3,542	3,480
Quebec	19,883	18,607	16,126	14,588	12,401	9,433	11,668
New Brunswick	4,039	3,797	3,525	3,349	2,408	1,934	2,420
Nova Scotia	1,785	1,557	1,308	1,224	817	540	864
Canada	83,514	82,890	78,222	71,844	58,693	45,068	52,576

[11] Statistics Canada Publication 35-003-X

The severe drop in lumber production essentially wiped out surpluses of mill residue by 2009. A 2005 mill residue survey[12] of Canadian pulp mills and sawmills indicated that 2004 production of bark, sawdust and shavings was 21.2 million ODt[13] (365 PJ) as shown in Table 3.2. Of this 17.8 million ODt was committed, either to produce onsite energy, or sold to independent power producers, board and pellet manufacturers, and to farmers for animal bedding, and landscapers for garden beds. Some was exported, but there was still an annual mill residue surplus of 2.7 million ODt (46 PJ). In 2009, with the drop in lumber production, the estimated production of mill residues was under 11 million ODt, or 61% of market demand for mill residue in 2004.

Since 2004 several large new biomass projects were built that anticipated using mill residue including 815,000 ODt[14] in BC alone. Projects included a new pellet plant in Houston BC, a pellet plant expansion in Price George, a pellet capacity increase at Canfor, and a bark boiler project at the AbitibiBowater pulp & paper mill in Ft. Frances in Ontario. The combined impact of lower mill residue production and new projects has been to leave plants scrambling for feedstock. Now harvest residues form 20-30% of the feedstock in BC pellet plants, and Ft Frances has been compelled to use 30% harvest residues in its feedstock.

Table 3.2- Canada Surplus Mill Residues 2009 (ODt)

	2004				2009
Province	Prod'n	Consump.	Export	Surplus	Production
BC	6,554	4,338	350	1,815	3,841
Alberta	2,406	1,924	0	481	1,985
Saskatchewan	580	416	0	164	0
Manitoba	225	212	0	13	0
Ontario	2,602	2,480	1	121	1,056
Quebec	6,669	6,400	169	100	3,171
New Brunswick	1,373	1,223	150	0	657
Nova Scotia	601	588	0	13	182
PEI	24	23			0
Nfld & Lab.	195	166	0	30	0
Total	21,229	17,770	670	2,737	10,892

3.1.2. Hog Fuel Piles:

In BC, Alberta and Manitoba, sawmills were required to incinerate bark and sawdust that was not used internally or sold in the year it was produced, while in Saskatchewan and the Eastern provinces incineration was disallowed and mills piled excess residue at

[12] Estimated Production, Consumption and Surplus Mill Wood Residues in Canada-2004, A National Report- NRCan & FPAC; Prepared by BW McCloy and Associates and Climate Change Solutions
[13] ODt- Oven Dry tonnes= Bone Dry tonnes
[14] Latest estimate by Brian McCloy, BW McCloy and Associates

the mill site. With the rising cost of mill residue, mills began looking to this bark as a fuel source. In some cases the bark is contaminated with rocks or soil, or is too wet to be economically usable, however many of these piles are excellent sources of biomass for energy. Table 3.3 shows estimates made by sawmills of bark volume in 2005; usable bark (fairly dry, little contamination), and bark available (not committed). In Canada on Jan 1 2005 there were 34.8 million ODt of bark. An estimated 22.5 million Odt was usable and 20.9 million Odt was available (359 PJ). Some piles have begun to be mined in Ontario and Quebec so that the volume in 2009 may be closer to 20.4 million ODt, equivalent to 2.0 million ODt annually if mined over 10 years. New analyses of the bark piles have shown that some bark piles were underestimated in terms of the amount that was usable, so these volumes, particularly in Quebec, could be 2 million ODt higher.

Table 3.3 Surplus Historic Bark Piles- 000 ODt

	2005 Re-estimated			2005-2008		
	Estimated	Usable	Available	Utilized	Remaining	Annual*
Saskatchewan	2,900	2,900	2,900		2,900	290
Ontario	19,371	13,270	11,684	80	11,604	1,160
Quebec	11,710	5,651	5,651	400	5,251	525
New Brunswick	300	257	257		257	26
Nova Scotia	213	206	148		148	15
Prince Edward Is.	30	30	30		30	3
Newfoundland	235	188	188		188	19
Canada	34,759	22,502	20,858	480	20,378	2,038

* if mined over 10 years

3.1.3. Forest Harvest Waste and Urban Wood Residue:

With mill residue surpluses essentially gone until the sawmill industry recovers, forestry and energy companies and provincial governments are looking to harvest residues as the next fuel source, vast, and much of it burned at roadside. The Canadian Biomass Innovation Network, the Canadian Forest Service, Agriculture and Agri-Food Canada and the National Land and Water Information Service have collaborated to develop the Biomass Inventory and Assessment Tool (BIMAT) to identify and characterize biomass sources potentially available for bioenergy conversion in Canada. BIMAT is based on internet map server technology and when complete will allow users to both view and query the spatially explicit inventory of biomass sources across the country. The model reflects harvest operations in all provinces and territories. Ontario for example uses full tree harvesting methods and 90% of harvest residue is left at roadside. Quebec uses cut-to-length methods in 40% of its operations, thus only 60% of residues are left at roadside. Since roadside residues are more cost effective than in situ residues, only roadside residues are considered available for bioenergy in this report. They include low-value materials resulting from harvesting and commercial thinning operations, primarily tops and branches, and in the case of full tree chipping, bark and log exterior

residue. The BIMAT woody biomass inventory does not include deforestation, silviculture recovery biomass or non-commercial whole trees in its inventory.

Table 3.4 shows estimated harvest residue volumes at roadside for the ten provinces, estimated by BIMAT to be 31.1 million BDt p.a. This estimate is a maximum sustainable level based on the allowable annual cut in each jurisdiction. In fact annual harvest has been below the allowable annual cut for several years, and the market factors related to US housing have even more reduced harvest levels. A better estimate of actual available harvest residue in 2008 might be 22 million BDt.

Table 3.4- Harvest Residue at Roadside and Urban Wood

	Roadside Residue				Urban
	BIOMAT Max Sustainable			2008	
	HW	SW	Total	Total	
BC	404	13,332	13,736	9,946	1,303
Alberta	1,397	1,972	3,368	2,544	1,017
Sask	275	467	743	424	251
Man	64	265	329	131	305
Ont	896	3,485	4,381	2,431	3,900
Que	1,367	5,447	6,814	5,213	2,490
NB	21	827	848	610	146
NS	175	448	623	419	198
PEI	0	0	0	0	24
NFLD	0	239	239	239	116
Total	4,599	26,482	31,081	21,957	9,750

Urban wood residue is already being used for bioenergy and it will increasingly be used if it is clean and low cost. Urban wood includes discarded wood products, whole trees, and pruned branches or stumps generated during street and park maintenance. Primary constituents of used wood residue include used lumber, trim shipping pallets and crates from construction, demolition, and other activities. BIMAT estimates urban residue volumes based on population size. An estimated 9.75 million BDt of urban wood residues are available annually for bioenergy, as estimated by BIMAT.

3.1.4. New Sources of Woody Biomass

Purpose-grown sources of wood biomass are being explored and now scaled-up in selected locations in Canada. There are several management regimes being developed that can recover biomass in as little as 3 years, or 12-20 years where large mature stems are the preference. Willow and hybrid poplar are the species of choice at the present for these short-rotation woody crop plantations, which have the yield capacity of 6-12 ODT/ha/yr. Land suitability potential in Canada for these applications under moderate cost scenarios range from 8-16 million hectares on presently non-forest lands primarily in the Prairies, Ontario, and Quebec. These plantations are positioned strategically to be

accessible to final bioenergy users, and harvest, transportation and storage infrastructure to minimize supply-chain costs. At the present time approximately 2500 hectares are being established annually with significant scale-ups planned in Ontario and the Prairies. The major limitation to these biomass sources are establishment costs which are 50-70% of the total delivery costs.

Another promising woody source is managed juvenile hardwood stands comprised of sucker oriented aspen and balsam poplar at 5-8 years of age post-logging. Yields of 30-60 ODTs of biomass are projected to be recovered using progressive chipping, baling or bundling harvest systems used in short-rotation operations. With no direct crop establishment cost and with existing initial logging infrastructure, including landings and access/transport routes utilized for harvest recovery and shipping, this option is very cost effective. On these sites with natural regenerating hardwoods, only one juvenile biomass harvest will be completed and then the site will left and returned to a 60-80 year large stem rotation cycle. There are 100,000-110,000 hectares harvested annually in the boreal forests that could consider this biomass option. Developmental trials are actively being conducted by forest companies and forest bioenergy research agencies to determine the cost effectiveness of the supply-chain associated with this source and management regime. The Prairies, northern British Columbia, Ontario and Quebec are the locations with significant opportunities for this source of woody biomass. High-density juvenile fire origin pine is another option being considered as well as the diverse tolerant hardwood sites of eastern Canada.

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), waste biomass (residual fraction of primary harvest), and livestock wastes. Total crop production in 2001 was estimated at 78.3 M Odt[15], 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 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. A June 2007 estimate suggests that 2 million tonnes agricultural residues annually would be available based assumptions of 10 year average yields and collecting residue in 1 in every 4 years[16].

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

[15] A Canadian Biomass Inventory- Feedstocks for a Bio-based Economy-2003 BIOCAP
[16] Mark Stumborg, presentation CanBio Bioenergy Conference Ottawa, June 2007

oxide, two potent greenhouse gases. Manure production is approximately 128 Mt[8] (million tonnes) of which 58 Mt, or 46%, is considered recoverable. This represents a biogas potential of 3.2 billion M^3 pa, or heating value of 65 PJ pa, although the energy is expected to supply on-farm requirements.

3.2.1. Ethanol Feedstock

In 2009, 67% of ethanol produced in Canada was made from corn (all in Eastern Canada), and 31% from wheat (all in Western Canada). Ontario is the largest corn-producing province in Canada, and 55% of Canadian ethanol capacity is in Ontario. In the 2008/09 growing season to Aug 31, 10.6 MT (million tonnes) corn was produced in Canada and 1.9 MT imported from the US for a total of 12.5 MT, shown on Table 3.5. 7.6 MT were used for feed and 4.1 MT were used for ethanol and domestic food.

Table 3.5 Agricultural Crops for Ethanol (000 tonnes)[17]

	2004/05	2005/06	2006/07	2007/08	2008/09	2009/10
Corn:						
Production	8,837	9,332	8,990	11,649	10,592	9,561
Imports	2,419	1,902	2,092	3,182	1,863	
Total	11,256	11,234	11,082	14,831	12,455	
for Feed	7,961	8,500	8,460	10,218	7,594	
Food and ethanol	2,359	2,280	2,980	3,570	4,120	
Wheat:						
Production	24,796	25,748	25,265	20,054	28,611	26,515
for Food	2,965	2,990	2,960	2,857	2,745	
for Ethanol	134	178	411	394	571	

Wheat is the feedstock for almost all the rest of Canadian ethanol production, and it will be an increasing share of feedstock as more Western plants come online. Of wheat production of 28.6 mt in 2008/09, only 2% or 571,000 tonnes, went to ethanol. Production patterns of Canadian wheat farmers are expected to change from high protein/low starch varieties used by the milling industry, to low protein/high starch varieties preferred by ethanol producers. The Canadian Wheat Board, which controls the sale of wheat for human consumption, will have no involvement in the marketing of wheat for ethanol. It is estimated that there is potential for 4.1 million litres ethanol from Western Canada; 600,000 l from cereal residues, 1,182,000 l from cereal grain (10% of crop) and 2,350,000 l from perennial biomass[18].

[17] Field Crop Reporting Series- March 31, 2010- Statistics Canada Catalogue no. 22-002-x
[18] Ibid 15

3.2.2. Biodiesel Feedstock

A 2% federal biodiesel mandate will alter the feedstock outlook for biodiesel. In 2007 feedstocks for biodiesel included 35 million litres of animal fats and 18 million litres of imported palm oil, as shown in Table 3.6. Abundant canola and soy beans can be used, but these crops are priced as food oils in international markets and sometimes carry a high price. Canola is in high demand as healthy oil by the food industry. Rendered oils (yellow grease), rendered animal fats (tallow) and palm oil are priced as feed and industrial use and carry a low price. If canola prices are too high, sometimes palm oil must be imported as a feedstock. Recent estimates suggest that there are more than 100,000 tonnes recycled cooking oils, 500,000 tonnes rendered oils from animal fats and more than 800,000 tonnes vegetable oil, totaling 1.5 million tonnes, are available for biodiesel production or export. Canada's canola production in 2008/09 was 12.6 MT, 40% higher than 9.0 MT in 2006/07, however canola exports grew from 5409 MT to 7908 MT over the same period. Some canola production cannot be sold as a food if it has been frozen or has other deficiencies, and this canola can be used for energy. The maximum potential biodiesel production based on 35 million ha in canola production and 10% of the crop in biodiesel is 2,620 million litres.

Table 3.6 Biodiesel Feedstock- million litres

	2005	2006	2007
Soybean Oil	0	0	0
Canola Oil	0	0	1
Palm Oil	0	0	18
Animal Fats	0	35	35
Recycled Veg. Oil	0	0	42

3.3. Municipal Solid Waste

In Canada, 33.2 million tonnes of municipal solid waste was generated in 2004[19], a 13% increase over 2000. 13.4 million tonnes were from households (418 kg/capita), the remainder in all other sectors. Of 33.2 million tonnes generated, 7.9 million tonnes (24%) were recycled or composted, 24.5 million tonnes were landfilled, and 763,000 tonnes were thermally treated. In 2002, 29% of disposed MSW was paper, 28% organics, 9% plastics, 7.6% wood, and 8% metals and glass. There are 7 main treating installations (5 with energy recovery, 2 without); 1 in PEI, 3 in Quebec, 1 in Ontario, 1 in Alberta, and 1 in BC. Emerging technologies at demonstration scales are;

- Plasco: Plasma technology producting Syngas (City of Ottawa)
- Enerkem: Gasification technology (City of Edmonton)

On Aug 31 2010 Enerkem started construction on its MSW to ethanol facility that will use 100,000 tonnes MSW to produce 35 million litres ethanol annually. This sized facility is economic for any city over 100,000 population, of which there are 35 in Canada.

[19] Overview of Municipal Solid Waste Management in Canada, A. David, Environment Canada Oct 2007

4. Use of Biomass

What are the current uses of biomass, how much is used, and what are the trends for the future? In 2008 Canada had 81.5 GW of capacity from renewable sources including 77.5 MW electric, 3.7 MW thermal and .3 MW biofuels, as shown in Table 4.1. 86% of renewable energy came from large hydro, 6% from small hydro, and 6% from biomass, most of which was from wood residues primarily at pulp mills and independent power producers. Only 3% was from wind, and 0.3% was from biofuels.

Table 4.1 Renewable Energy Capacity 2008 (MW)[20]

	Electric	Thermal	Elec & Thermal	Liquid Fuels	Total	
Large Hydro	69,999.5		69,999.5		69,999.5	85.9%
Small Hydro	3,396.4		3,396.4		3,396.4	4.2%
Biomass Wood Residue	1,446.0	3,359.1	4,805.1		4,805.1	5.9%
Biomass Other	93.3	0.0	93.3	152.2	245.5	0.3%
Total Biomass	1,539.4		4,898.4		4,898.4	6.0%
Wind	2,449.2		2,449.2		2,449.2	3.0%
Biogas	53.4	275.4	328.9	118.9	447.7	0.5%
Other	70.2	53.2	123.4		123.4	0.2%
	77,508.0	3,687.7	81,195.7	271.0	81,466.8	

4.1. Heat and Power

Wind power proponents tout capacity, never production. Wind cannot produce renewable heat, only power, and only at low efficiency. Biomass produces renewable energy on demand, and can produce renewable heat, power, fuels and bio-chemicals. Table 4.2 shows production of renewable energy in 2008; 94% for electricity, 5.6% for thermal uses, and 0.4% for liquid biofuels. Biomass produced 32.2 TWh of energy, or 7.6% of all renewable energy, compared with wind, which produced 6.7 TWh, or 1.6%. 70% of biomass energy was thermal, 30% electrical.

Table 4.2 Renewable Energy Production 2008 (GWh)[21]

	Electric	Thermal	Elec & Thermal	Liquid Fuels	Total	
Large Hydro	361,356		361,356		361,356	85.6%
Biomass	9,829	21,448	31,277	972	32,249	7.6%
Small Hydro	18,140		18,140		18,140	4.3%
Wind	6,677		6,677		6,677	1.6%
Biogas	340	1,765	2,105	762	2,867	0.7%
Other	421	319	740		740	0.2%
	396,763	23,532	420,295	1,734	422,029	
	94.0%	5.6%	99.6%	0.4%		

[20] A Review of Renewable Energy in Canada, 2008- CIEEDAC, March 2010
[21] A Review of Renewable Energy in Canada, 2008- CIEEDAC, March 2010

Sometimes large hydro is not considered in "new renewable energy". Not including large hydro, 53% of renewable heat and power production in 2008 was from biomass, 31% from small hydro, 11% from wind, and 4% from biogas, shown in Fig 4.1.

Fig 4.1 New Renewable Heat and Power Production (TWh)

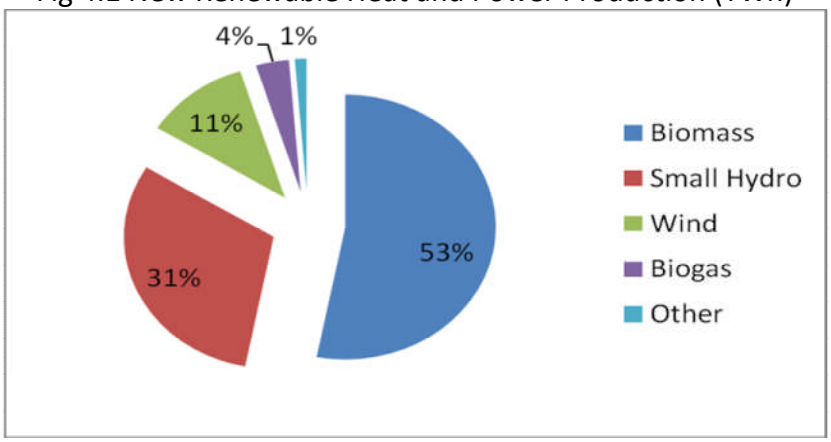


Table 4.3 shows renewable energy by province. Quebec has the highest capacity of renewable energy because of its large hydro projects. Ontario has the largest biomass capacity at 2021 MW, largely cogeneration at pulp mills and independent power producers. BC is second in biomass capacity at 1601 MW.

Table 4.3 Renewable Energy Capacity by Province 2008 (MW)

	Conven Hydro	Lo-Impct Hydro	Biomass	Wind	Solar, Tidal & Earth	Biogas	MSW	Total	w/o large Hydrp
Ontario	7,111	1,057	2,021	966	52	269	21	11,496	4,385
BC	11,744	633	1,601	0	11	118		14,106	2,362
Quebec	36,906	799	267	532	3	53		38,558	1,652
Alberta	632	242	276	438	1	5		1,593	961
New Brunswick	851	81	437	96	0			1,465	614
Saskatchewan	831	23	246	171	2	0		1,273	442
Nunavut & NWT	230	170	167	62	29	4		661	431
Manitoba	4,981	10	35	104	3	0		5,134	152
Newfdld & Labr	6,713	250	0	27				6,990	277
Yukon	0	77	0	1				78	78
Nova Scotia	0	56	0	0	0			56	56
PEI			2	53			1	56	56
Canada	69,999	3,396	5,051	2,449	100	448	22	81,466	11,466
	85.9%	4.2%	6.2%	3.0%	0.1%	0.5%	0.0%		

There is no complete, up-to-date record of bio-heat and bio-power plants in Canada. CIEEDAC has the most up-to-date list of cogeneration installations, and is now building a database of power-only and heat-only installations. Table 4.4 provides estimates of biomass power/heat capacity by installation for non wood products companies, totaling 426 MWe, and Table 4.5 shows wood products companies, totaling 1397 MWe. Data is from a number of sources, primarily CIEEDAC. Since total capacity from Tables 4.4 and 4.5 is 1823 MWe, but total capacity from Table 4.1 is 1446 MWe, either some of the plants have shut down, or Table 4.1 is incomplete, or both. CanFor, the largest softwood pulp producer in North America and 3rd largest globally, itself has installed capacity to produce 136 MWe from biomass at four pulp installations in BC, with current production at approximately 100MW$_e$. Canfor recently sold the Howe Sound Pulp mill and onsite 62MWe cogen plant in BC to Paper Excellence BV.

Table 4.4 Power & Heat Producers- Non Pulp & Paper (MW)[22]

				Capacity	
Facility	Business	City	Prov	Mwe	MWth
Capital Power		Williams Lake	BC	65	0.0
UNBC gasification plant	University	Prince George	BC	0.0	0.0
City of Revelstoke District Energy	District Energy	Revelstoke	BC	0.0	1.5
Canadian Gas and Electric Inc.	Utilities	Grande Prairie	AB	25	15.0
Whitecourt Power Partnership	Utility	Whitecourt	AB	24	0.0
Drayton Valley Power	Utility	Drayton Valley	AB	12	0.0
Fort saskatchewan Cogen project	Utilities	Fort Saskatchewan	AB	123.8	80.0
Northland Power	Utility	Kirkland Lake	ON	20	0.0
Northland Power	Utility	Cochrane	ON	13	0.0
Capital Power	Utility	Calstock	ON	35	
Robert O. Pickard Environ. Centre	Waste Mgt	Ottawa	ON	2.4	2.5
Humber Treatment Plant	Wastewater	Toronto	ON	4.7	2.9
AbitibiBowater, Thunder Bay	Paper Mfg	Thunder Bay	ON	67.0	0.0
Delta Energy Atitokan Cogen.	Biomass Power	Atitokan	ON	0.0	0.0
PLT3	Agric. Crop	Beamsville	ON	0.5	1.3
White River Biomeg LP		White River	ON	0.0	0.0
PLT2	Agric. Crop	Beamsville	ON	1.0	2.6
Rosa Flora	Agric. Crop	Dunnville	ON	1.6	0.0
St. Felicien Cogeneration Project	Power Gener.	Saint-Félicien	QC	0.0	0.0
Charlottetown District Energy	Utilities	Charlottetown	PE	1.2	
Brooklyn Power Corporation	Utilities	Brooklyn	NS	30.0	56.7
Yukon College biomass gasifier	College gasifier	Whitehorse	YK	0.0	0.0
				426.3	0.0

[22] Various sources; CIEEDAC- 2010, company websites.

Table 4.5 Power & Heat Producers- Pulp & Paper (MW)[23]

				Capacity	
Facility	Business	City	Prov	Mwe	MWth
Louisiana Pacific EWP Power Plant	Wood Products	Golden	BC	7.5	18.8
Tembec Industries Inc.	Pulp Mill	Cranbrook	BC	58	
Neucel Speciality Cellulose	Paper Mfg	Port Alice	BC	15	97.5
Cariboo Pulp & Paper Co., DMI	Paper Mfg	Quesnel	BC	32	387.9
Nanaimo Forest Products	Paper Mfg	Nanaimo	BC	30	
Catalyst Paper, Crofton	Paper Mfg	Crofton	BC	38.7	45.3
Domtar	Pulp	Kamloops	BC	70	1,058.0
Catalyst Paper, Powell River	Paper Mfg	Powell River	BC	36	254.5
Celgar	Paper Mfg	Castlegar	BC	52	342.8
Canfor Northwood Pulp- STG- A	Pulp	Prince George	BC	27.4	
Canfor Northwood Pulp- STG- B	Pulp	Prince George	BC	28.0	
Canfor	Pulp	Prince George	BC	60.0	
Canfor	Pulp	Intercon	BC	12.0	
Howe Sound	Paper Mfg	Port Mellon	BC	112.5	414.6
Skookumchuck	Pulp	Skookumchuck	BC	58.5	276.6
Kamloops Pulp	Pulp	Kamloops	BC	69	
Tolko Industries Ltd, Armstrong Div.	Wood Products	Armstrong	BC	14	33.0
Tolko Industries Ltd, Kelowna Div.	Wood Products	Kelowna	BC	12	55.6
Krüger Products LP	Tissue	New Westminister	BC	0.0	
DMI Peace River Pulp Division	Market Kraft pul	Peace River	AB	45	
West Fraser Timber, Hinton Pulp Mill	Paper Mfg	Hinton	AB	51	
Alberta Pacific Forest Industries	Pulp	Boyle	AB	96	695.7
Weyerhaeuser	Paper Mfg	Grande Prairie	AB	35	
Tolko	Paper Mfg	La Pas	MB	22	
Domtar Inc.	Paper Mfg	Espanola	ON	25	
AbitibiBowater, Fort Frances	Utilities	Fort Frances	ON	45	39.9
Sonoco Can Corp	Paper Mfg	Brantford	ON	3.8	13.9
Tembec Industries, Spruce Falls	Newsprint	Kapuskasing	ON	15	
Tembec Inc, Chapleau Co-Gen.	Power Plant	Chapleau	ON	7.2	
Tembec	Paper Mfg	Temiscaming	QC		
Fibrek	Pulp	St. Felicien	QC	29	
Boralex	Paper Mfg	Dolbeau	QC	28	126.0
Domtar Inc.	Paper Mfg	Windsor	QC	32	309.4
Temiscaming	Multi-Products	Temiscaming	QC	12	
Kruger Énergie Bromptonville (under Constr)		Bromptonville	QC	26	100.5
UPM Kymmene Miramichi Inc.		Miramichi City	NB		
AV Cell	Paper Mfg	Atholville	NB	21	121.0
Irving Pulp	Paper Mfg	Saint John	NB	33	310.6
AV Nackawic Inc.	Paper Mfg	St. Anne Nackawic	NB	25	176.1
Twin Rivers Paper Company	Paper Mfg	Edmundston	NB	46	156.8
Minas Basin Pulp And Paper Ltd.	Paper Mfg	Huntsport	NS	6.4	
Northern Pulp Nova Scotia	Pulp	Pictou County	NS	25.7	82.2
New Page	Paper Mfg	Port Hawkesbury	NS	17.5	
Taylor Lumber		Middle Musquodoboi	NS	1.1	
Corner Brook Pulp & Paper Ltd.	Paper Mfg	Corner Brook	NF	17.5	120.0
				1,396.9	

[23] Various sources; CIEEDAC-2010, company websites.

The 65MWe Williams Lake biomass cogen plant in central BC, formerly owned by Epcor but now by Capital Power Income LP, is the largest cogen plant in Canada. In 2008 Boralex, a major biomass power producer in Canada and the US, ran its Senneterre and Dolbeau cogen plants at below capacity due to the inability of AbitibiBowater to supply contracted amounts of mill residue. In 2010, Boralex began to use old bark piles owned by AbitibiBowater for up to 40% of the feedstock at Senneterre. Including its US plants, Boralex now sources 83% of its fibre from forest residues, and finds them equal to or better than mill residue in quality. AbitibiBowater just completed a 55MWe heat and power plant at Fort Frances Ontario. It uses harvest residues and slash piles for up to 50% of the feedstock mix, compared with planned 25%. NewPage, North America`s largest producer of coated papers, is seeking approval from the Nova Scotia Power Board to build a 60 MWe biomass cogeneration plant at its Port Hawksbury pulp mill, to replace the existing 17MWe facility. NewPage is optimistic that the environmentally beneficial project will be approved, but Nova Scotia authorities are being influenced by environmental activists that harvest practices in the province including harvest residues, are unsustainable, while studies by Canadian Forest Service experts show that they are.

4.2. Biofuels Production

4.2.1. Ethanol

In 2004, Canada had 5 ethanol plants producing 230 million litres (ml) of ethanol, primarily from corn. As a result of government policies, by 2007 there were 12 plants with total capacity of 890 ml; 611 ml from corn, and 274 ml from grain. Three more plants came on-stream in 2008 adding 500 ml for a total built capacity of 1,390 ml. Actual production reached 1 million litres in December 2008. In 2009, a Saskatchewan plant added 25ml. Four plants under construction will bring capacity to 1,931 ml, as illustrated in Fig 4.2. Engineering is currently underway for a 200 ml expansion for corn-based ethanol in Sarnia Ontario. Canada's target for 5% ethanol in gasoline requires 1.4 ml ethanol. This target will be reached with capacity now underway.

Figure 4.2 Projected Ethanol Capacity

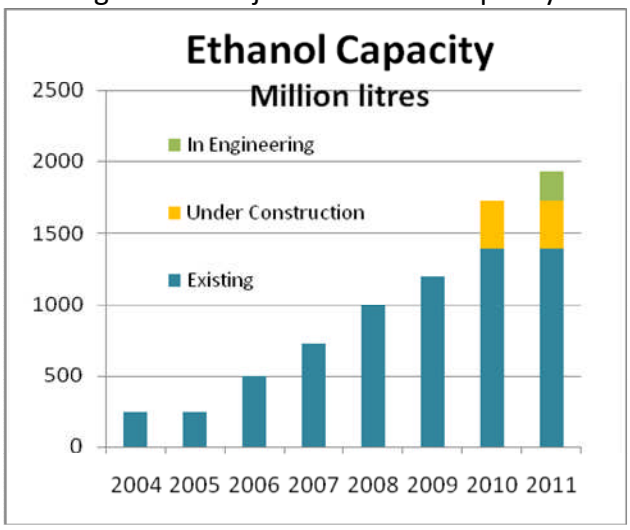


Table 4.5 shows the location, company, feedstock and capacity of Canada's ethanol plants. As of Oct 2009 there are 16 plants in operation with a combined capacity of 1415 ml; 7 in Ontario, 2 in Quebec, 5 in Saskatchewan, and one each in Alberta and Manitoba. All of the eastern plants use corn as a feedstock except Enerkem, which will use wood poles after the ethanol module is in operation, and Iogen, which uses a mix of straws in its demonstration plant. All the plants in the west use wheat as a feedstock, except Husky in Manitoba, which also uses some corn.

Table 4.5 Ethanol Plant Capacities-Sept 2009 (million litres)[24]

Map	Plant	Province	Company	Start	Feedstock	Capacity
5	Tiverton	Ontario	Greenfield Ethanol	1989	Corn	26
17	Lanigan	Sask	Poundmaker	1991	Wheat	12
16	Red Deer	Alberta	Permolex	1996	Wheat	40
6	Chatham	Ontario	Greenfield Ethanol	1996	Corn	150
12	Ottawa	Ontario	Iogen	2004	Straw	2
2	Westbury	Quebec	Enerkem	2005	wood waste	5
14	Weyburn	Sask	NorAmera BioEnergy	2005	Wheat	25
18	Sarnia	Ontario	Suncor St. Clair	2006	Corn	200
9	Lloydminster	Sask	Husky	2006	Wheat	130
4	Varennes	Quebec	Greenfield Ethanol	2007	Corn	120
10	Minndosa	Manitoba	Husky	2007	wheat, corn	130
1	Collingwood	Ontario	Amaizelingly Green. L.P	2007	Corn	50
19	Belle Plaine	Sask	Terra Grain Fuels	2008	Wheat	150
3	Johnstown	Ontario	Greenfield Ethanol	2008	Corn	200
11	Aylmer	Ontario	IGPC	2008	Corn	150
15	Unity	Sask	North West Terminal Ltd.	2009	Wheat	25
					Total:	1415
	Under Construction:					
13	Havelock	Ontario	Kawartha Ethanol	constr.	Corn	80
7	Hensall	Ontario	Greenfield Ethanol	constr.	Corn	200
8	Edmonton	Alberta	Enerkem/Greenfield	constr.	MSW	36
18	Sarnia	Ontario	Suncor Expansion	planned	Corn	200
	Prince Albert	Sask	Iogen Commercial	planned	wheat/barley	100

Three plants in Ontario with combined capacity of 316 ml are under construction, with these plants possibly awaiting funding announcements from the ecoENERGY Biofuels Program. On Aug 31, 2010 construction officially began on the next generation biofuel plant by Enerkem in Edmonton. Fig 4.3 gives the location of these plants.

[24] Canadian Renewable Energy Association- web site http://www.greenfuels.org/

Figure 4.3- Locations of Biofuel Plants

Quebec outlawed any future corn ethanol plants, but Quebec-based Enerkem is a world leader in 2nd generation ethanol technology. In all likelihood all future ethanol plants in Quebec will be 2nd generation. Enerkem is leading the way. After testing its Sherbrooke plant using various feedstocks and producing 0.5 million litres annually of alcohols, Enerkem built a commercial demo plant at nearby Westbury that will produce 5 million litres annually made from old utility poles. The syngas island is in production 24-7. Methanol production will begin in 2010, ethanol in 2011. Construction has begun on a plant in Edmonton that will use 100,000 tonnes p.a. of MSW to make 36 ml of ethanol.

Lignol Innovations is commercializing its proprietary bio-refining technology for the production of fuel-grade ethanol and biochemical co-products from non-food lignocellulosic biomass feedstocks. The technology has been fully demonstrated in a complete end-to-end industrial scale pilot bio-refinery located in Burnaby BC that Lignol operates on various feedstocks to generate test quantities of products and engineering design data. Lignol is the recipient of $30US million grant which will go towards the construction of a commercial demonstration facility in the US Pacific Northwest.

4.2.2 Biodiesel

Canada consumes 26 billion litres of diesel fuel per year. Production of biodiesel went from 6 million litres in 2006 to almost 100 million litres in 2007-08 due to new capacity and expansions. Capacity reached 141 ml in 2009 after a plant in Delta BC added 10 ml annually. A 2% renewable mandate for 2012 would require a 4-fold increase in production to 520 ml per year. As of mid 2010 there are 6 plants under construction that will add capacity of 330 ml of biodiesel; 4 with a combined capacity of 259 ml will

use canola oil as a feedstock, and 2 will use a mix of feedstocks which will added an additional 71 ml. Total built capacity will be 471 ml, as shown in Fig 4.4. Table 4.6 lists biodiesel plants, both operating and those under construction.

Figure 4.4

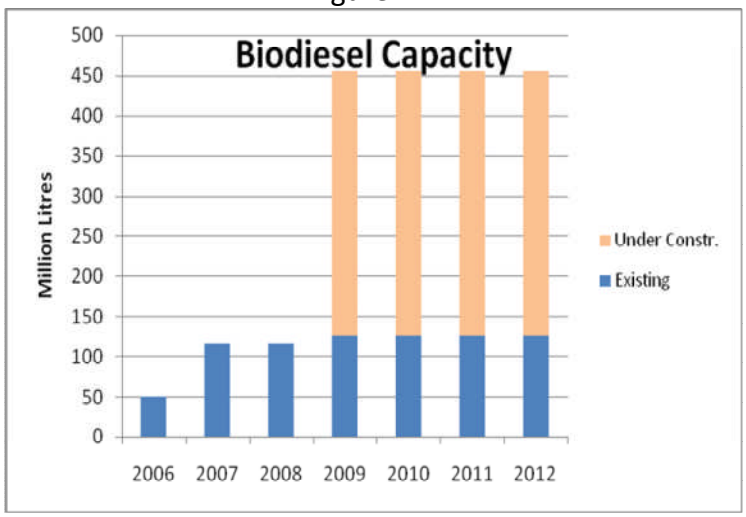


Table 4.6 Biodiesel Plant Capacity (million litres)- as of mid 2009

Map	Company/Plant	Plant	Province	Start	Feedstock	Capacity
29	Milligan Biotech	Foam Lake	Sask	1996	canola	1
30	Rothsay	Montreal	Quebec	2005	tallow, yel. grease	35
31	Western Biodiesel	Calgary	Alberta	2005	multi-feedstock	19
22	BIOX	Hamilton	Ontario	2006	multi-feedstock	66
21	Biodiesel Quebec	St-Alexis	Quebec	2008	yellow grease	10
23	City-Farm Biofuel Ltd.	Delta	BC	2008	recycled oil, tallow	10
						141
	Under Contruction in mid 2009:					
27	Kyoto	Lethbridge	Alberta	constr	multi-feedstock	66
24	Canadian Bioenergy	Sturgeon	Alberta	constr	canola	225
20	Bifrost Bio-Blends	Arborg	Manitoba	constr	canola	3
25	Eastman Biofuels	Beausejour	Manitoba	constr	canola	11
26	Greenway	Winnipeg	Manitoba	constr	canola	20
28	Methes Energies	Mississauga	Ontario	constr	multi-feedstock	5
						330

4.3. Pyrolysis Oil

Fast Pyrolysis is a process by which small particles of biomass waste are rapidly heated to high temperatures in the absence of oxygen, vapourized, and then condensed into liquid fuel. Products of the process are typically 65-72% liquid pyrolysis oil, 15-20% solid char and 12-18% non-condensable gases, depending on the type of feedstock and other factors. Common feedstock for pyrolysis oil is forest waste such as sawdust and bark, and agricultural waste such as sugar cane bagasse, though pyrolysis oil has been made successfully from over 100 different biomass feedstocks. Fast pyrolysis oil is a brown,

free-flowing liquid fuel that has a density of 1.2 kg/litre. Its heating value is 40% of diesel by weight, 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. It is acidic, with pH 2-3, so special tanks and piping are required for storage and transportation. However, 2009/10 research has succeeded in moderating acidity to enable transportation & storage with standard materials. Canada is a leader in pyrolysis oil technology and development with two systems at a commercial scale: Ensyn Corp, Ottawa, and Dynamotive Energy Systems, Vancouver

Ensyn has been making pyrolysis oil from wood waste in the US since 1989, primarily for chemical and fuel products markets. By 2005 6 small plants were operating in Wisconsin and one in California. In 2004-7 Ensyn built its largest plant, located in Renfrew Canada. It uses 100 BDt per day of sawmill residues. Ensyn has focused on food and chemicals markets, but trends in energy prices are motivating Ensyn to enter the energy market by way of expansion. Accordingly, in June 2010 Ensyn announced a partnership with Tolko Industries, a major forest products company in Canada, whereby Ensyn would build and operate a pyrolysis plant of capacity up to 400 tpd at the Tolko sawmill in High Level Alberta. The plant would be the largest pyrolysis plant in the world. All the pyrolysis oil would be used to make power for Tolko operations, with excess being fed into the grid.

Ensyn has also embarked on a trail to make transportation fuel. Ensyn and UOP, a Honeywell Company, formed a joint venture, Envergent Technologies, in 2008 to deploy Ensyn's commercially proven RTP technology globally. The joint venture will also design and build oil-refinery-scale equipment that will allow pyrolysis oil to be upgraded to green gasoline, green diesel, and green jet fuel, with equipment available in 2011.

Dynamotive built a 100-tpd commercial scale demonstration plant at West Lorne Ontario in 2005, and in 2008 it completed a 30-tpd expansion and upgrade. The plant used up to 130-tpd of wood fibre, primarily from the adjacent Erie Flooring and Wood Products plant, to produce up to 94-tpd or 31,000 tonnes p.a. of pure Pyrolysis Oil. Some of the pyrolysis oil fueled a 2.5 MW turbine to make power for the Ontario grid, and the remainder was exported to the US to replace light or heavy oil in stationary engines. In June 2010 the plant, owned by West Lorne Bioenergy Cogen, was put into receivership, a victim of the economic downturn, the lengthy bureaucratic process to allow alternative biomass feedstocks, and shutdowns of some of its US customers.

Dynamotive is part-owner in a 200-tpd pyrolysis oil plant in Guelph, Ontario, completed in 2007. It is the largest pyrolysis oil plant in the world, built to use post-industrial wood from Megacity recycling operations in Toronto. With insufficient customers to justify running, and it is now sitting idle. Dynamotive demonstrated its technology in two commercial-size plants, and it will now focus on its main business- licensing technology.

The first markets for pyrolysis oil were small chemicals and food products markets. Later markets were replacing light and heavy fuel oils in stationary engines for industrial

heating, and producing power in specialized turbines. However, pyrolysis oil is still essentially a new product and building energy markets has been a slow process. It can easily be transported long distances and co-fired in large energy plants, but lengthy trials must first prove the advantages and minimize any difficulties with pyrolysis oil.

Recent research proved pyrolysis oil as a feedstock to produce green gasoline in existing refineries. In 2009, Dynamotive successfully produced renewable gasoline and diesel through a 2-stage upgrading process. Pyrolysis oil was hydro-reformed to a stage-1 gas-oil equivalent liquid fuel that can be blended with hydrocarbon fuels for stationary power and heating applications, or further upgraded in a stage-2 hydrotreating process to make green gasoline or diesel. Dynamotive estimated it could deliver 2nd generation biofuels at $2US/gal (0.38€/litre) ethanol-equivalent fuel from a 200-tpd plant. Green gasoline may supplant heating and stationary engines as primary markets.

The byproduct of fast pyrolysis is char, the remains of solid biomass that has been incompletely combusted, a black powder and similar to charcoal. Char is 65-76% carbon by weight, 5-12% ash, and less than 2% moisture. It has heat value of 28-30GJ/tonne. It is a charcoal powder with particle size less than 1 mm, and has bulk density of 0.25-3 tonnes/m^3. Dynamotive has just completed a year-long test in the application of biochar into commercial framing test plots that increased crop yields from 6% to 17%. Char is also a candidate feedstock for the production of carbon nanotubes.

4.4. Wood Pellets

Manufacture and export of wood pellets in Canada has grown exponentially in the past several years, primarily on the west coast. As shown in Table 4.7, capacity grew from 500,000 tonnes in 2002 to 2.1 MT in 2009, #4 in the world behind the US (4.1 MT), Germany (3.0 MT) and Sweden (2.2MT)[25]. Canadian pellet production declined in 2008 because of the severe shortage of mill residues due to the economic downturn. For many pellet manufacturers, the primary fibre source is now harvest debris and non-commercial roundwood, in some cases 70% of feedstock, supplemented by mill residues. Supply chains to draw from this source have not been fully developed. Raw material costs have increased 3-4 fold, requiring export contracts to increase 30-40% in order to sustain financial viability for pellet mills. Ontario, Quebec and BC are all working with mechanisms to ensure sufficient fibre for pulp mills, sawmills, pellet plants and other uses. Pellet production is was 1.4 million tonnes in 2009 compared to capacity of 2.1 million tonnes. Pellet production can reach 20 million tonnes sustainably[26].

Table 4.7 Canadian Pellet Manufacturing- 000 tonnes p.a.

	2002	2003	2004	2005	2006	2007	2008	2009
Capacity	500	540	730	950	1,300	1,600	2,085	2,083
Production	499	533	727	936	1,135	1,485	1,335	1,400

[25] Bioenergy International- Dec 2009
[26] John Swaan

There are 33 pellet plants operating in Canada as shown in Table 4.8; BC-12, Alberta-3, Ontario-1, Quebec-5, New Brunswick- 6, Nova Scotia-3 and Newfoundland-3. Pinnacle Pellet is the dominant producer, operating four plants in BC, and in partnership with CanFor and the Moricetown First Nations in the 150,000-tonne plant in Houston.

Table 4.8- Pellet Plants in Canada- 000 tonnes

	Name	City	Province	(tonne/yr)
1	Northwest Wood Preservers	Vanderhoof	BC	30,000
2	Pacific BioEnergy	Prince George	BC	180,000
3	Pinnacle Pellet - Armstrong	Armstrong	BC	50,000
4	Pinnacle Pellet - Meadowbank	Strathnaver	BC	200,000
5	Pinnacle Pellet - Quesnel	Quesnel	BC	90,000
6	Pinnacle Pellet - Williams Lake	Williams Lake	BC	150,000
7	Houston Pellet	Houston	BC	150,000
8	Premium Pellet	Vanderhoof	BC	140,000
9	Princeton Co-generation	Princeton	BC	90,000
10	SBC Firemaster	Kamloops	BC	30,000
11	Westwood Fibre Products	Kelowna	BC	50,000
12	Highland Pellet Manufacturing	Merritt	BC	29,000
13	Foothills Forest Products	Grande Cache	AB	25,000
14	La Crete Sawmills	La Crete	AB	35,000
15	Vanderwell Contractors	Slave Lake	AB	60,000
16	Gildale Farms	St Marys	ON	4,000
17	Granule Boreal	Amos	QC	50,000
18	Energex Pellet Fuel	Lac Megantic	QC	120,000
19	Lauzon Recycled Wood Energy	St-Paulin	QC	30,000
20	Lauzon Recycled Wood Energy	Papineauville	QC	40,000
21	Granules LG	St-Felicien	QC	50,000
22	Crabbe Lumber	Bristol	NB	40,000
23	Marwood	Tracyville	NB	10,000
24	Nashwaak Valley Wood Energy	South Portage	NB	17,500
25	Shaw Resources	Belledune	NB	75,000
26	TP Downey	Hillsborough	NB	40,000
27	Groupe Savoie	St-Quentin	NB	55,000
28	Enligna	Middle Musquidoboit	NS	105,000
29	Shaw Resources	Shubenacadie	NS	90,000
30	Finewood Flooring	Baddeck	NS	10,000
31	Cottles Island Lumber Company	Summerford	NL	12,000
32	Exploits Pelletizing	Bishops Falls	NL	15,000
33	Holson Forest Products	Roddickton	NL	10,000
				2,082,500

BC and Nova Scotia plants sell primarily to European power plants. The market for Canadian pellets in the US North East has dried up owing to the BCAP incentive in the US that provides US pellet producers a $50/tonne feedstock advantage. New Brunswick plants are forced to sell to the EU. Biomass co-firing in coal power plants is uncommon in Canada and not widely accepted. In a case of sheer ridiculousness, the Belldune pellet plant in New Brunswick ships all of its pellets to Europe, yet the plant is adjacent to a New Brunswick coal power plant that imports all its coal.

Pellet production in 2010 is running at an annual level of 1.4 million tonnes, 67% of capacity. However, due to expectations on future markets there are a large number of new pellet plants in the late stages of planning and financing. In BC there are several proposals to use wood killed by the Mountain Pine Beetle to feed new large pellet plants for export markets. In Ontario, OPG (Ontario Power Generation) is committed to phasing out coal-based power production by Dec 2014 and is planning to convert several units to biomass. It will close two units at the 1920 MW Lambton generating station and two units at the 3640 MW Nanticoke generating station in late 2010. It plans to convert the 211MW Atikokan power station to pellets beginning in 2012, which will need 90,000 tonnes of pellets. OPG could require 2-3 million tonnes pellets if it also converts one unit at Thunder Bay, two units Nanticoke, and units at Lambton.

4.5. Trends in Biomass Production and Consumption

Go Pellets Program:
90% of Canadian pellet production is exported to the EU, and pellet producers are paid in Euros. In the last several months the Euro has plummeted almost 20% relative to the Canadian dollar, so plant owners received a far lower mill net for pellets than in 2009. In the US the Biomass Crop Assistance program essentially reduced the cost of fibre to US pellet plants to such an extent that Canadian suppliers became uncompetitive in this market. To improve markets for Canadian pellets, the Canadian Bioenergy Association, with the support of the Wood Pellet Association of Canada, is preparing a strategy to implement Go Pellets, a program to promote domestic use of pellets. It is still expected that most pellets will be exported.

Densified Pellets:
Canada expects to begin construction on a 30,000 tonne demonstration plant in late 2010 that will produce a dense pellet with 15-20% more energy by volume than normal wood pellets, significantly reducing the cost of ocean transportation. The pellet would also water proof, thus making storage and transportation easier.

Torrefied Wood:
While Europe is buying pellets, they are talking torrefied wood and pyrolysis oil. While pellet markets will continue to grow, there is keen interest in torrefied wood because it is more energy dense than pellets and water proof, thus easier to store and handle and cheaper to transport long distances. There are several proposals to build torrefied wood

plants in Canada, some at the financing stage. Alterna Energy already has technology to produce `wood coal`, a torrefied wood-like product.

Cyclical Reduction in Residue Production:
Historically 80% of Canadian lumber has been exported to the US. The housing crisis in the US and the resulting decline in housing starts sharply reduced US demand for lumber. Also, the rising Canadian dollar vs. the US dollar has made Canadian mills less competitive forcing the closure of many Canadian sawmills, particularly small ones. Since mill residue is a by-product of lumber production, there has been a huge decline in mill residue production from 83.5 million m^3 in 2004 to 45 million m^3 in 2009, shown in Table 4.9. Sawmill production began to recover in the first half of 2010 and mill residue production is expected to grow by 5 million BDt 2009-2011.

Table 4.9 Mill Residue Production- Sawmills

Production	2004	2005	2006	2007	2008	2009	2010LE	2011 Est
Lumber (000m3)	83,514	82,890	78,222	71,844	58,693	45,068	52,576	65,000
Mill Residue (000 BDt)	21,229	21,070	19,884	18,263	14,920	11,456	13,365	16,523

Community Heat:
Charlottetown PEI has had a district heating system for. e s

Pulp Mills:
Many pulp mills use internally generated residue and also residue purchased from surrounding sawmills for heat and power. Since 2005 there have been several pulp mill shutdowns, which often resulted in closure of bioenergy facilities. Full closures free up biomass that mills formerly absorbed from local sawmills. Partial closures may result in their purchasing either more or less residues from local sawmills. More recently the Forest Products Association has begun implementing a "bio-pathways" program whereby pulp mills will begin transforming to produce bioenergy, bio-chemicals and other bio-products, in favour of traditional commodity products.

Calls for Power:
European incentives have been a key driver for turning residue into pellets for export. The provinces now are seeing environmental and socioeconomic benefits of bioenergy and are providing incentives for power from biomass. The Ontario Standard Offer programs provide superior rates for new renewable power, and BC and Quebec have issued “calls for power” with bid rates. However, so far these programs have yielded only a few projects aligned with pulp mills. If provinces begin providing incentives for renewable heat, more projects will be built.

Use of Harvest Waste and hog piles:
With the ceiling for mill residue now reached, hog fuel piles and forest residue are seen to be the new sources for energy wood. BC is now promoting use of harvest waste and in standing MPB wood. In its call for power BC Hydro requested a feedstock plan

including mill residue, harvest waste and standing timber. In Ontario the 50 MW Abitibi-Bowater biomass cogen facility at Ft. Frances has started up, harvest slash forming a much higher proportion of the feedstock than originally planned. This mill will pave the way for use of harvest waste in energy plants in Ontario. In future, cogen plants will also draw on existing hog fuel piles to complete their feedstock mix. Boralex Senneterre is drawing on hog piles now.

European Incentives:
Strong European incentives will continue to drive bioenergy activity in any region with a port. BC policy supports both domestic power AND exportable products such as pellets. Quebec wants to find viable uses for its large amount of harvest waste, and will consider power or transportable products. New Brunswick has roadside biomass and 12-month ocean ports, however, whether harvest slash will be used to make transportable products or local heat and power is open to conjecture. A large amount of biomass is privately owned by JD Irving, which may use its energy internally. Nova Scotia has no roadside harvest waste, only insitu, and this source has not been part of current government thinking. However, private wood harvesters are already planning projects that will make pellets from standing timber, in situ slash, and small amounts of mill residue. Newfoundland has surplus mill residue, hog fuel piles, unused annual allowable cut, and 12-month ocean ports. It can become a biomass product centre.

Alternative Transportable Products:
Pellets will utilize white mill residue, harvest residue, standing timber, and eventually a proportion of bark. Heat and power projects can use bark, hog piles, mill sludge, and any mill residue that remains. Pyrolysis oil can use just about any woody or agricultural material as a feedstock. Although Ensyn has produced pyrolysis oil for 20 years, it is still not a widely known product. However, EU power plants want Gigajoules from renewable biomass at the lowest possible cost, whether it be pellets, torrefied wood or pyrolysis oil. Pyrolysis oil is twice as energy dense as wood pellets and ultimately will be half the cost of pellets to ship. In addition, though pyrolysis oil is currently acidic with pH 2-3 and requiring special piping and storage containers, in a year pyrolysis oil will be sufficiently pH neutral so that no special transportation and storage materials will be needed. Pyrolysis oil exports may one day rival pellets.

4.6. MSW

Though much waste still goes to landfill, some communities do have limited combustion programs. Concerns about emission of particulates led to a decline in support for MSW incineration; however this reflects open incineration common in small communities. Modern combustion technology shows emission of particulates to be manageable and there are obvious benefits in energy capture and reduced need for landfills.

The City of Charlottetown in Prince Edward Island built Canada's first MSW to energy facility, three small district heating plants in 1981–85. The first system burned all the provinces municipal solid waste to provide steam heat to a hospital, a second burned

woodchips to provide steam and hot-water heat to buildings in the downtown area, and a 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-art emissions controls were installed at that time. A 1.2-MW turbine generates electricity to operate the plant with any surplus is exported to the grid. The capacity is 1.2 MW of electricity and 33 MW heat, fueled 41% from MSW, 42% from wood residue and 17% from oil.

There are 8 MSW treatment centres as shown in Table4.10. Six produce usable energy, two do not. Four produce a total of 26 MW of electricity, or 9.6 MW from an average biomass fraction of 37% in MSW. Three plants also produce 1,688 TJ heat.

Table 4.10 Energy from MSW Biomass[27]

			MSW		Biomass Energy	
	Owner	Location	tpd	2006	MWe	Heat (TJ)
1	GVRD	Vancouver	720	273318	4.9	867
2	Algonquin Power	Peel	455	147700	2.5	0
3	Incinerateur de Quebec	Quebec	920	293300	0.0	639
4	Trigen	Charlottetown	99	25623	0.4	183
5	Wainwright Energy	Wainwright-AB	27	3681	0.0	?
6	Incinerateur de Levis	Levis- QC	80	24768	0.0	0
7	MRC des Iles de la Mad.	Iles d.l. Madelaine	31	4500	0.0	0
8	Plasco (2008)	Ottawa	85	30600	1.8	0
	Total				9.6	1,688

Enerkem of Montreal and Greenfield Ethanol have entered into a joint venture to produce ethanol from MSW. They have concluded a 25-year contract with the City of Edmonton for 100,000 tonnes annually of MSW and will produce 36 million litres of ethanol. Phase 1 construction started in August 2010.

5. Biomass Prices

There have been no definitive surveys of biomass pricing since a 2005 Nation Mill Residue Study [28], and an update of Ontario pricing in 2007.

5.1. Mill Residue and Hog

A commodity market for biomass does not yet exist, and there is no “market” price. Before 2005 many sawmill owners were happy to have biomass removed from the

[27] Municipal Solid Waste Thermal Treatment in Canada (2006)- Genivar Ontario Inc Mar 2007. Updated for Plasco in 2008.

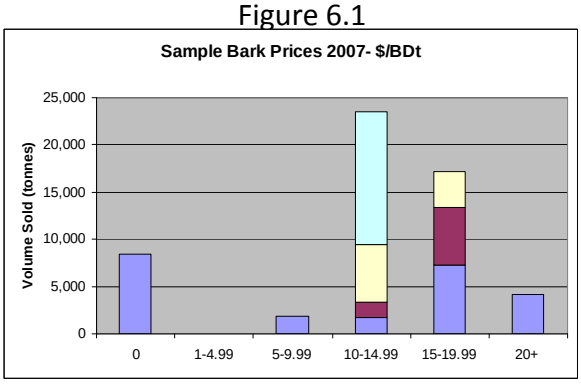
[28] Estimated Production, Consumption and Surplus Mill Wood Residues in Canada 2004- Nov 2005- Natural Resources Canada/Forest Products Association of Canada

property at no charge. With growth in demand for biomass by pellet manufacturers, power companies, and landscaping companies, more and more sawmill owners became aware of its value. They stopped selling biomass under 10-15 year agreements and began to sell only on short-term contracts, sometimes keeping some for the spot market to get the highest price. Prices for mill residue are set by negotiation and are usually for a maximum of one year, sometimes even one load. There is a tremendous range in prices. As shown in Table 5.1 and Fig 5.1, some bark was given away in 2007, while some sold for up to $22.50/BDt (15€). The weighted average for price for bark was $13.80/BDt (9.2€). Sawdust sold in the $2.90-32.50/BDt range, with the average $23.60/BDt (15.7€). In 2010 prices for bark are believed to be $30/BDt, and sawdust $35-40/BDt. In 2007 in Ontario, most historic mill pile bark was given away, but the weighted average price was $2/BDt (1.3€). While volumes of relatively uncontaminated, dry bark piles are estimated at over 20 million BDt, very little is actually being harvested, mostly in Quebec.

Table 5.1- 2007 Prices Eastern Ontario

- $/BDt			
	Low	High	Avg
Bark	0	22.50	13.80
Sawdust	2.90	32.50	23.60
Bark Piles	0	7.80	2.00

Figure 6.1



5.2. Forest Harvest Waste and Standing Timber

Currently all of the forest products provinces are examining options to allow harvest waste to be taken away for energy. In Ontario, long-term contracts for standing non-commercial timber for will begin to be awarded in the fall of 2010, with a preference for biomass projects that can support the fledgling forest industry, otherwise provide the most jobs within the local community, and have First Nations involvement. The province will not charge stumpage for this wood. Harvest residues must still be acquired through business-to-business arrangements with the holder of Sustainable Forest Licenses.

There will be a range in costs to gather and transport forest harvest residue, the most expensive being unharvested wood on Crown land in remote locations, the lowest cost

being roadside slash on private lands. Generally, Crown wood is more expensive than private wood due to fees and mandatory costs for forest management including: Crown dues (stumpage), Renewal Trust Fund, Forestry Futures Fund, road building and maintenance rules, and a number of additional environmental rules and regulations. Private lands have guidelines only for forest management.

There is a considerable volume of standing timber that can be used for biomass including non-commercial timber and wood impacted by fire, insects, disease, blow down etc. However, this wood has to bear the cost of harvesting, and thus may be a back-up wood supply only. Wood already harvested is lower cost than wood that is not. Tops and branches are already on the ground. Costs can vary greatly depending on landscape, distance to roadside, technology used, labour, and even moisture content of the slash. In BC the estimated cost of standing MPB wood is $80/BDt (53€).

FPInnovations, a forestry research group, estimated the achievable cost of the roadside slash supply chain with roadside grinding. Three cases are shown in Table56.2. If tops and branches are pre-piled at roadside in the roundwood harvest, the cost of chipping and transporting roadside residue 100 km would be approximately $43.60/BDt (29€).

Table 5.2 Roadside Waste Costs $/BDt

	Optimistic	Realistic	Pessimistic
	50 km	100 km	150 km
Pre-piling	2.64	2.64	0.00
Comminution (grind)	10.25	13.04	18.56
Transport	12.4	21.51	30.02
Stumpage	0	0.00	0.00
Road Improvement	1	3.00	7.96
Planning & Supervision	1	2.25	2.25
Overhead	0	2.25	2.25
Compliance	0	0.50	0.50
Silviculture Rebate	-3.18	-1.59	0.00
Total:	24.11	43.60	61.54

Chipping/trucking of harvest residues has been practiced for a long time in Scandinavia. Bundling technology was tested in Finland and for several years was the lowest cost method for long distance transport of residues, over 60 km. Perhaps 50-60 bundlers are operating worldwide. However, in Finland improvements were made to woodchip transportation so that it became the lowest cost method for all distances. A study in Finland proposed several enhancements to bundling technology that would enable a considerable reduction in costs, but these enhancements have not been tested.

Table 5.3 provides estimates of delivered costs of the two technologies adapted to the Canadian situation. Chipping and trucking would cost $34.49/BDt (23€) over 50 km,

while bundling would cost $38.07/BDt (25€). Cost savings are achieved through practice and innovation. Though chipping is the better option at short distances, bundling may yet become the lower cost method over longer distances after years of innovating. Costs over 100 km are estimated at $43.60/BDt (29€) for chipping but $41.76/BDt (28€) for bundling. Note that bundling is not currently practiced in Canada, and that costs can be expected to be higher in the first 1-2 years.

Table 5.3 Roadside Residue Costs 2010-15 ($/BDt)

	50 km		100 km	
	2010	2015	2010	2015
Chip	34.49	31.32	43.60	39.79
Bundle	38.07	33.99	41.76	37.39

6. Imports and Exports

6.1. Ethanol and Biodiesel

No official trade statistics exist for ethanol or biodiesel in Canada, however the World Biofuels Report-FAPRI 2010 provides viable data. In 2005-06 a small amount of trade occurred, but this was primarily cross-border trades to save east-west transportation costs. Canada imported significant amounts of ethanol beginning in 2007, in order to reach renewable fuels targets, as shown in Table 6.1. In Canada, Ethanol production passed 1 million litres in 2009, yet still imports from the US increased to 647 Ml.

Table 6.1- Canadian Ethanol Trade (Million litres)[29]

	2005	2006	2007	2008	2009	2010LE
Production	288	337	625	840	1,056	1,143
Consumption	405	379	1,120	1,465	1,703	1,878
Imports	117	42	496	625	647	734

6.2. Pyrolysis Oil

The capacity of the Ensyn plant in Renfrew is approximately 23,000 tpa pyrolysis oil. All production is exported to a customer in the US. Production and export volumes are confidential. When completed, all production at Ensyn's 400 tpd plant in Alberta will be used to produce electricity, and exports are not envisioned. For Dynamotive, a major portion of the 23,000 tonnes annual production at the West Lorne demonstration plant was fed into a 2.5 MW turbine to make power for the Ontario grid, with the rest exported to the US as a fossil fuel substitute. However, with the loss of some US customers as a result of the recession, the West Lorne plant has shut down. There are now no exports of pyrolysis oil from West Lorne.

Future markets for pyrolysis oil and prospects for export will depend totally on price. It is anticipated that Europe will have a strong demand for products such as pyrolysis oil

[29] World Biofuels Outlook:FAPRI 2010 Agricultural Outlook

for co-firing in 100% biomass plants. Europe imports over 1 million tonnes wood pellets annually, much of it from as far away as BC in Canada, yet pyrolysis oil is twice as energy dense as pellets and has an opportunity to become a favoured export fuel. Currently the UK and Belgium have dominant incentives to use biomass. Also, ocean freight costs are now at a historical low, thus promoting the alternative of exporting pyrolysis oil.

In Canada, there are incentives for renewable power, but none for bio-products, and carbon trading is still not a factor. These factors favour exporting, however, if recent research on pyrolysis oil as a feedstock for gasoline production in existing oil refineries becomes commercially viable, then it could be that domestic targets and incentives will keep a meaningful proportion of pyrolysis oil at home.

6.3. Wood Pellets

In 2002 46% of Canadian pellet production was exported to the US and 30% to Europe. By 2008, exports to the US doubled but they only comprised 25% of Canadian pellet production. In 2008, 58% of production went to Europe, including the Netherlands, Sweden, Denmark, Belgium, Italy, Ireland and Germany. In 2002-04, primary EU markets were Sweden and the Netherlands. By 2008-09, most pellets were destined to Belgium and the UK due to superior incentives in these countries for pellet utilization. Canadian pellets are often preferred owing to excellent quality and assurance of sustainability.

Though plant capacity reached 2 million tonnes in 2009, production did not rise appreciably due to the lack of mill residues. Producers began making the transition to using harvest residues and standing MPB wood, which bear a much higher cost than mill residues. In 2009, the impact of the Biomass Crop Assistance Program in the US provided US pellet producers with a $50/tonne cost advantage over Canadian plants. This advantage, combined with a strong Canadian dollar, left Canadian producers uncompetitive, and consequently they lost the US market. Exports to the US are now zero, as shown in Table 6.2. In 2009, approximately 100,000 were shipped to Japan, and 1,200 tonnes were shipped to Europe, primarily Belgium, the UK and the Netherlands.

Table 6.2 Pellet Exports- 000 tonnes

	2002	2003	2004	2005	2006	2007	2008	2009
Domestic	99	88	87	88	135	250	230	100
US	230	210	265	265	400	495	335	0
Europe	170	235	375	583	600	740	770	1,200
Japan	0	0	0	0	0	0	0	100
	499	533	727	936	1,135	1,485	1,335	1,400

In 2010, owing to the debt crisis in Greece, the Euro plummeted to new lows vs the Canadian dollar. Some Canadian pellet plants became uncompetitive, and most are having trouble making money in the pellet business, since contracts are in Euros. In BC, pellet export potential is almost limitless, but it will depend on European power plants'

ability to absorb the increased costs of fibre. Thankfully ocean shipping rates have collapsed since mid 2008, helping cost competitiveness of Canadian pellets offshore. Vast amounts of harvest slash from Mountain Pine Beetle harvest are available. Domestic markets are growing only marginally, so most of new production would be exported. BC pellets destined for Europe are loaded onto 100 tonne rail hopper cars for the coast and then loaded into cargo ships holding 4,000-15,000 tonnes. The Fibreco Terminal and Kinder Morgan Terminal in North Vancouver have capacity to handle 1 million tonnes of pellets annually and can be expanded to 2 million tonnes. Northern BC pellet plants would rail to the Ridley terminal in Prince Rupert. Trade is through the Panama Canal to Europe. Mactara in Nova Scotia exports primarily to Europe via the port of Halifax. Quebec mills also export by way of the port of Montreal, however Montreal is not a winter port.

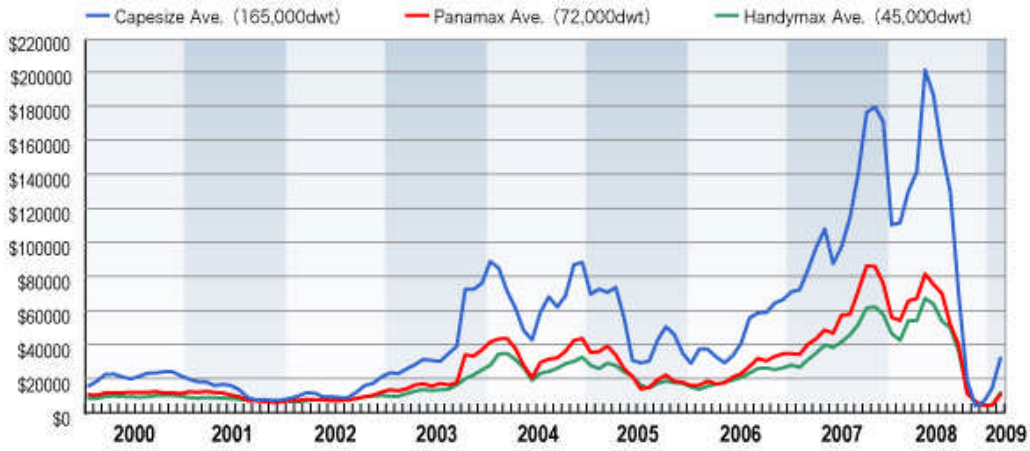
7. Barriers and Opportunities to Trade

7.1. Barriers

7.1.1. Ocean Transport Costs

High ocean freight rates are a barrier to long-distance maritime trade. As shown in Fig 7.1, charter rates for dry bulk goods, such as wood pellets, rose steeply early in the decade and skyrocketed to all time highs in 2007-08, largely due to the huge demand for shipping by Chinese manufacturing, and the inability of new shipping capacity to keep up with demand. The onset of recession in 2008 caused demand for shipping to collapse, along with prices. Pellets exported from BC travel 14,000 km through the Panama Canal, and freight costs are critical to maintaining a competitive supply. Many of the pellet exporters had 3-year contracts at low shipping rates during the period of peak prices, but when the contracts ended they were hard pressed to make a profit at new, higher freight costs. While ocean transport costs are at historically low levels now, producers are at risk to surging freight costs again. Freight costs

Figure 7.1 Dry Bulk Market Trends, time charter rates in US-$/day, Period: January 2000 - February 2009; Source: NYK Researched



7.1.2. Location of Biomass

While BC has considerable biomass and is well positioned to export, much of Canada's biomass is in the far interior, such as Ontario, too far from ocean ports. Also, with much of the centralized biomass already developed, many remaining biomass sources are smaller and widespread. In Quebec there is significant opportunity to develop a strong export presence via the St. Lawrence River corridor.

7.1.3. Exchange Rates

Exchange rates are often a barrier to trade as well as an opportunity. The collapse of the Euro in 2010 left Canadian pellets at an extreme cost disadvantage relative to pellets produced in Europe. Similarly the rising Canadian dollar relative to the $US reduced our exports to the US.

7.1.4. Funding Investments

The subprime financial crisis begun in the US has put tremendous pressure on banking worldwide. Banks have limited funds to lend, and only at higher rates. Equity investors are also limited in financial resources and often now can fund perhaps 5 in 100 biomass projects. Until the financing crisis is over, it will be difficult to add capacity for tradable bioenergy products to increase trade.

7.1.5. Four Season Ports

Vancouver and Prince Rupert in BC and Halifax in Nova Scotia are year-round ports and can handle a constant supply of transportable biomass for export. Montreal and Quebec have ocean ports but they are not open year-round, owing to Canada's cold winter. The port of Saguenay off the St. Lawrence River is a 12-month port

7.1.6. Undeveloped Supply Chains

Biomass projects are now targeting to utilize forest harvest biomass and Canada does not have low-cost supply chains established for this biomass. It will take a major effort by Nordic and Canadian Associations, companies and governments to transfer technology and learning to Canadian forests. The Canadian Bioenergy Association is arranging trade missions to and from Scandinavia to enable transfer of technology and know-how.

7.1.7. Domestic Pressure to Keep Biomass at Home

Although exports are expanding rapidly there are factions in Canada that feel more biomass should be used domestically. The challenge will be to develop resources fast enough so that there will be sufficient volumes both for export and domestic use.

7.1.8. Increasing Domestic Incentives

Over time, domestic incentives have been increasing, and while development of bioenergy has been extremely slow (Except for pellets, and ethanol) eventually local packages of incentives may be sufficient develop projects for domestic energy in meaningful volumes.

7.1.9. Pyrolysis Oil A New Untested Product

Testing has been underway on many applications for pyrolysis oil and product markets are very promising. However, to-date it there has been too little volume produced to test any one application over a long period. Similarly, volumes have not been large enough to prove the reliability and competitiveness of long distance supply chains. This is an excellent product with concentrated energy, but market barriers remain.

7.2. Opportunities

The greatest opportunities for trade are to

- Establish pellet and/or pyrolysis oil plants in Quebec, Eastern Ontario and New Brunswick, and improve 5,000 km ocean supply chains to the EU
- Establish partnerships between prospective EU pyrolysis oil customers and domestic biomass owners to build pyrolysis plants dedicated to export
- Succeed in research on super-densified pellets
- Raise ocean shipping capacity dedicated to biomass products to keep shipping rates down
- Establish a biomass industry in Newfoundland Labrador, on Canada's East Coast
- Continue to turn Mountain Pine Beetle wood into transportable energy products with world-scale sized plants

Appendix 1- Government Programs (at 2008)

Canadian Bioenergy Initiatives and Programs

Initiative / Program	Start Date	End Date	Type of Initiative / Program	Existing Legislation	Target Area	Description	Funding		Contact		
								Repayable	Name	Telephone	E-mail
FEDERAL											
FEDERAL DEPARTMENT											
Agriculture and Agri-Food Canada (AAFC)											
Agri-Opportunities Program	Announced January 23, 2007 / Launched February 2007	March 31, 2011	Incentive	Yes	Agriculture	Aims to accelerate the commercialization of new agricultural products, processes or services that are currently not produced or commercially available in Canada, and are ready to be introduced to the marketplace by providing a maximum repayable contributi	$134 M	Yes		1-866-367-8506	agri-opps@agr.gc.ca
Agricultural Bioproducts Innovation Program (ABIP)	Announced December 20, 2006		R&D / Education		Government / Industry / University	Supports new and existing research networks and encourages the development of clusters to build greater research capacity in agricultural bioproducts and bioprocesses. Through supporting networks and clusters, the program promotes research, development, t	$145 M			1-866-912-ABIP (1-866-912-2247)	abip-piba@agr.gc.ca
Agriculture - Co-operative Development Initiative (Ag-CDI)	October 2007	March 2009	Education / Support	No	Transport Fuels (Agricultural Producers)	Provides support to individuals, groups, and communities wishing to develop co-operatives as a way to take advantage of opportunities associated with biofuels and other value-added opportunities in the agricultural sector. The Co-operatives Secretariat wi	$3.25 M	No		1-888-781-2222 613-759-7193	coops-progr@agr.gc.ca
Biofuels Opportunities for Producers Initiative (BOPI)	Announced July 2006	2008	Education / Support		Transport Fuels (Agricultural Producers)	Helps farmers and rural communities hire experts who can assist in developing business proposals and undertake feasibility and other studies necessary to create and expand biofuels production capacity involving significant (greater than 1/3) ownership by	$20 M (Up to $13 M was available in 2006-2007 and $7 M is available in 2007-2008)	No			

ecoAgriculture Biofuels Capital Initiative (ecoABC)	Announced December 2006 / Launched April 23, 2007	March 31, 2011	Incentive	Yes (Authority under Section 4 of the Department of Agriculture and Agri-Food Act)	Transport Fuels (Agricultural Producers)	Provides repayable contributions of up to $25 M per project or 25% of eligible project costs (which ever is less) for the construction or expansion of transportation biofuel production facilities. Funding is provided for projects that use agricultural feedstocks to produce biofuels and that have new agricultural producer equity investments in the projects equal to, at minimum, 5% of the total eligible project costs. This initiative provides an opportunity for agricultural producers to diversify their economic base and participate in the biofuels industry through equity investment / ownership in biofuels production facilities helping them overcome the challenges of raising the capital necessary for the construction or expansion of biofuel production facilities.	$200 M ($186 M is available for contributions)	Yes		1-866-367-8506	ecoABC@agr.gc.ca
Agriculture and Agri-Food Canada (AAFC) and Natural Resources Canada (NRCan)											
Ethanol Expansion Program (EEP)	Announced August 12, 2003 / Launched October 20, 2003	March 31, 2007	Incentive	Yes (Authority under the federal Energy Efficiency Act (1992); and the Department of Agriculture	Transport Fuels (Industry / Infrastructure)	Aims to increase the production and use of fuel ethanol in Canada and reduce transportation related GHG emissions by providing repayable contributions, amounting to $99.3 M for the construction or expansion of ethanol plants. The EEP sets the goal of having 35% of the consumption of gasoline-type fuels be E10 by 2010, ethanol demand should represent 3.5% of all gasoline-type fuels by 2010. Although project submissions to the EEP terminated in 2005, program activities are expected to last until 2018 (9 ethanol projects are supported for which contributions are repayable in the coming years). This program is a component of the Future Fuels Initiative.	$100 M	Yes	Claude Robert	613-996-5377	E-mail
Future Fuels Initiative	2001		Incentive / Education		Transport Fuels (Industry / Infrastructure / Consumers)	Plans to accomplish a four-fold (by 750 M litres) increase in Canada's annual ethanol production and use. That could mean 25% of Canada's total gasoline supply would contain 10% ethanol. Contingent loan guarantees are provided to encourage financing for new plants that produce ethanol from biomass if all or part of the excise gasoline tax on ethanol is imposed before December 31, 2010. This initiative promotes increased supply and use of ethanol produced from biomass; provides for funding of activities such as public education on fuel ethanol, analysis of fuel ethanol markets, and producer economics; and provides a liaison with provinces/territories and industries that are interested in ethanol plant expansion. This initiative is part of the Government of Canada's Action Plan 2000 on Climate Change and renews the National Biomass Ethanol Program (NBEP) launched in the mid-1990s to help overcome lender resistance to investing in ethanol plants as a result of uncertainty about the excise tax policy.	$3 M over 5 years to provide market information to retail consumers $140 M in contingent loan guarantees from the NBEP	Yes			
Department of Finance Canada											
Accelerated Capital Cost Allowance for Class 43.1	1996		Incentive	Yes	Industry	Encourages business and industry to reduce energy waste and to use renewable energy sources for energy production equipment by providing an accelerated capital cost allowance at a rate of 30%. Eligible investments include co-generation and specified waste-fuelled electrical generation systems, heat recovery systems, and specified waste-fuelled heat production equipment.		/	Class 34/43.1 Secretariat	613-996-0890	
Removal of Excise Tax Exemption for Renewable Fuels	April 1, 2008		Incentive	No (Under Development)	Transport Fuels	Eliminates the excise tax exemptions for ethanol and biodiesel. This measure is in accordance with the implementation of the ecoENERGY for Biofuels Initiative.		/			
Tax Exemptions for Renewable Fuels (Excise Tax Act)	1992 (ethanol) 2003 (biodiesel)	March 31, 2008	Incentive	Yes	Transport Fuels (Producers / Suppliers)	Encourages the production and use of renewable fuels in Canada by implementing an exemption from the federal excise tax of $0.10/litre on ethanol and $0.04/litre on biodiesel.		/			

Environment Canada (EC)											
Federal Regulation Requiring Renewable Fuels	Announced December 2006		Target / Criteria	No (Under Development)	Transport Fuels	Will require 5% renewable content based on the gasoline pool by 2010 and 2% renewable content in diesel and heating oil by 2012, upon successful demonstration of renewable diesel fuel use under the range of Canadian conditions. This requirement is approximately equivalent to a renewable fuel content requirement for 5% of on-road diesel fuel. These new regulations will require enough renewable fuel to reduce GHG emissions by about 4 megatonnes per year, the GHG equivalent of taking almost 1 M vehicles from the road.		/			
Natural Resources Canada (NRCan)											
Biodiesel Initiative	Announced August 2003	2007	Education		Transport Fuels (Industry)	Addresses technical and market barriers to the development of a Canadian biodiesel industry based on low-cost feedstocks such as yellow grease and severed canola. This initiative is part of the Climate Change Plan for Canada and builds on the federal government's announcement under Budget 2003 to exempt biodiesel from the fuel excise tax for diesel ($0.04/L).	$11.9 M	No	Cara-Lynn Baas	613-995-9043	Cara-Lynn.Baas@nrcan.gc.ca
Biomass for Energy Program	2000		R&D		Biomass Supply	Assesses biomass resources in the fields of forestry and agriculture and develops methods to grow fibre for the production of bioenergy. This includes harvesting technologies, transport system efficiencies, and storage systems as well as designing scenarios to improve supply. This program identifies sources of increased biomass supply, for both existing and new biomass; develops efficient methods of growing, harvesting, collecting and transporting biomass; and demonstrates the sustainability of increased biomass supply which can potentially be employed for bioenergy production.	Funded by the Canadian Forest Service (CFS)				
Canadian Transportation Fuel Cell Alliance (CTFCA)	2001	March 2008	R&D		Transport Fuels	Demonstrates and evaluates fuelling options for fuel cell vehicles in Canada and encourages advancements in hydrogen and fuel cell technologies that are potentially transferable for use with other bioenergy sources. This initiative is part of the Action Plan 2000.	$33 M	No	Richard Fry	613-943-2258	rifry@nrcan.gc.ca
ecoENERGY for Biofuels	Announced July 5, 2007 / Effective April 1, 2008	March 31, 2017	Incentive		Transport Fuels (Producers)	Aims to boost Canada's production of renewable fuels such as ethanol and biodiesel by providing operating incentives to producers of renewable alternatives to gasoline and diesel based on production levels and other factors. This initiative will make investment in production facilities more attractive by partially offsetting the risk associated with fluctuating feedstock and fuel prices. Incentive rates will be up to $0.10/L for renewable alternatives to gasoline and up to $0.20/L for renewable alternatives to diesel for the first 3 years, then decline thereafter. Incentives are available to eligible facilities meeting a minimum production volume (undetermined) constructed before March 31, 2011, subject to program volume limits (2 B litres of renewable alternatives to gasoline and 500 M litres of renewable alternatives to diesel with a cap of 30% of program volume limits per facility) for up to 7 years	Up to $1.5 B	No			E-mail
ecoENERGY for Renewable Power	April 1, 2007	March 31, 2011	Incentive		Electricity Suppliers	Aims to increase Canada's supply of clean electricity from renewable sources including biomass by providing $0.01/kWh for up to 10 years to eligible low-impact, renewable electricity projects. The program will encourage the production of 14.3 terrawatt hours of new electricity from renewable energy sources, enough electricity to power about one million homes.	$1.48 B	Yes			ecoenergyrp@nrcan.gc.ca

ecoENERGY Technology Initiative (ecoETI) Bio-based Energy Systems Portfolio	Announced January 17, 2007	2011	RD&D		Government / Industry / University	Harnesses the potential for bioresources to produce bioenergy, biofuels, industrial bioproducts and bioprocesses to help Canadian industry and communities meet the challenges of improving efficiency and reducing toxic air emissions. Planned activities will develop new and improved technologies for producing energy from plants, wastes and microorganisms; develop the knowledge for moving towards a bio-based economy; support the development of associated regulations; and contribute to the revitalization of rural economies and Aboriginal communities.	$230 M for ecoETI	No			ecoeti-iet@nrcan-rncan.gc.ca
Program of Energy Research and Development (PERD) Bio-based Energy Systems and Technologies (BEST) Program		On-going	R&D		Government / Industry / University	Supports the development of cost-effective technologies using biomass feedstock to produce bioenergy, biofuels, biomaterials, biochemicals, and bioprocesses to reduce the energy and greenhouse gas (GHG) intensity of Canadian industries and provide sustainable energy and product alternatives to consumers. Activities focus mainly on: existing and new biomass supply; biomass conversion and utilization technologies; integrated bio-applications and cross-cutting activities.	Funded by the Office of Energy Research and Development (OERD)	No	Lesley Dawes	613-947-3481	Lesley.Dawes@NRCan.gc.ca
Promoting Forest Innovation and Investment (Forest Industry Long-Term Competitiveness Initiative)	Announced February 8, 2007	2009	R&D		Government / Industry	Supports 3 initiatives: 1) Restructuring the Forest Innovation System - Consolidation of Forest Engineering Research Institute of Canada (FERIC), Forintek Canada Corporation, and the Pulp and Paper Research Institute of Canada (PAPRICAN) into FPInnovations for greater efficiency and strength in innovation and R&D; 2) Investing in Transformative Technologies - Investments in forest innovation will provide for pre-competitive, non-proprietary research to address the development and adaptation of emerging and breakthrough technologies, such as forest biomass, forest biotechnology, and nanotechnology; and 3) Implementing the Canadian Wood Fibre Centre (CWFC) - The CWFC will focus on wood fibre research from forest to end use to increase Canada's knowledge of wood fibre quality and how best to grow and utilize it in the long term.	$70 M	No	Kathleen Olson	613-996-2007	kaolson@nrcan-rncan.gc.ca
Technology and Innovation Research and Development (T&I R&D) Biotechnology Program	2003	2008	R&D		Government / Industry / University	Supports R&D to increase biomass-derived energy and/or develop long-term solutions for GHG reduction. Activities focus mainly on: conversion of waste to bio-based gases; conversion of cellulosic materials into ethanol; more energy-efficient enzymes for separating natural fibres into valuable components; biomass conversion to heat and power; and combined heat and power technologies.	$115 M for T&I R&D	No			
Technology Early Action Measures (TEAM)	1998	August 31, 2007	RD&D		Government / Industry	Supports late-stage development projects and first-time demonstration projects designed to reduce GHG emissions nationally and internationally, at the same time sustaining economic and social development. The TEAM program was transferred to the Office of Energy Research and Development (OERD) effective September 1, 2007.	$56 M	No			E-mail
Natural Resources Canada (NRCan) and Agriculture and Agri-Food Canada (AAFC)											
Ethanol Expansion Program (EEP)	Announced August 12, 2003 / Launched October 20, 2003	March 31, 2007	Incentive		Transport Fuels (Industry / Infrastructure)	Aims to increase the production and use of fuel ethanol in Canada and reduce transportation related GHG emissions by providing repayable contributions, amounting to $99.3 M for the construction or expansion of ethanol plants. The EEP sets the goal of having 35% of the consumption of gasoline-type fuels be E10 by 2010, ethanol demand should represent 3.5% of all gasoline-type fuels by 2010. This program is a component of the Future Fuels Initiative.	$100 M	Yes	Claude Robert	613-996-5377	E-mail

Future Fuels Initiative	2001		Incentive / Education		Transport Fuels (Industry / Infrastructure / Consumers)	Plans to accomplish a four-fold (by 750 M litres) increase in Canada's annual ethanol production and use. That could mean 25% of Canada's total gasoline supply would contain 10% ethanol. Contingent loan guarantees are provided to encourage financing for new plants that produce ethanol from biomass if all or part of the excise gasoline tax on ethanol is imposed before December 31, 2010. This initiative promotes increased supply and use of ethanol produced from biomass; provides for funding of activities such as public education on fuel ethanol, analysis of fuel ethanol markets, and producer economics; and provides a liaison with provinces/territories and industries that are interested in ethanol plant expansion. This initiative is part of the Government of Canada's Action Plan 2000 on Climate Change and renews the National Biomass Ethanol Program (NBEP) launched in the mid-1990s to help overcome lender resistance to investing in ethanol plants as a result of uncertainty about the excise tax policy.	$3 M over 5 years to provide market information to retail consumers $140 M in contingent loan guarantees from the NBEP	Yes			
OTHER											
Sustainable Development Technology Canada (SDTC)	November 2001		RD&D		Industry / Infrastructure	Supports the late-stage development and pre-commercial demonstration of clean technology solutions: products and processes that contribute to clean air, clean water, and clean land, that arrest climate change, and improve the productivity and global competitiveness of the Canadian industry.	$550 M (SD Tech Fund™)			613-234-6313	info@sdtc.ca
	2007	2015				Supports the establishment of first-of-kind commercial scale demonstration facilities for the production of next-generation renewable fuels and co-products and accelerates the commercialization of new technologies in order to encourage the retention and growth of technology expertise and innovation capacity for cellulosic ethanol and biodiesel production in Canada.	$500 M (NextGen Biofuels Fund™)	Yes			
PROVINCIAL											
ALBERTA											
Ministry of Energy											
Bioenergy Infrastructure Development Grant Program	2008	2009	Incentive		Infrastructure	Leverages industry / investors / municipal funds (maximum is 35% of eligible costs for capital projects) to develop and expand the distribution infrastructure to connect Alberta produced ethanol, biodiesel, and biogas (methane) to the marketplace. This initiative accommodates micro-generation interconnections and biogas processing and pipeline infrastructure and supports rural development regional distribution priorities facilitating the application of new technology in biofuel and energy transmission and distribution infrastructure. This approved initiative is part of Alberta's Nine-Point Bioenergy Plan.	$6 M		Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	

Bioenergy Producer Credit Program	Announced October 2006 / Effective April 1, 2007	March 31, 2011	Incentive		Industry (Suppliers)	Encourages the production and incorporation of bioenergy products (ethanol, biodiesel, biogas-electrical) within the marketplace; helps Alberta industry effectively compete with other jurisdictions that provide programs and tax exemptions to distributors who blend biofuels; and enables the introduction of renewable products into the traditional fuels and energy marketplace. This approved initiative is part of Alberta's Nine-Point Bioenergy Plan and replaces the existing Alberta ethanol fuel tax exemption policy of $0.09/litre. Credits are given to producers of biofuels or biogas of $0.14/litre (production capacity less than 150 M litres/year, up to a maximum of $15 M/year) or $0.09/litre (production capacity of or greater than 150 M litres/year, up to a maximum of $20 M/year and total of $75 M for the project). Those generating electricity receive $0.02/kWh (production capacity of or greater than 3 MW) or $0.06/kWh (production capacity less than 3 MW).	$209 M for renewable fuels $30 M for commercialization support (from the Energy Innovation Fund)		Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	
Bioindustrial Network Development			Policy Initiative (Strategy)	No	Industry	Facilitate the demonstration and integration of bioenergy processing with existing manufacturing processors for increased regional development and demonstrate "cluster" efficiency - through the strategic integration and clustering of key processors providing a significant improvement in competitiveness and reduced environmental impact. This proposed policy initiative is part of Alberta's Nine-Point Bioenergy Plan.		/	Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	
Biorefining Commercialization and Market Development Program	2008	2009	Incentive / Education		Industry	Leverages industry funds (maximum is 20% of eligible costs for capital projects and 50% of eligible costs for non-capital projects) to focus on biofuel research commercialization, technology transfer, new generation co-operatives, capacity building, market development, and advocacy for ensuring market acceptance. This program develops / expands / strengthens Alberta's biodiesel, biogas, and ethanol production capacity in response to market opportunities. Feasibility studies, opportunity analysis, and product development costs related to concept and technology evaluation, technical assistance, and equipment development; in addition to market research costs related to specific product opportunities, costs related to buyer presentations, product reformulation, and transportation of samples are covered as part of this program. This approved initiative is part of Alberta's Nine-Point Bioenergy Plan.	$24 M		Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	
Energy Microgeneration Standards and Policy Revisions			Policy Initiative (Strategy)	No	Industry / Infrastructure	Clearly define the regulatory protocols required to establish processing plants like biogas digesters and biodiesel processing facilities and through a cross-ministry approach ensure a timely and transparent review of investment applications better meeting the needs of industry. This proposed policy initiative is part of Alberta's Nine-Point Bioenergy Plan.		/	Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	
Investment Support through Existing Programs that Align with Bioenergy Development			Policy Initiative (Incentive)	No	Investment Programs	Programs include Agriculture Financial Services Corporation (AFSC) lending programs, New Generation Cooperative Initiatives, Industry Development Research Funds, AVAC commercialization funding, Municipal Industrial Wastewater Infrastructure for Agricultural Processing Program, and Rural Development Project Fund. This proposed policy initiative is part of Alberta's Nine-Point Bioenergy Plan.			Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	

National Renewable Fuel Standard and Energy Market Targets			Policy Initiative (Target / Criteria)	No	Transport Fuels	Align to a 5% national renewable fuels standard by 2010 to create market stability that will benefit existing renewable fuel industries and establish a future market for newly established fuel technologies. Within the overall renewable fuels mandated target, support ethanol and biodiesel mandates should be specifically designated to ensure the emerging biodiesel industry has an opportunity to capture some of the benefits of a renewable fuels mandate. This proposed policy initiative is part of Alberta's Nine-Point Bioenergy Plan.		/	Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside Edmonton)	
Specified Risk Material (SRM) Disposal Protocol			Policy Initiative (Education)	No	Government	Investigate and establish regulatory protocol with the federal government in the safe disposal of SRMs through appropriate bioenergy technology adaptation. This proposed policy initiative is part of Alberta's Nine-Point Bioenergy Plan.		/	Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside	
Taxation and Investment Instruments for the Bioenergy Sector			Policy Initiative (Education)	No	Government	Work with Federal counterparts to investigate options to improve capital flow to bioenergy industry. This proposed policy initiative is part of Alberta's Nine-Point Bioenergy Plan.		/	Alberta Ag Media Line	780-422-1005 310-0000 (toll free access outside	
BRITISH COLUMBIA											
Ministry of Finance											
Renewable Fuels Incentive			Incentive	Yes	Transport Fuels	Road Tax Exemption: $0.1375/L in the Greater Vancouver Service Region and $0.0775/L outside of this region for ethanol; $0.1425/L in the Greater Vancouver Service Region and $0.0825/L outside of this region for biodiesel (provided the ethanol and biodiesel are consumed in British Columbia).		/			
MANITOBA											
Department of Science, Technology, Energy, and Mines											
Renewable Fuels Incentive		August 2007	Incentive		Transport Fuels	Provincial Fuel Tax Credit for ethanol: $0.20/litre, provided the ethanol is produced and consumed in Manitoba.		/			
	September 2007	August 2010				$0.15/litre, provided the ethanol is produced and consumed in Manitoba.		/			
	September 2010	August 2013				$0.10/litre, provided the ethanol is produced and consumed in Manitoba.		/			
Renewable Fuels Incentive			Incentive		Transport Fuels	Provincial Fuel Tax Credit for biodiesel: $0.115/L, provided the biodiesel is consumed in Manitoba.		/			
Renewable Fuels Mandate			Criteria		Transport Fuels	Requires 10% ethanol content in 85% of gasoline.		/			
NEW BRUNSWICK											
Renewable Portfolio Standard			Policy			Requires NB Power to purchase 10% of it electricity sales from new renewable sources by 2016.		/			
NOVA SCOTIA											
Department of Finance											
Renewable Fuels Incentive	July 1, 2006		Incentive		Transport Fuels	Motive fuel tax exemption of $0.154/L for biodiesel produced in Nova Scotia (biodiesel portion of blends only) that meets the American Society for Testing and Materials fuel-quality specification.		/			

ONTARIO											
Ontario Power Authority											
Standard Offer Program	March 21, 2006		Incentive		Electricity Suppliers	Sets a fixed price (feed-in-tariff) for small renewable energy (including biomass energy) generation projects in order to make it easier and more cost effective for businesses and entrepreneurs to sell renewable power to the provincial grid. All small-scale renewable energy producers will be able to sell renewable power to the grid for 20 years. Over the next 10 years, this will add up to 1,000 megawatts of renewable power to Ontario's electricity system.		/			
Ministry of Agriculture, Food, and Rural Affairs (OMAFRA)											
Ontario Biogas Systems Financial Assistance Program	Announced July 26, 2007 / Launched September 6, 2007	March 31, 2010	Incentive		Agricultural Producers and Agri-Food Businesses	The program is designed to promote sustainable biogas production in the Ontario agri-food and rural sectors. Biogas systems can help achieve reductions in GHG emissions, increase production of renewable energy, promote use of digestate as a land-applied nutrient, improve biogas utilization, and foster agricultural innovation and economic opportunities. Phase 1 will support 70% of the costs of feasibility, design and planning studies, to a maximum of $35,000 per project. Phase 2 will provide 40% of construction, implementation and commissioning costs for biogas systems, to a maximum of $400,000 (total of Phase 1 & 2 per project).	$9 M			1-888-588-4111	biogas.program@ontario.ca
Ontario Ethanol Growth Fund (OEGF)	Announced June 17, 2005		Incentive		Transport Fuels (Producers) (Industry / Infrastructure)	Provides 1) capital assistance (not exceeding $0.10/L of plant capacity) in the form of capital grants or loan guarantees for eligible new or expanding ethanol plants being built in Ontario to help meet financial challenges; 2) operating grants (not exceeding $0.11/L of ethanol produced in a particular year for a maximum of 750 M litres per year paid over a period of up to 10 years) to eligible producers in production from 2007-2016 to address changing market prices; 3) support for independent blenders of ethanol and gasoline; and 4) a R&D fund to pursue opportunities for research and innovation.	$520 M over 12 years (up to $32.5 M available for capital assistance for all proponents combined)				oegf@omaf.gov.on.ca
Renewable Fuels Incentive	June 2002		Incentive		Transport Fuels	Excise tax exemption of $0.143/L for biodiesel, provided the biodiesel is consumed in Ontario.		/			
Ministry of Finance											
Renewable Fuels Mandate - Ontario Regulation 535/05	Passed October 7, 2005 / Effective January 1, 2007		Criteria	Yes	Transport Fuels	Requires an annual average of 5% ethanol in gasoline.		/			
QUEBEC											
Department of Finances											
Renewable Fuels Incentive (2005-06 Budget)	April 1, 2006	March 31, 2018	Incentive		Transport Fuels	Variable Rate Income Tax Credit for Ethanol: up to $0.185/L, provided the ethanol is produced and consumed in Quebec. A maximum of $182.4 M in financial assistance is available to an eligible corporation for a maximum of 10 years.		/ /			
Renewable Fuels Incentive	March 23, 2006		Incentive		Transport Fuels (Consumers)	Tax refund of $0.162/L on the purchase of pure (B100) biodiesel fuel (> 3000 L) that is not blended with any other type of fuel (provided the biodiesel is consumed in Quebec).		/			
Department of Natural Resources and Wildlife											
Renewable Fuels Mandate			Target	No (Proposal)	Transport Fuels	Sets a goal of 5% ethanol in gasoline by 2012 and expected to be met by next-generation cellulosic ethanol.		/			

SASKATCHEWAN											
Department of Industry and Resources											
Renewable Fuels Incentive			Incentive	Yes	Transport Fuels	Fuel Distributor Tax Credit for Ethanol: up to $0.15/L, 5 years, provided the ethanol is produced and consumed in Saskatchewan.		/			
Renewable Fuels Mandate	November 1, 2005	January 14, 2007	Criteria	Yes	Transport Fuels	Requires an average of 1% ethanol in gasoline.		/			
	January 15, 2007					Requires an average of 7.5% ethanol in gasoline.		/			
Department of Regional Economic and Co-operative Development											
Saskatchewan Biofuels Investment Opportunity (SaskBIO)	Announced June 2007 / Launched August 10, 2007	2011	Incentive		Transport Fuels (Agricultural Producers)	Provides repayable contributions of up to $10 M per project for the construction or expansion of transportation biofuels production facilities in Saskatchewan that have a minimum of 5% farmer-community investment. This program provides an opportunity for farmers and communities to participate in the value-added biofuels industry in Saskatchewan through investment ownership in biofuels facilities.	$80 M	Yes	Ken Magnus	306-787-4484	ken.magnus@gov.sk.ca