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on Socio-economics and Sustainability

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PREFACE

This report has been elaborated in the framework of the Global-Bio-Pact project (Global Assessment of Biomass and Bioproduct Impacts on Socio-economics and Sustainability) supported by the European Commission in the Seventh Framework Programme for Research (FP7). Global-Bio-Pact is coordinated by WIP Renewable Energies and runs from February 2010 to January 2013.

The main aim of Global-Bio-Pact is the improvement and harmonisation of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of raw material production and a variety of biomass conversion chains. The impact of biomass production on global and local food security and the links between environmental and socio-economic impacts are analysed. Furthermore, the Global-Bio-Pact project investigates the impact of biomass production on food security and the interrelationship of global sustainability certification systems with international trade of biomass and bio-products as well as with public perception of biomass production for industrial uses. Finally, Global-Bio-Pact focuses on socio-economic sustainability criteria and indicators for inclusion into certification schemes, and the project elaborates recommendations on how to best integrate socio-economic sustainability criteria in European legislation and policies on biomass and bio-products.

A core activity of Global-Bio-Pact is the description of socio-economic impacts in different countries and continents in order to collect practical experience about socio-economic impacts of bio-products and biofuels under different environmental, legal, social, and economical framework conditions. The results of these surveys are described in different case studies.

The present report presents the Global-Bio-Pact Case Study for 2nd generation biofuels and products from lignocellulosic material in Canada. This Case Study was elaborated by BTG Biomass Technology Group and ProForest.

1 INTRODUCTION

A strong public debate on sustainability aspects for biomass use for energy and products emerged in the last few years. This debate focused mainly on negative social and environmental impacts. In consequence, several initiatives were setup, which are engaged in developing tools to ensure sustainability of biofuels. One option to ensure the sustainability of biofuels is the application of certification systems.

The main aim of the Global-Bio-Pact project is the improvement of global sustainability certification systems for biomass production, conversion systems and trade in order to prevent negative socio-economic impacts and to promote positive ones. Thereby, emphasis is placed on a detailed assessment of the socio-economic impacts of feedstock production and a variety of biomass conversion chains.

In order to generate data on the ground, five in-depth case studies for socio-economic impacts were investigated in the framework of Global-Bio-Pact:

- Biodiesel from soy in Argentina
- Palm oil and biodiesel in Indonesia
- Bioethanol from sugarcane in Brazil
- Bioethanol from sugarcane in Costa Rica
- Jatropha oil and biodiesel in Tanzania
- Jatropha oil and biodiesel in Mali
- 2nd generation biofuels and products from lignocellulosic material in Canada

The present report presents the Global-Bio-Pact Case Study for 2nd generation biofuels and products from lignocellulosic material in Canada. This Case Study was elaborated by BTG Biomass Technology Group and ProForest.

2 CASE STUDY SELECTION

Since the impacts of the production of biofuels and bio-products depends on the investigated scale, different levels were investigated in all Global-Bio-Pact Case Studies, including the national, regional, and local/company/project level (Figure 1). In each Case Study country of the Global-Bio-Pact project the following assessments were made:

- One study at national level
- One study at regional level
- Two studies at local level.

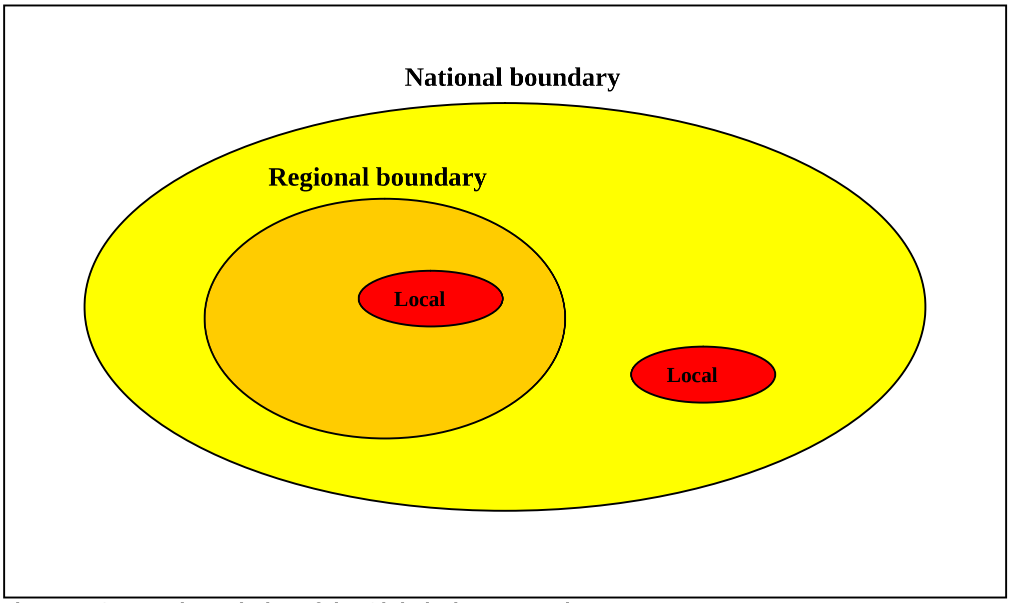


Figure 1 System boundaries of the Global-Bio-Pact project

2.1 Case studies at national level

The case studies at the national level were selected in order to ensure a balance in geographical distribution (Africa, Latin America, Asia, Europe, N-America), feedstock sources (soy, palm oil, jatropha, sugarcane, lignocellulosic feedstock), conversion technologies (e.g. fermentation, pressing, transesterification, hydrolysis, gasification) and products (biodiesel, pure plant oil, ethanol, bioproducts, 2nd generation technologies).

The case study about 2nd generation technologies, specific technologies has been selected based on an initial draft report on current and future industrial and small-scale conversion chains (task 3.1, September 2010). According to this report, two general types of technologies were selected:

- The lignocellulosic feedstock biorefinery (with ethanol production from cellulosic biomass)
- Thermochemical biorefineries (with pyrolysis and upgrading of pyrolysis in existing refineries).

Both conversion technologies utilize lignocellulosic biomass (like straw, miscanthus, wood, husks, etc.) which is widely available and – if produced from residues – do not compete for land for food and feed. The case of pyrolysis introduces the concept of the use of both centralized (pyrolysis) oil and decentralized (upgraded products) production in one biorefinery concept. Given that the other case studies focussed on agricultural commodities, this paper focussed mainly on woody biomass from forestry feedstock as case study. Subsequently, Canada was selected as the focus country for this case study in view of the country's forest resources and the fact that the 2nd generation technology is gradually advancing in the country.

2.2 Case Studies at regional level

In this project, the regional level was defined as a homogenous region in climate, soil, and socio-economic parameters. The size of the region depends on the country and can be a province or district. For this paper, the British Columbia was chosen as the regional case study given that it is one of the most important forestry province within the country and also because one of the local case studies was located in the province.

2.3 Case Studies at local level

At the local level, the system boundary is a local area from an e.g. farmer, company, association or project level. The local area refers to the area where the biomass feedstock (including by-products) is produced and converted into the final or intermediate product. In most Global-Bio-Pact case studies, two different local cases were selected and investigated. One complicating factor is that the number of operational second generation facilities at a commercial scale is limited. Annex A provides a list of possible projects. Another factor is that the companies need to be willing to share their experiences. The result of the selection process is that two processes were selected: the lignin and ethanol production process of Lignol, and the pyrolysis oil production process of BTG. The process of BTG was selected for practical reasons: collection of technical, financial, economic and social data can be performed at a substantially more detailed level. Both BTG and Lignol have no large demo plants in Canada yet. Tembec's forestry operations in the Kootenay area in British Columbia was selected as a case for biomass supply. Tembec is one of the largest forest products companies in Canada and has one of the largest estate of certified forestry operations.

3 GENERAL DESCRIPTION OF THE CASE STUDY

3.1 Case Study at the national level: Canada

3.1.1 Land use

Canada is the second largest country in the world extending from the Atlantic Ocean in the east to the Pacific Ocean in the west with the Arctic Ocean to the north. The country covers an area of 9,984,670 sq km of which land area is 9,093,507 sq km and area covered by water is 891,163 sq km (CIA World Fact-book, 2011). Located in the northern part of the continent, the climate of the country varies from temperate in the south to sub-arctic and arctic in the north. There are 15 terrestrial ecozones ranging from coastal rainforests in British Columbia to sparse and slow growing forests in the Arctic tree line (Arseneau and Chiu, 2003).

As one of the countries with the largest forest estates in the world, Canada has about 397.3 million hectares of forests, other wooded lands and lands with tree cover which represents 10% of the world's total forests and 30% of world's boreal forests. This forested area comprising mainly of boreal forests (80%) has been fairly constant within the past decades (FAO, 2009) and currently covers up to 54% of the country's land mass. The country is one of the leading exporters of forest products globally, with the United States of America being the major export destination and receiving over 70% of exports (TreeCanada, 2011). The forestry industry continues to be a major player in the country, accounting for a fifth of Canada's exports and 1.9% of GDP in 2008.

About 67,600,000 ha of land is set aside for agriculture of which 45,100,000ha is arable with 7,050,000 being for permanent crops (FAOSTAT, 2011). Grains, oil seeds and livestock are the major agricultural commodities. Agriculture in Canada is highly mechanized. As a result of shifts from an agricultural to an industrial economy, agriculture now accounts for less than 1% of GDP.

3.1.2 Economy

Canada was known for its large agricultural sector and rural based lifestyle before the Second World War, but is now transformed into a primarily industrial and urban country. Mainly due to the growth in manufacturing, mining and service sector and due to the North American Free Trade Agreement (NAFTA) of 1989, the economy gained a large boost. Canada possesses a large amount of natural resources as well as a skilled labour force and modern capital goods. Because of its situation next to the United States of America (USA) most of the export goes to this country (CIA, 2010).

In 2010 the gross domestic product (GDP) of Canada was 1,620 trillion Canadian dollars (1215 trillion Euro). After a decrease of GDP in 2008 and 2009, due to the worldwide financial crisis, the gross domestic product is growing again in 2010 with 1.4% in Q1, 0.6% in Q2 and 0.3% in Q3. The GDP per capita also slightly increased to 43,100 Canadian dollars (32,325 Euro) (Statistics Canada, 2010).

The Canadian economy is mainly service-oriented, with the service sector contributing 71.3% to national GDP in 2008. Industry is listed second with a contribution of 26.4%. The agricultural sector, which was once the greatest sector in Canada, now only contributes 2.3% to national GDP. The labour force of 18.39 million inhabitants is divided quite evenly over the sectors when comparing to the contribution to GDP. The service sector takes 76% of the working force, manufacturing 13%, construction 6%, agriculture 2% and other 3%. The unemployment rate was 8.3% in 2009 (CIA, 2010). Significant parts of the population reside in the major cities (Toronto, Vancouver, Montreal) which results in a skew towards the service sector. In rural areas forestry, agriculture, mining, oil and gas dominate in employment provision.

The Low Income Cut-Off LICO is an income threshold below which a family will likely devote a larger share of its income on the necessities of food, shelter and clothing than the average family. In 2007 the LICO was computed at 21,359 Canadian Dollars (16,019 Euro) and 10.8% of the Canadian population has an income below this level (Statistics Canada, 2007; CIA, 2010). So according to Canadian standards there is some poverty, but this is not comparable to other countries around the world. Moreover, extensive social programmes are in place, such as welfare payments for low income and food from the food bank.. The GINI-index for 2005 was 32.1. The lowest 10% of the inhabitants gained 2.6% of GDP and the highest 10% gained 24.8% of national GDP (CIA, 2010). The distribution of income in Canada is fairly even; Sweden has the lowest GINI index of 23.0; Namibia has the highest GINI index of 70.7.

3.1.3 Population

Canada had 33,759,742 inhabitants in July 2010 with a growth rate in 2010 of 0.804%. About 16.1% of the inhabitants are below 14 years, 68.7% between the 15 and 64 years and 15.2% over 65 years. The median age is 41.8 years (male: 39.6 years; female: 41.8 years) with 0.98 males to every female (CIA, 2010).

In Canada 80% of the inhabitants lives in urban areas, leaving 20% in rural areas (CIA, 2010). A map is attached below (Figure 2).

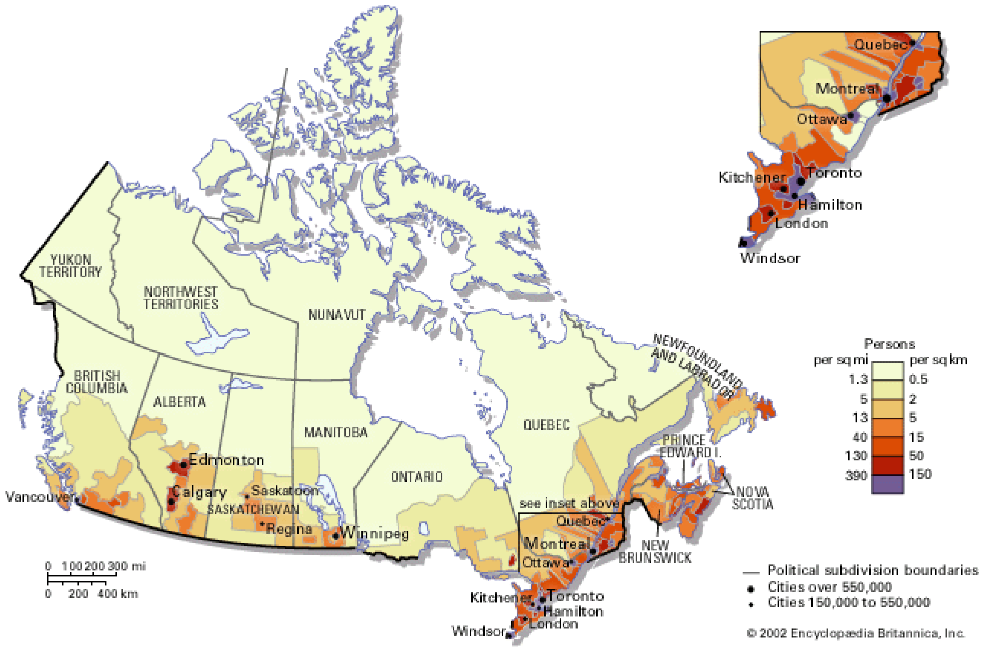


Figure 2 Population density in Canada (EB, 2002)

According to the CIA, 28% of the inhabitants are from British Isles origin, 23% is of French origin, 15% are from other European countries, 2% are First Nations, 6% is from another background and 26% of the inhabitants have a mixed background (CIA, 2010). Canada has the highest per capita immigration rate in the world and >15% are visible minorities. See also Table 1.

Table 1 Aboriginal identity population per region (Statistics Canada, 2010)

	Total Population	Aboriginal identity population	North American Indian	Métis	Inuit	Non-aboriginal identity population
Canada	31,241,030	1,172,785	698,025	389,780	50,480	30,068,240
Newfoundland and Labrador	500,610	23,455	7,765	6,470	4,715	477,160
Prince Edward Island	134,205	1,730	1,225	385	30	132,475
Nova Scotia	903,090	24,175	15,240	7,680	325	878,920
New Brunswick	719,650	17,650	12,385	4,270	185	701,995
Quebec	7,435,905	108,425	65,085	27,980	10,950	7,327,475
Ontario	12,028,895	242,495	158,395	73,605	2,035	11,786,405
Manitoba	1,133,515	175,395	100,640	71,805	565	958,115
Saskatchewan	953,850	141,890	91,400	48,120	215	811,960
Alberta	3,256,355	188,365	97,275	85,495	1,610	3,067,990
British Columbia	4,074,385	196,075	129,580	59,445	795	3,878,310
Yukon	30,190	7,580	6,280	800	255	22,615

Territory						
Northwest Territories	41,060	20,635	12,640	3,580	4,160	20,420
Nunavut	29,325	24,915	100	130	24,635	4,405

3.1.4 Agricultural sector

The arable land in Canada is rather small with only 4.57% of the country's total surface. From this surface only 0.65% is cultivated with permanent crops in 2005. Main reason for this low number is that the climate in most of Canada is not suitable for agriculture. For example, in the province of New Foundland there is a lot of forested and tundra geography, even with permafrost. Canada has a large coastline with 202,080 kilometres; in the coastal provinces, fishery is the main contributor to agriculture (CIA, 2010).

In the provinces with a suitable climate and geography – mainly Manitoba, Saskachewan and Alberta – the main crops harvested are wheat, barley, oilseed, tobacco, fruits and other vegetables (CIA, 2010). In Table 2 a summary is given on the crop production in hectares and tonnes.

Table 2 Production of principal field crops (Statistics Canada, 2010b)

Product	Area Hectares x 1000	Production Tonnes x 1000
All wheat	8,268.7	23,166.8
Oats	841.4	2,297.6
Barley	2,387.2	7,605.3
Fall rye	89.1	216.4
Mixed grains	79.7	232.5
Flaxseed	353.3	423.0
Canola	6,514.4	11,866.2
Corn from grain	1,202.9	11,714.5
Dry peas	1,322.1	2,862.4
Soybeans	1,476.8	4,345.3
Dry white beans	46.9	102.3
Dry coloured beans	80.3	151.5
Fodder corn	218.4	8,536.6
Tame hay	7,362.2	32,681.4

The total exports of agri-food in 2009 were 35.169 billion Canadian dollars. The total imports of agri-food accounted for 28 billion Canadian dollars. This leaves Canada with a positive trade balance of 7.169 billion Canadian dollars. The five products which were exported most are: non-durum wheat, canola seeds, durum wheat, live cattle and shelled dried lentils. The agricultural products which were imported most in 2009 are: grape wine; food preparations; bread, pastry, cakes, biscuits; beer and dog or cat food (Statistics Canada, n.d.).

3.1.5 Forestry sector

Canada is a net exporter of wood products with a trade surplus of $14.4 billion in 2009. Being the world's largest wood exporter, Canada netted about $30.2 billion in forest product exports in 2008, which generated 273,700 direct jobs and supported some 300 forest-based communities (Poon, 2009). These exports included newsprint, other paper and paperboard, softwood lumber and wood pulp. The value of imports in 2009 stood at $9 billion. Lumber currently accounts for more than half of Canada's wood exports. Other exported wood products include pallets, railway ties and engineered wood products (Poon, 2009).

Canada currently leads globally as the country with the largest area of third party certified forests (over 142.9 million hectares as at December, 2009 representing over 40% of the global certified forest area) and also as the country with the largest proportion of its managed forests certified (Tikina *et al*., 2010). The forests of Canada comprise mainly of Softwoods (68%), Mixed wood (16%) and Hardwoods (17%) with spruce (53%), poplar (12%) and pine (9%) being the predominant tree species. The total growing stock as at 2009 was 32,983,000,000 cubic metres of which an Annual Allowable Cut (AAC) of 208 million cubic metres was allowed for year 2008. Annually, less than 1% of the country's forests are harvested and approximately 90% of the forest products are harvested in old growth and primary forests under management (Forestwatch, 2011). Aside their extractive use, Canada's forests serve as an important source of tourism and recreation attracting up to 11.9 million visitors to the national parks alone in 2009. Additionally, the forests play important traditional and spiritual functions for local communities.

3.1.6 Land ownership concentration

In Canada, land ownership is generally held by the government, native groups, corporate entities and individuals. A major portion of the forests of Canada are held in federal trust by federal and provincial governments on behalf of the monarchy. These are referred to as Crown Lands. However, with the exception of a section of southern Quebec, all of Canada is subject to Aboriginal title. Native groups historically negotiated treaties in which they traded tenure to the land for annuities and certain legal exemptions and privileges. Those Native groups, which never signed treaties or are dissatisfied with the execution of those treaties can lodge Aboriginal land claims against the government.

Of the 397.3million hectares of forest lands in Canada, 93% is publicly owned. Of this, 77% is under provincial or territorial jurisdiction whilst 16% is under federal purview. The remaining 7% is on private property owned by over 450,000 landowners (NRC, 2011). The provinces and territories manage their own natural resources including forests except on federal lands such as First Nations Reserves and National Parks.

An estimated 1,000 forest operations are owned by First Nations. More than three quarters of Canada's indigenous people reside inside forested areas. An estimated 17,000 indigenous people work in the forest products industry, though many of them work in seasonal, low skilled and part time positions.

Contemporary treaty and land claims negotiations represent an attempt to resolve the question of Indigenous land rights in Canada. Since 1973, Canada has had a land claims policy that recognizes two types of land claims, comprehensive and specific. Comprehensive claims assess existing First Nation land and resource rights and include limited land title and resource rights, traditional harvesting rights, financial compensation, and local self-government. Specific claims address grievances by First Nations with regard to treaty or Indian Act obligations.

3.1.7 Food security

As one of the wealthiest nations in the world, food security is not necessarily a major issue in Canada. The daily amount of kilocalories consumed per inhabitant was, on average, 3,530 in 2007, which is above the threshold of 2,500 kilocalories a day. In addition, there are no children underweight in Canada. Canada is, however, developing another health issue, namely the amount of inhabitants who are overweight. In 2004 23.1% of the inhabitants were overweight. Although obesities become a problem, the life expectancy has increased from 77 years in 1990 to 81 years in 2007 (FAO, 2008).

In addition, food supply in Canada is quite certain. As was shown in subsection 3.1.4 Canada has a positive trade balance of 7.169 billion Canadian dollars and is therefore exporting more food than it imports. The country is mainly importing luxury products such as prepared food, wine and other alcoholic beverages (FAO, 2008).

3.1.8 Energy sector

The energy production in Canada is the seventh largest in the world, with a total production of 407,378 ktoe in 2008. Total imports of energy accounted for 85,553 ktoe and exports for 230,226 ktoe leaving Canada with a positive energy balance of 144,673 ktoe. Total electricity production was 651,324 GWh in 2010 with an import of 25,189 GWh and an export of 57,675 GWh (Statistics Canada, 2010a).

Most of the electricity production comes from hydro power, which accounts for almost 60% of total electricity produced. Electricity from coal accounts for 17% whilst nuclear energy accounts for almost 15% of electricity production. Biomass only accounts for a small portion of renewable electricity production, but is the largest contributor to renewable energy if we leave out the hydro power. In 2008 7,528 GWh of electricity was produced using solid biomass and 770 GWh using biogas, which is equal to 1.2% and 0.12% of total electricity production respectively. The biogas plants also accounted for 50 TJ of heat production. (Statistics Canada, 2010a).

Canada has the second largest oil reserves in the world. These estimated oil reserves are around 28 billion cubic meters with more than 95% of these reserves situated in oil sands. The ultimate recoverable oil from sands in Alberta is even 50 billion cubic meters, but this is at high costs (CIA, 2010; NRC, n.d.). The total proved gas reserves are 1,754 billion cubic meters of gas according to the CIA (2010) and 1,437 billion cubic meters of gas according to Natural Resources Canada (n.d.).

In the World Energy Outlook of 2009 (OECD & IEA, 2009) a figure is supplied stating that 1.3 billion people do not have access to electricity worldwide. A lot of developing countries are mentioned, but Canada, and other developed countries, are left out. Therefore, it can safely be assumed that Canada does not have problems with energy access, although the country is geographically widely spread.

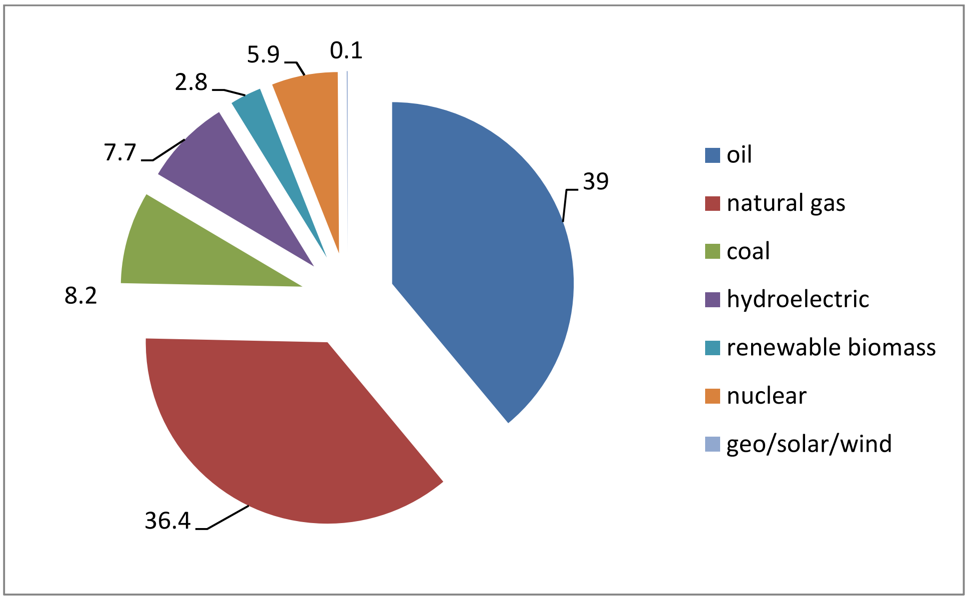


Figure 3 Canada's energy production by source for 2007 (Canada Bioenergy Report, 2010)

3.1.9 Policy framework

In 1992, Canada developed a National Forest Strategy. The policy document which has been revised in 1998 and 2003 outlines Canada's plans and commitments to sustainable forest management. Forest management at the local level is guided by federal, provincial and territorial legislations. The 10 provinces and 3 territories have legislative authority over the enhancement, conservation and management of forest resources. They develop and enforce policies, legislation and regulations, allocate timber licences and collect forest management fees (Canadian Council of Forest Ministers, undated). The federal government on the other hand is responsible for matters related to the national economy, trade, international relations, federal lands and parks as well as issues related to First Nations. Approximately 8% of Canada's forest area is protected by legislation (NRC, 2011).

By law, all areas harvested on public lands must be regenerated. About 72% of all crown lands harvested are regenerated through tree planting or direct seeding whilst the rest is regenerated naturally. The annual allowable cut on crown lands is determined on a provincial basis based on data on bio-physiological and other social indicators to inform the sustained yield concept. Long-term forest tenure rights are allocated to private companies to provide a continuous secure timber supply to mill owners.

The forest industry is also known to have a major dependency on forest residues as their source of energy through cogeneration. Though Canada is the fifth largest energy producer in the world (being a major producer of coal, natural gas, petrochemicals, uranium and hydroelectric power), it continues to make major headways in the development of alternative energy sources including cogeneration from forest residues and municipal waste. Canada is also one of the most energy intensive countries in the world on a per capita basis. This is partly due to the energy intensive industries in the country such as the aluminium smelting and pulp and paper industries. The energy sector in Canada is regulated by both federal and provincial arrangements. The federal government is basically responsible for regulating trade (international and interprovincial) as well as overseeing international relationships and the management of non-renewable resources on government lands whilst the provincial governments have a jurisdiction of the exploration, development, exploitation and management of the resource as well as the production of electricity.

In 2006 the government announced a new biofuel strategy to increase ethanol production. The strategy introduced a legal annual renewable content requirement of 5% ethanol by volume in all gasoline for ground transportation by 2010, and 2% in diesel for ground transportation and heating by 2012 (Canada Report on Bioenergy, 2010). Including diesel in the renewable fuel standards (RFS) was 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 (Canada Report on Bioenergy, 2010).

A social issue that forest policy makers are dealing with is the issue of the rights of First Nations. A number of First Nations reside in forested areas and hold traditional use and/or ownership rights over some forested areas. In areas where lands are owned by the Crown, First Nations may have some use and treaty rights over the resource that include the rights to hunt, fish, trap, gather and use other forest resources for their own benefits. These rights may be alienated from them when such lands are allocated as long term 'concessions' to various companies. The requirement for an established milling facility to be able to qualify for forest concessions, also makes investments in the forest industry capital intensive, and small forest dwelling communities may not be able to meet such a requirement.

Towards the end of July 2010, Canada ratified its first ILO convention in over a decade- the Convention on Maritime Labour. Though Canada has ratified 28 out of the 188 International Labour Regulations, it is yet to ratify some three core ILO conventions deemed as fundamental to basic human rights: Convention 29 on Forced Labour (1930); Convention 98 on Rights to Organize and Collective Bargaining (1949); Convention 138 on Minimum Age (1973).

3.1.10 The lignocellulosic biomass supply chain in Canada

The cellulosic bioliquid industry is an emerging one, with little reliable data on feedstock demands and supply. Because the industry depends mainly on co-products and by-products from various wood processing operations, it is difficult to quantify the actual demand and supplies attributable to cellulosic bioliquid alone. Nevertheless, data on logging residues, mill residues and the pulp and paper market may be useful indicators.

The Canadian timber sector which in previous years produced excess quantities of logging and milling residues was one of the worst hit sectors during the global financial crisis from 2006. With the USA housing market being the major buyer of Canadian timber, the rapid decrease in housing starts in the USA had a significant impact on sawmilling in Canada and consequently reduced the production of milling residues for from 83.5 million m^3 in 2004 to 45 million m^3 in 2009 (table 5). The drop in lumber production wiped out surpluses of mill residue by 2009.

Table 3 Mill residue production - sawmills (Canada Report on Bioenergy, 2010)

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

At the same period that available milling residues were declining in Canada, the manufacture and export of wood pellets (which relied heavily on milling waste as input materials) in the country was growing at an exponential rate. Several large new biomass projects were built that anticipated using mill residue. The projects included a new pellet plant in Houston BC, a pellet plant expansion in Prince George and a pellet capacity increase at Canfor. The national pellet production capacity grew from 500,000 tonnes in 2002 to 2.1 million tonnes in 2009 making Canada the 4th largest in the world. However, the reduced availability of milling residues due to the economic downturn and lower lumber productions has left the industry scrambling for feedstock and led to a decline in wood pellet production in Canada in 2008. Consequently, pellet producers have had to resort to harvest debris and non-commercial round wood which account for about 70% of the feedstock now.

Currently, all provinces with vibrant forestry industries are examining the option of allowing harvest wastes to be taken away for energy purposes. Long term contracts for standing non-commercial wood are being awarded in Ontario to fledgling biomass projects that can support forest based employment for local communities and have First Nation involvement. Additionally, 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, wind throws, etc. However, this may not be always economical as the wood has to bear the cost of harvesting. Such wood may thus be a back-up wood supply only as wood already harvested is lower cost than wood that is not. Costs of extraction of biomass from the forest can vary greatly depending on landscape, distance to roadside, technology used, labour, and even moisture content of the slash (Canada Report on Bioenergy, 2010).

3.1.11 Supply chain actors and governance

Given the diverse nature of possible feedstock for use in the cellulosic bioliquid process, key actors in the supply chain would differ depending on the feedstock in question. However, likely actors would include local communities and First Nations some of whom depend on the forest for their livelihoods. Other key actors include local forestry authorities, staff and management of forest management companies, hauling companies and allied businesses and staff/management of the processing company. Figure 4 gives an outline of possible stakeholders involved in feedstock production for the simplest form of supply chain where the wood moves directly from the forest base to the processing plant. Additionally, several other actors may be involved in the process if the feedstock is sourced further down the supply chain after the timber has gone through some form of processing. Currently, the major actors who will be likely to support feedstock for a commercial plant in British Columbia would include Canfor, West Fraser and Tembec.

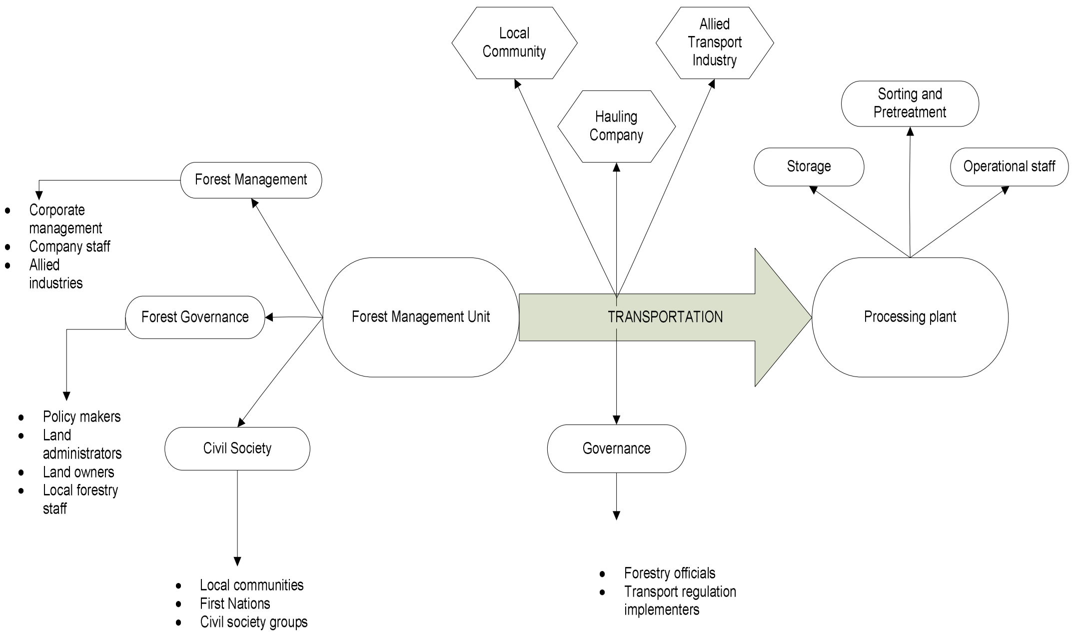


Figure 4 Supply chain actors and governance

The supply chain is governed by regulations from the Ministry of Agriculture, Ministry of Environment en Ministry of Natural Resources. Some local authorities are involved for environmental and building permits. There are also actors involved in the sales of ethanol as a biofuel. In lot of countries there are for example blending quotas or tax benefits on bioethanol. In the end, end-users of the products are also governance actors. They need a constant quality of the product in their production processes.

3.2 Case Study at the regional level: British Columbia, South West Canada

3.2.1 Land use

British Columbia is one of the most important forestry provinces in Canada in terms of resource base and forest industry. Though it is only the fourth largest province in the country, it has the biggest forest estate covering an area of 57,910,000 ha which represents close to two-thirds of the land area of the province. These forests are made up primarily of conifers (mainly lodgepole pine, spruce, douglas fir, true fir and hemlock) which account for about 96% of the forest area.

The topography and climate of BC divide the province into two distinct forest regions: coastal forests and interior forests. The interior forests, made up mainly of spruce and lodgepole pines account for over 70% of timber harvests while the remaining 30% come from the hemlock dominated forests of the coastal areas.

The forests contain approximately 11 billion cubic metres of wood, half of which is located on lands available for harvesting. Currently, there is about 22 million hectares of timber harvesting land base (THLB) in BC. THLB refers to publicly owned lands on which timber harvesting is both feasible and permitted. This is complemented by some

2million hectares of privately owned forests that are suitable for timber harvest. Of this, only 0.4% of the total forest area (or 0.8% of the area suitable for harvesting) is harvested each year.

Some 94% of the forest is owned by the Province of British Columbia. For management purposes, the forest resources are divided into units known as timber supply areas and tree farm licences. Timber harvesting in these units is delegated to private operators under various license agreements. Harvesting rights issued to private interests confer varying rights and responsibilities. In all cases, forest managers are expected to implement sustainable management practices to ensure the continued maintenance of the forest resource. The British Columbia's Forest and Range Practices Act specifies the requirements for maintaining high levels of environmental protection and outlines the requirements for soil conservation, reforestation of logged areas, the protection of riparian areas, biodiversity etc. Under this Act, forest companies are required to develop forest stewardship plans outlining how they will meet the objectives set by government for soil, timber, wildlife, water, fish, biodiversity and cultural heritage resources.

Since 1999, the proportion of timber allocated through large, long-term licences has declined and the proportion allocated through smaller, short-term licences has increased and currently, the ten largest operators have 44% of the harvesting rights, a proportion relatively stable since 1975. There is also an increasing involvement of First Nations in the forest based economy and since 2002, the Province has entered into interim measures agreements with 158 First Nations to provide access to 39 million cubic metres of timber and over $230 million in forest revenues.

The forests of BC continue to be an important source of employment accounting for 7% of the province's employment in 2007. According to the State of BC's Forests report (2010), forest based industries provide lucrative remuneration with average income being up to 12% greater than other industries.

Recreation is also a key function that these forests provide and BC's forest recreational infrastructure includes 1,650 campgrounds (totalling 23,000 campsites) and 20,000 kilometres of trails. Seventy million user-days of forest recreation are estimated to occur each year. Expenditures on forest recreation contribute $2.2 billion to provincial GDP each year.

Like the rest of Canada, BC has a commitment to moving towards including renewable energy in transportation fuels. Consequently, a target of 5% inclusion in both gasoline and diesel was set to be met by 2010.

Figure 5 Land use in British Columbia

3.2.2 Economy

The Gross Domestic Product (GDP) of the British Columbia region was 191,006 million Canadian dollars in 2009. Compared to 2008 the GDP decreased with 3.4%. The real per capita GDP of British Columbia was 36,287 Canadian dollars which is a decrease of 3.5% compared to 2008. It can therefore be stated that the economy of British Columbia was on a decrease in 2009 just like the economy in Canada (BC Stats, 2010a).

In 2009 the largest contributing sector was the service sector which accounted for around 75% of national GDP. Within the service sector the largest contributors are the finance, insurance and real estate services. The goods sector, on the other hand, accounted for only 25% of national GDP. Within this sector the manufacturing and construction industries are the main contributors (BC Stats, 2011a).

The GDP per capita in British Columbia is slightly lower (about 15%) than in the rest of Canada. The unemployment in British Columbia is 7.8% as can be noted from the figure below (BC Stats 2011b).

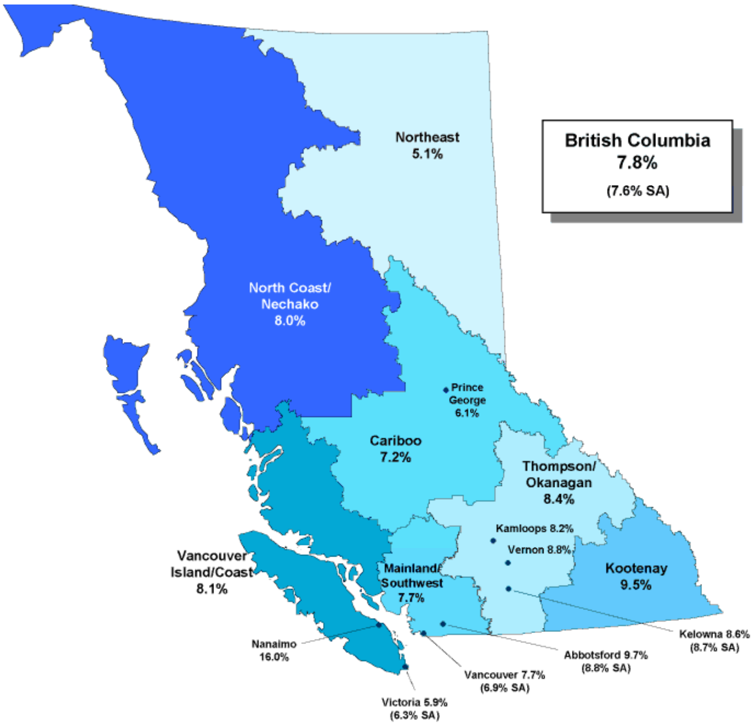


Figure 6 Unemployment in British Columbia

3.2.3 Population

British Columbia had 4,530,960 inhabitants at the end of 2010. This is around 13% of the inhabitants of Canada as a whole. The population of British Columbia is still growing, with a rate of around 1% a year. The population density is the largest in the South West of the province. This is near the United States border where Vancouver is situated. In addition, the population density is higher around cities such as Kamloops, Kelowna and Prince George which are located in the mid-south and centre of the region (BC Stats, 2011c). A geographical representation of the population density is supplied in Figure 7.

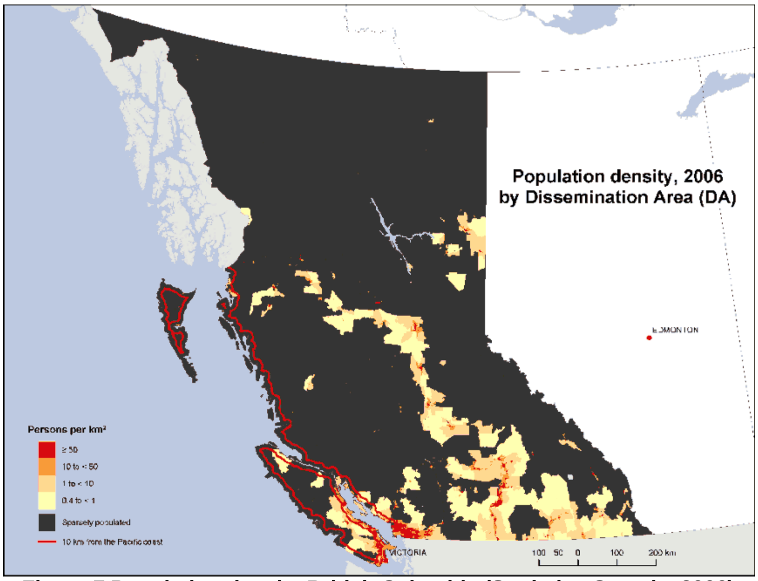


Figure 7 Population density British Columbia (Statistics Canada, 2006)

British Columbia had around 200.000 indigenous inhabitants in 2006. Around 70% of the indigenous people are North American Indians and 30% are Métis. Another small group of indigenous people are the Inuit (BC Stats, 2006). A map of the population density of the indigenous people is provided in Figure 8 below.

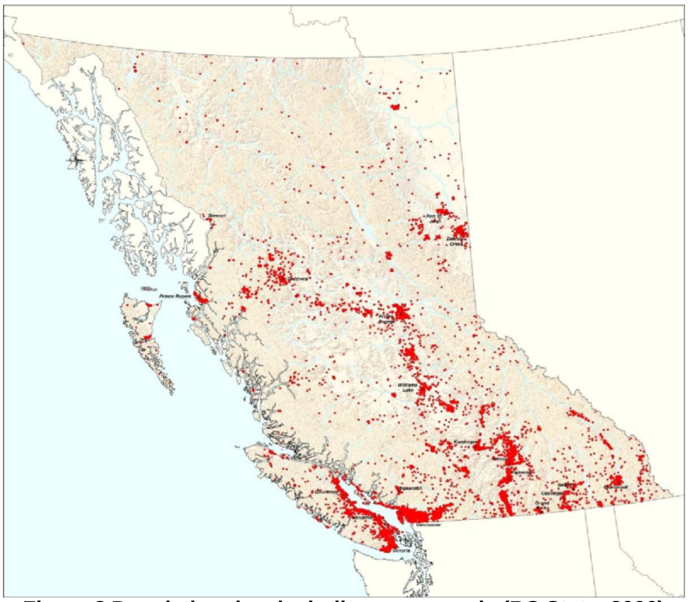


Figure 8 Population density indigenous people (BC Stats, 2006)

3.2.4 Agricultural sector

The agricultural sector in British Columbia is rather large with a total area farmed of 2,835,458 hectares in 2006. The farmland is dived amongst 19,844 farms with an average size of 143 hectares. Between 1996 and 2006 the amount of farms decreased with 10%, but the average size of the farms increased by 20%. This increase of scale leads to an increase of total farm land with 10% between 1996 and 2006. In 2006 the agricultural sector employed 280,430 people.

The farm land is mainly used for managed and unmanaged pasture which increased during the years. The amount of land used for crops and summer fallow decreased. Most of the land used for crops is cultivated for field crops, which has a quite stable production during the last 10 years. Fruits, berries & nuts and vegetables are the other main categories of cultivation in British Columbia (BC Stats, 2007). See also Table 4 and Table 5 below.

Table 4 Farmland used in British Columbia (BC Stats, 2007)

Numbers in hectares	**1996**	**2001**	**2006**
Crops	565,738	617,545	586,238
Summer fallow	39,017	36,765	25,581
Pasture (managed)	240,236	233,044	245,793
Pasture (unmanaged)	1,172,591	1,203,533	1,499,563
Other	511,478	492,211	478,283
Total	**2,529,060**	**2,583,098**	**2,835,458**

Table 5 Farmland used for crops (BC Stats, 2007)

Numbers in hectares	1996	2001	2006
Field Crops	536,201	585,644	553,439
Fruits, Berries & Nuts	18,316	19,558	19,822
Vegetables	7,117	7,277	6,957
Other	4,104	5,066	6,020
Total	**565,738**	**617,545**	**586,238**

Farm and food imports equalled 3.3 billion Canadian dollars in 2005. The exports were only 2.4 billion Canadian dollars. With the exports being lower than the imports in British Columbia it can be stated that the region has a trade deficit when it comes down to agricultural and food products (Ministry of Agriculture and Lands, 2006).

3.2.5 Forestry sector

Forestry is a major contributor to the economy of British Columbia, accounting for at least some 15% of the province's economy. Outside of the Greater Vancouver Regional District area, the forestry sector supports more communities than all other business sectors combined. BC produces more than one fifth of Canada's softwood lumber supplies each year. The combined annual harvest of the country comes from less than 200,000 ha of land which represents less than 1% of the working forests in the area.

As with the rest of Canada, the forestry industry in BC has been adversely impacted by the USA housing crisis and sawmill production in the region has declined in the past half decade with lumber production falling from 41,050 m^3 in 2006 to 22,975 m^3 in 2009. However, the industry is expected to gradually recover from the downturn and production figures in 2010 have showed signs of improvement. The sawmill production coupled with the increased capacity of cogeneration facilities have ensured that locally produced sawmill residues have been wiped off. However, there may be alternative sources of woody biomass from logging waste and salvaged trees for use in various energy applications.

Table 6 Sawmill production in Canada (Canada bioenergy report, 2010)

Production	2004	2005	2006	2007	2008	2009	2010est
Lumber (000m3)	39,205	41,014	41,050	36,677	28,192	22,975	26,758

Spreading through the forests of Western Canada since 2006 is the mountain pine beetle (*Dendroctonus ponderosae*) which had attacked up to 13 million hectares of pine forests as at 2009 (FAO, 2009) and is expected to kill up to 80% of all the pine trees in British Columbia. As at 2007, more than 530 million cubic metres of wood had been lost and it has been predicted that about one billion cubic metres would be lost by 2018.
British Columbia's attempt to tackle the situation also involved the salvage logging of millions of trees to minimise the damage and prevent the spread of the insect.

In the past 30 years, the numbers of wildfires in BC alone have averaged around 2,300 incidences per year and they burn some 67,500 ha. Mountain pine beetle killed timber will be a temporary source of biomass that will be available for the next 20 years[1].

3.2.6 Land ownership concentration

Most of the forests of British Columbia are owned by the Province of British Columbia, and rights to harvest trees on these forest lands are granted to various entities through timber harvesting licenses. As at 2010, the Province of BC owned about 94% of the forests, the federal government owned 1% and private owners held 4%. The rest is owned by various First Nation Groups (see Figure 9). Just over half of the rights to harvest Crown timber are held under long-term licences. Presently, the 10 companies with the largest shares of rights to harvest Crown timber hold 42% of government-set allowable annual cuts (AACs). Changes in ownership and allocation of license are driven by government priorities which change in response to public opinion and change to address emerging issues opportunities and challenges. Over the past 25 years, 350,000 hectares within provincial forests changed ownership category. This amounts to less than 1% of the province′s forests.

Forest ownership has been stable over the past 25 years, and less than 1% has changed from provincial to other ownerships. Since 1999, the volume allocated to longer-term replaceable licences has decreased, and correspondingly the volume allocated to small, shorter-term tenures has increased. The portion of government- set AACs held by the top 10 companies peaked at 57% in 1999/2000. The timber volume under licence to the top 10 companies has remained relatively constant over the past 30 years at roughly 40 million cubic metres per year.

Their combined AAC holdings have decreased both in terms of volume and percentage, despite ongoing consolidation of companies, due to the reallocation of AACs and short-term AAC increases. The number of licences and the associated timber volume dedicated to First Nations, small woodlots, and community forest agreements are increasing.

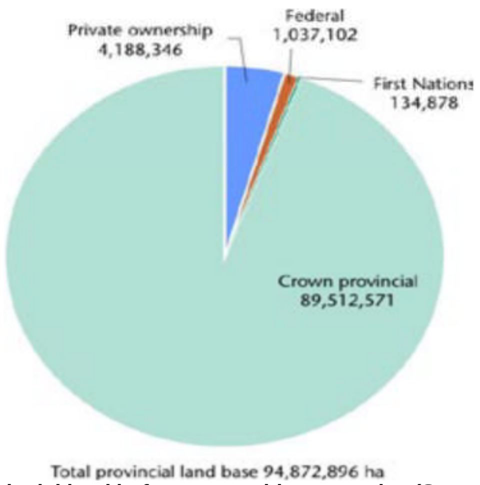


Figure 9 Area of provincial land in four ownership categories (State of BC Forests, 2010)

[1] http://www.empr.gov.bc.ca/EAED/InvestmentInfo/Documents/BioenergySector25May2010.pdf

Table 7 The 10 companies with the largest share of the provincial AAC in 2009

AAC Rank	Company
1	Canadian Forest Products
2	Western Forest Products
3	West Fraser Mills
4	Tolko Industries
5	International Forest Products
6	Weyerhaeuser Company
7	Tembec Industries
8	Ainsworth Lumber Co
9	Louisiana Pacific Canada
10	RPP Holdings

3.2.7 Energy sector

British Columbia is the third largest energy producer in Canada with 11% of the total Canadian production. In 2009 the total installed capacity was 13,168.6 MW which generated over 62.2 TWh of electricity. Just like in the rest of Canada hydro power is the largest contributor with 88% of total electricity production. This is 15% of the total hydro power produced in Canada. Hydro power is followed by natural gas fired power plants, which accounts for 9% of total electricity production. Only 3% of the electricity is produced by renewable alternatives other than hydro power. Wind power has an installed capacity of 103.5 MW in 2009 and biomass a capacity of 190.1 MW (Centre for Energy, 2011a; Centre for Energy, 2011b).

British Columbia possesses two main energy resources, namely crude oil and natural gas. The oil reserves are 104.1 million barrels and 1,043 wells have a production of 21,937 barrels a day in 2009. The natural gas reserves are 17052.5 billion cubic feet and 7,129 wells have a gross production of 3,184.8 million cubic feet a day (Centre for Energy, 2011b). A map with the energy resources and main electricity plants is provided in Figure 10.

In 2009 the international trade balance of electricity was -4,577,774 MWh, which means that British Columbia imported more electricity internationally than it exported. The interprovincial trade balance of electricity is 982,792. So British Columbia exported more electricity to other provinces in Canada than it imported..

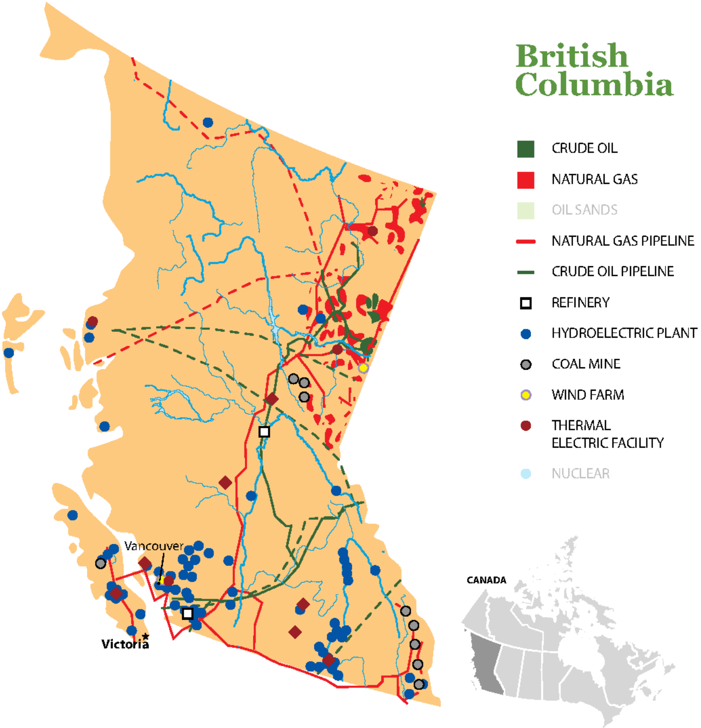


Figure 10 Energy resources in British Columbia (Centre for Energy, 2011a)

3.2.8 Policy framework

Forest use and management are controlled primarily through provincial laws and policies, and to a lesser degree by international, national, and local laws and policies. Extensive forest practice regulations apply to forest land owned by the Province. Private forest land use regulations apply to some private land designated as managed forest land. Private owners have the right to control public access to private land. Forest policies and legislations in British Columbia date back to 1910 when a royal commission on timber and forestry made recommendations that led to the introduction of timber tenures in the Forest Act in 1912 and the establishment of the Forest Services to protect forests and regulate their use. In 1945, another royal commission was set up to make recommendations on sustainable allocation and exploitation of timber resources. This led to the amendment of the Forest Act in 1947 to regulate harvests with annual allowable cuts and help to ensure an orderly transition from harvesting old-growth timber to long term management of second-growth forests.

Area-based tenures, later named TFLs, were granted in exchange for private sector commitments to invest in manufacturing facilities and provide long-term forest management, thereby supporting the province′s goal of economic development (State of BC forests, 2010). In 1979, there was a new Forest Act and a new Ministry of Forests Act to ensure the integrated resource management. The AAC concept was established, and a strategic management system was initiated that included periodic publication of provincial information in forest and range resource analyses.

Other relevant forestry legislations include the *Forest Practices Code of British Columbia Act* in 1995 and the *Forest and Range Practices Act* (FRPA) in 2004.

The Ministry of Forests, Mines and Lands (formerly Ministry of Forests and Range) and the Ministry of Natural Resource Operations are the main government agencies responsible for stewardship of the province′s public (non-park) forest lands. The province relies on private sector investment to develop B.C. forests, creating jobs and revenue, while retaining public ownership to enable conservation measures consistent with public expectations. The issuance of timber tenures under the *Forest Act* to private forest operators is the key vehicle that establishes rights to forest development and the generation of public revenues through the payment of stumpage. The two main types of long-term tenures issued are the area-based tree farm licences (TFLs) and volume based forest licences (FLs). In addition, short-term timber sale licences (TSLs) facilitate market-based pricing and value-added opportunities. Tenure holders must be compliant with the planning and practices requirements established by the provincial government.

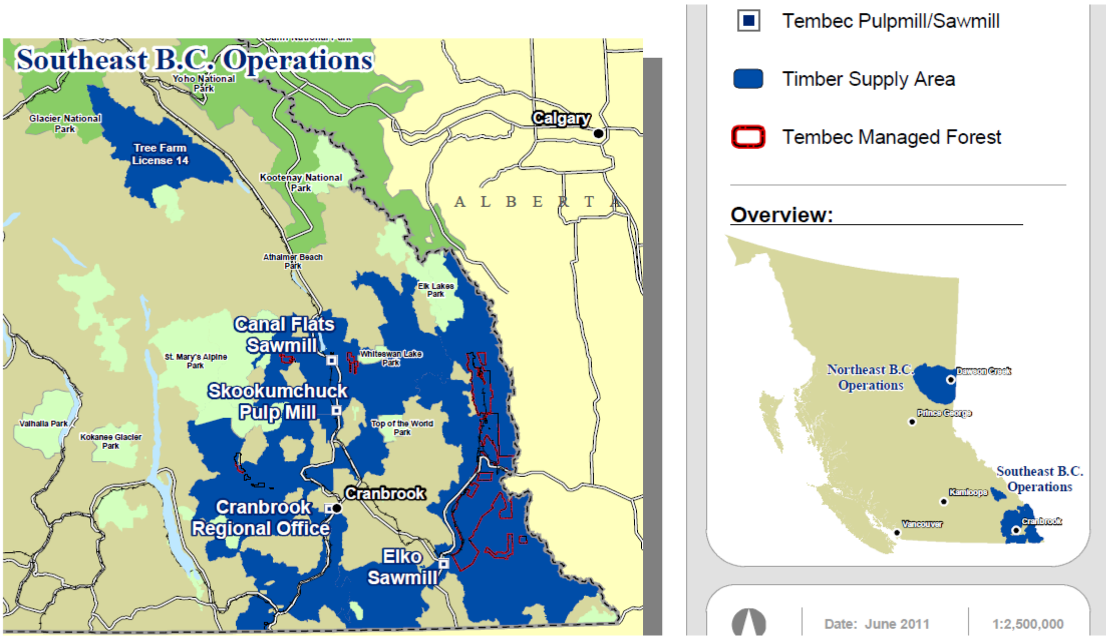
3.3 Case study at the local level

3.3.1 Description of the project location: Tembec

To greater appreciate the dynamics of wood based feedstock supply for possible use in lignocellulosic bioliquid production, this paper focussed on the forest management operations of one of the largest forestry industries in the British Columbia area. Tembec is a leading integrated forest products company, with operations in North America and France. With sales of approximately $2 billion and some 4,300 employees, it operates over 30 market pulp, paper and wood product manufacturing units, and produces silvichemicals from by-products of its pulping process and specialty chemicals. Tembec markets its products worldwide and has sales offices in Canada, the United States, China, Korea and Japan. The Company also manages forest lands in four Canadian provinces in accordance with sustainable development principles and has committed to obtaining Forest Stewardship Council (FSC) certification for all forests under its care.

In British Columbia, Tembec’s forestry operations started in 1999 when the company acquired its initial forest operations from the Crestbrook Forest Industries in the Kootenay region. The previous company had over 100 years of forestry operations including logging, sawmilling and pulp production. Currently, Tembec’s operations in BC also include a Bleached Chemical Thermomechanical Pulp mill in the north east of BC including two forest licenses and a pulpwood agreement near Chetwynd (which are not included in this case study). For the case study, Tembec’s forest management operations in the Kootenay area were assessed. Kootenay is located in the south-eastern corner of British Columbia.

In 2007, most of Tembec’s forest management tenures in Kootenay were certified. However, in the following years an assortment of additional temporary non-renewable licenses were added to the company by their owners (including First Nations, businesses and private owners) to be managed. This assessment only focussed on the certified management units under Tembec’s Kootenay operations. These areas are also covered by the company’s sustainable forest management plan.



3.3.2 Description of project / company: Lignol

Lignol Innovations Ltd. or Lignol, is a company based in Burnaby, a suburb of Vancouver, British Columbia, Canada. The organization was founded in 2000 and in 2002 Lignol acquired the Alcell technology including intellectual property, marketing data, project files and a pilot plant from UPM-Kymmene Canada and Industry Canada. This process was developed by the University of Pennsylvania, General Electric and Repap Enterprises Inc between 1973 and 1997.

Lignol has developed the Alcell technology further during the years. Now, the technology is an integrated cellulose-to-ethanol process for biorefining ethanol (fuel alcohol), pure lignin and other valuable co-products from readily available biomass. With this process Lignol delivers an alternative to the current dominant production of ethanol - the fermentation of grain.

Currently Lignol owns a fully-integrated pilot plant where the process is tested and developed further. This development has led the company into the use of enzymes, which can be used to make valuable products from the biomass. In the near future, Lignol wants to construct a commercial demonstration plant, to test the technology further to show that it can be a viable investment. The organization also looks into other options besides the Alcell technology, such as pulp mill conversion to alternative energy options (Lignol Innovations, 2011a; Lignol Innovations, 2011b).

The Alcell technology, which is used by Lignol, employs an organosolv process. With this process biomass pre-treatment and lignin/hemicellulose removal are combined in one process step. The two main products from this entire process are lignin and ethanol. These are produced from lignocellulosic material – often wood, straw and stover – which contains 10-12% lignin for some short annual plants and up to 30% and more for some coniferous wood types.

Within the organosolv process the input biomass is treated with an aqueous organic solvent – in this case ethanol (ethyl alcohol) and water – at temperatures in the range of 180-200 degrees Celcius. This is necessary to open up the tight structure of the woody fibre to expose cellulose more for enzymatic attack. Two products remain from this organosolv delignification, namely the solid mass (cellulose) and “black liquor” containing the other elements of the input and the remaining alcohol and water. The cellulose mass is transformed into alcohol by enzymatic saccharification, fermentation and distillation in the presence of enzymes and yeast.

The black liquor is treated in another process called lignin precipitation. In this process most of the lignin is removed from the black liquor. The black liquor is then transformed into yellow liquor which is distilled to retrieve the alcohol, furfural and other extractives. Using enzymes a few other steps can be performed to extract more products and the remaining lignin fraction (Pye, Rushton et al, 2007). A visual representation of the supply chain can be found in Figure 11.

The demonstration plant of Lignol is planned to have an input of 200 to 300 tonnes of dry biomass a day. However, the actual amount still needs to be determined.

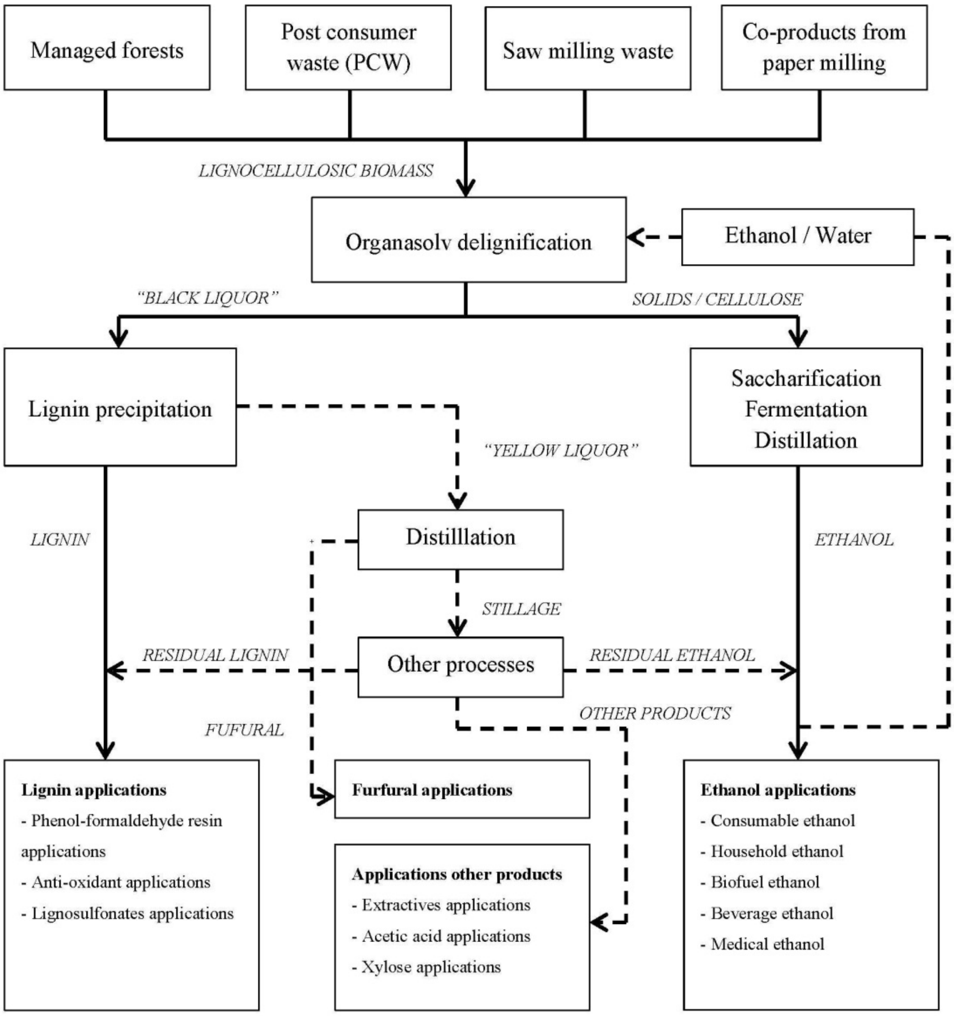


Figure 11 Flowchart of the Lignol process

3.3.3 Flowchart of the supply chain

The major forest based feedstocks used by Lignol at its pilot plant in Burnaby are typical pulping chips obtained from debarked whole log chippings and chips from lumber mill residues such as slabs and trim ends of logs. These conventional wood chips have been supplied in the past by pulp mill operators throughout North America and also by the FP Innovations (formerly Paprican). Currently the company does not have any long term supply arrangements as it is yet to finalize the location of its commercial bio-refinery plant. Other non-forestry feedstocks that have been used by Lignol include corn stover, straw, bagasse and oil palm empty fruit bunches

For a hypothetical commercial plant that would be situated in British Columbia, typical forestry feedstock would come from the sources described below:

- ***Mill residues***: This generally refers to wood waste from sawmills and woodwork shops (Reman secondary operations) that are collected and transported to processing facilities. This includes slabs, shavings, sawdust, trimmings, end pieces of wood, non-commercial logs and log cores. Until recently these were incinerated in BC in beehive burners at the sawmill site.

Across Canada, the chief feedstock for bioenergy production in the broader sense has been from mill residues, and the primary use has been in cogeneration plants for the production of heat and power.

- ***Logging residues***: This refers to the residual biomass from logging and pre-commercial thinning operation. Materials used include logging tops, culls and stumps. Also, damaged, rotten/dead, undersized and non-commercial trees removed from woodlots may be used.
  With the current low availability of mill residue surpluses, forestry and energy companies are looking to logging residues as a feedstock source (Canada Bioenergy Report, 2010). Additionally, salvage operations after disturbances could produce a source of biomass. Fires burn approximately 2 million hectares of forests per year, while pests severely damage or kill another 16 million hectares in Canada. The use of salvaged logs is currently particularly relevant to the province of British Columbia because of the mountain pine beetle epidemic. However, the availability of these infested trees for use as a biomass feedstock may be limited in some cases due to possible high costs associated with accessing, extraction and haulage.

- ***Post-consumer waste (PCW) woody biomass***. This refers to post-industrial wood waste and all urban wood wastes.
  Urban wood residues are also currently being used as feedstock, and their deployment in bioenergy systems could rise if it can be secured clean and at low costs. Currently, Enerkem has a commercial demonstration plant in Westbury, Quebec where 'negative cost' used electricity poles are being utilized to produce cellulosic ethanol, methanol and acetates.

- ***Purposely grown stands***: These are stands grown specially for biomass production and commercial thinnings dedicated to cellulosic biomass. In view of the significant cost of forest management and the costs associated with lignocellulosic bioliquid conversion chains, it is usually not considered economical to manage forests mainly for the production of bioliquids alone.

A diagrammatic representation of the various categories of wood residues used in the btl process is presented below.

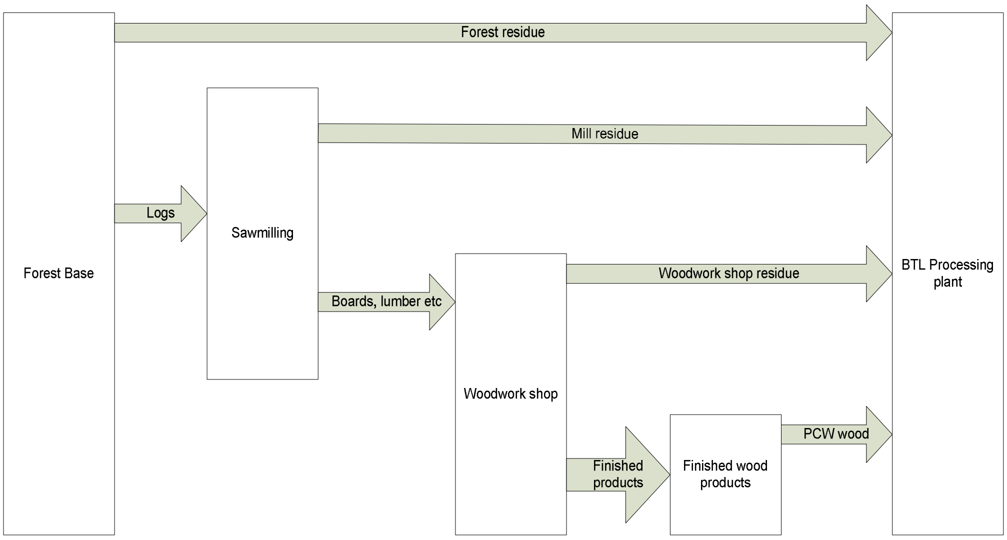


Figure 12 Various categories of wood residues in the BtL proceses

The structure of the supply chains for woody biomass feedstocks tends to be fairly straightforward with btl companies securing their feedstocks directly from various forest management companies and sawmills through long term contracts. The companies may also use one-off purchases of feedstock as and when these are available.

Early Lignol biorefineries would be small compared to modern pulp mills would probably be sized to process 600 to 900 tonnes of wood (50% moisture) per day, while later biorefineries might be sized to process 2,000 tonnes of wood per day at 50% moisture. Forestry operations, whether they be Lignol owned or contractors, would involve cutting and delimbing the tree. In the ***short wood*** system, the tree would be cut down, topped, delimbed and the round wood (logs) would be skidded to the nearest logging road, cut into truck bed lengths and then trucked to public roadside stacking areas. Larger logging trucks would then transport the logs to the biorefinery where they would be weighed, debarked and chipped. The chips would be either sent directly to the digester/extractor or dumped onto chip piles to create an inventory or reserve of chips. Some newer and cheaper systems are now being used in the pulping industry. These are *tree length systems* and *full tree systems.* In both systems trees are cut and topped, but in the tree length system the delimbed tree length log is hauled directly to the mill without length reduction. In the whole tree system, the topped tree is stacked onto truck beds and transported to the mill where it is chipped in its entirety but quality chips are recovered from a chip screening and classification system. The remaining residues are used as fuel in a hog fuel boiler. Saw mill chips are hauled to the mill by rail or truck, weighed and moisture content assayed and then added to the chip pile for reclaim.

Production process
With the production process (see also subsection 3.3.2) two important products are produced: lignin and ethanol. Lignin is utilized in phenol-formaldehyde resin applications, anti-oxidant applications, thermoplastic and lignosulfonates applications. These products can be sold to multiple organizations, for example the wood panel board and the electric wire industry. Ethanol applications can be split into consumable, household, biofuel, beverage and medical ethanol. In addition, there are also two other applications which are currently researched. These are furfural applications and the application of other products. These products can also be sold to multiple organizations, but it is not sure if recovery and marketing of these products are technically and financially feasible. See also Figure 11 (section 3.3.2) for a graphical representation.

Products
One of the main products of the Lignol process is ethanol, which accounts for around 22-23% of total input. This percentage depends on the cellulose content of the input. The worldwide ethanol market is still in development and grows slowly every year. In 2010 the total production reached 85,800 million litres of ethanol. The projected production for 2011 is even larger with 88,700 million litres of ethanol. This amount saves around one million barrels of crude oil a day (The Bioenergy Site, 2011). The Canadian production is also on the increase and reached 10,300 barrels a day or 1,637,700 litres in 2008. Canada is the fourth largest producer of ethanol in 2008 (Canadian Centre for Energy Information, 2010). The current ethanol price is fluctuating around 2.40 US dollars a gallon.

Due to the relatively low price for a gallon of ethanol, the sales of high value lignin is essential for Lignol's business case. Around 80-85% of the lignin from the input can be retrieved in the process. This accounts for around 20% of the biomass input of the installation. One of the most important applications of this lignin is the replacement of phenol-formaldehyde (PF) resin applications. PF is produced by reacting phenol and formaldehyde in the presence of an acid or alkaline catalyst. Since phenol is now produced almost exclusively from benzene instead of from coking operations, increases in crude oil prices cause a significant rise in the cost of raw materials and a consequent increase in the prices for phenolic resins. The manner of substituting lignin for PF-resins can vary from a simple blending of dry powder lignin with dry powder phenolic resin to the use of organosolv lignin as a primary phenolic component during the manufacture of the resin. In Table 8 the main present applications of PF in which lignin could play a role as a substitute are shown. The degree of substitution varies and depends highly on the specific application and R&D efforts. One of the alternatives Lignol is currently working on is the insulation material in the form of epoxy coatings for electric wires (Kamm, Gruber et al, 2006, pp. 181-199).

Table 8 Applications for phenol-formaldehyde resins

PF-Applications	Current market size (tonnes/year)	
	USA	*World*
Panel board adhesives	550,000	1.2 mln
Thermoset resins for moulded products	55,000	200,000
Friction materials	27,000	>120,000
Foundry resins	55,000 – 60,000	150,000
Insulation materials	110,000	-
Decorative laminates	100,000	300,000

The lignin from the biorefinery can also serve as an anti-oxidant, for instance in animal feed supplements, rubber products and the lubricant industry. It could also be used in markets currently served by lignosulfonates, i.e. in concrete admixtures, dye dispersants, asphalt emulsifiers, agricultural applications, and as dispersants for herbicides, pesticides and fungicides (Kamm, Gruber et al., 2006, pp. 181-199).

With the ethanol and lignin around 40% of the input is actually used. After the distillation step a stillage component (solids) remains which accounts for 20% of the installation's input. The remainder of the input exits the process as CO_2 in the fermentation stage where it is produced in almost the same amount as the ethanol. Also, some water is produced in the process. Which products are economically feasible to extract from this process is still unknown and should be determined with further R&D. Examples of other products are acetic acid and xylose.

3.4 Case Study at the local level: pyrolysis

3.4.1 Description of the project location

Because both the Lignol and pyrolysis case share the same (fictitious) project location of Tembec in British Columbia, please refer to section 3.3.1 for the description of the project location.

3.4.2 Description of project / company

BTG Biomass Technology Group BV is a private SME company, which for the past 30 years has specialized in the conversion of biomass into biofuels and bio-energy. BTG has two business units: consultancy and R&D. BTG is active in the field of studies & consulting, project and business development, applied R&D, technology development and engineering. BTG focuses on biomass energy technologies including thermal and biological conversion. In addition, BTG is – together with the University of Twente – the developer of the flash pyrolysis technology. In 2007 BTG established BTG Bioliquids BV (BTG-BTL) which is a full daughter of BTG. This company is concerned with the worldwide commercial implementation of the flash pyrolysis technology. BTG has its own pilot plant, which is located at the BTG headquarters in Enschede. In addition, BTG constructed a commercial scale pyrolysis plant in Malaysia (2 tons / hour).

Due to the fact there are no commercially operating pyrolysis factories in British Columbia, a fictitious case is assumed in this report. The case will be based on the flash pyrolysis technology of BTG and information is used from the project (5 tons an hour) which is currently developed by BTG and BTG-BTL in Hengelo, the Netherlands (The EMPYRO project). The EMPYRO project will have a capacity of 25 MWth. For Canada this project is scaled up to 50 MWth. The input of the plant will then equal 240 tons of dry biomass a day (80.000 ton dry biomass a year).

3.4.3 Flowchart of the supply chain

The flowchart of the pyrolysis process is outlined in Figure 13 below. The feedstock supply part of the flowchart is exactly the same as the Lignol process. Because this part of the flowchart was already described in subsection 3.3, this subsection only focuses on the pyrolysis process and its possible applications.

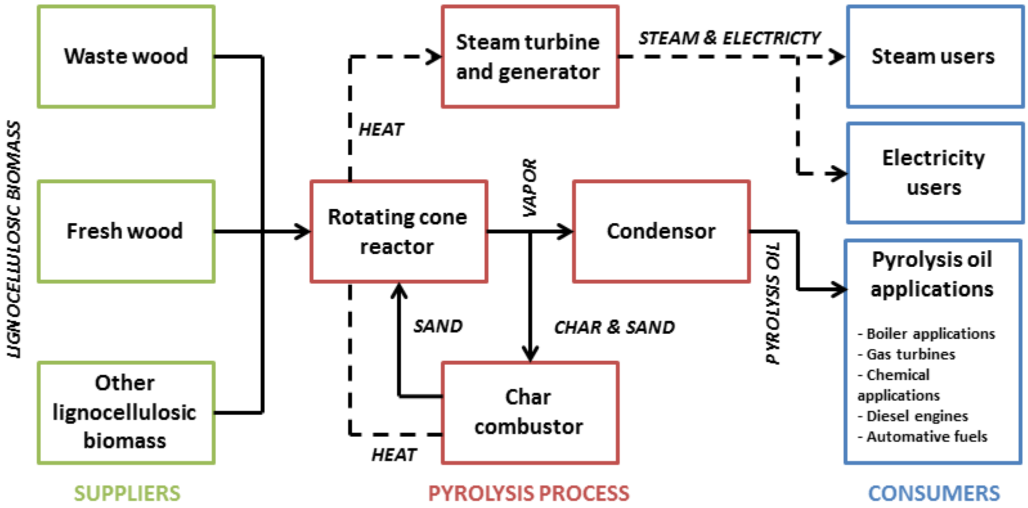


Figure 13 Flowchart of the pyrolysis process

When the wood enters the production site it first needs pre-treatment. The pyrolysis process needs biomass with a particle size smaller than 6 mm and a moisture content of 10% for optimal production. Therefore the wood needs to be shredded and dried beforehand. When this is done the biomass is fed into a rotating cone reactor where it is transformed by hot sand – and in the absence of air – to gas, oil vapor and char. The gas and char are combusted and used to reheat the cooled sand. The reheated sand can now be used in the process again. The energy which is left after reheating the sand can be used to produce steam. This steam can be used directly in a production process – for example to dry the biomass – or transformed by a generator to electricity. This electricity can also be used in the production process directly or delivered to the electricity grid.

The oil vapor is cooled and condensed in a condenser to pyrolysis oil. This pyrolysis oil has multiple applications. The pyrolysis oil can, for example, be distilled in two separate fractions: an oil fraction and an aqueous fraction. From this aqueous fraction products with chemical applications can be derived. An example is acetic acid. The pyrolysis oil itself can also be burned in boilers or gas turbines to produce heat and electricity directly. In the future it can become possible to use the pyrolysis oil as a second generation fuel in diesel engines or for automotive fuels. For now the applications are mainly in boiler applications to replace domestic fuel oil. The pyrolysis oil has a lower heating value between 17 and 19 GJ a ton. The conversion efficiency of the plant is about 65% on mass basis. This is based on clean wood with a moisture content of 5%.

4 SOCIO-ECONOMIC IMPACTS OF THE LIGNOCELLULOSIC BIOMASS CHAIN

4.1 Economics

4.1.1 Macroeconomics in the lignocellulosic biomass chain in Canada

Feedstock production

Given that currently, there is no well-defined market for lignocellulosic biomass, this section evaluates indicators in the forestry industry in general. It should however be noted that most of the wood products that will end up being used as lignocellulosic biofuels would probably be from residues from the industry rather than purposely grown stands.

Though Canada is a highly industrialised country, the forest sector made a significant contribution of 1.7% to the country's GDP in 2009. The forest management and logging industry alone accounted for some $3.571 billion while the entire sector (including the pulp industry and the wood manufacturing sector) accounted for a total of $19.887 billion According to the State of Canada's Forest report (2010), the forestry sector constitutes about 50% of the economic base for about 200 communities in Canada generating some 238,200 direct jobs and $10.3 billion in salaries in 2008.

Feedstock conversion

For the pyrolysis case the theoretical potential of the technology can be sketched, by assuming that all 913 paper and pulp mills established in Canada would host a pyrolysis plant. This would result in a total investment of almost 20 billion euro's. The plants will generate more than 110 billion euros of revenue in ten years' time. In the same period, the total profit is estimated to be over 18.5 billion euro's. This type of potentials could also be reached by assuming Lignol plants at each paper and pulp mill.

Table 9 Macroeconomics pyrolysis oil in Canada[2]

Paper and pulp mills	913
Total investments (billion Euro)	€19
Total turnover (10 years) (billion Euro)	€111
Total result (10 years) (billion Euro)	€18

4.1.2 Macroeconomics in the lignocellulosic biomass chain in British Columbia

Feedstock production

As this study focuses on the use of woody biomass for bioliquid production, the forest industry in BC is used to provide economic indicators for the production of feedstock. Given that there is no exclusive industry for producing lignocellulosic biomass and that by-products and co-products from the production of other forest goods are used as feedstock, the assessment from this point onwards focuses on the entire forestry industry in British Columbia, and the associated socio-economic indicators.

[2] Investment, turnover and result calculated by multiplying the amount of paper and pulp mills times the micro-economic information from paragraph 4.1.4.

The forests of British Columbia provide a variety of products generating substantial private and public revenues. The forestry sector in the province accounts for over 7% of employment and 15% of all economic activity in the province when indirect and induced economic activity are considered (State of BC Forest, 2010). The forest sector is the major employer in rural areas. In 2009, B.C. forest products accounted for 30% of B.C.'s total exports, and B.C. forest industry shipments accounted for 26% of B.C. total manufacturing shipments. Due to its reliance on the export market, the forestry sector tends to be susceptible to changes in international markets and trade restrictions. Though these indicators represent the forestry industry in its entirety and most of the products accounted for by the figures here are high grade wood products, there is nevertheless an opportunity to produce significant amounts of feedstock for woody bioliquid from the residues generated from forestry and processing activities.

According to the 2010 State of Canada's forests, there was 62.1 million dollars of new investments in Canada's forestry and logging industry in 2009. In 2008, a total of 858 million dollars in wages and salaries was paid in British Columbia's forestry and logging industry. Revenue generated by the forestry and logging industry alone in 2008 amounted to 4.4 billion dollars. Harvested volume amounted to 61.8 million m^3 while the value of domestic exports in primary wood products was 464 million dollar. The use of wood biomass to produce electricity, heat and bio-products represents a significant opportunity in B.C. B.C. has an abundance of underutilized wood in the form of sawmill residues, logging debris, and timber killed by the mountain pine beetle.

It worth noting that the timber harvested in B.C. is used primarily to make lumber, pulp and paper, panel boards, and a multitude of value-added wood products. Non-timber forest products include forage for livestock, mushrooms, and medicinal products. On average, each cubic meter harvested contributes $126 (constant 2002 dollars) to the provincial economy.

<u>Feedstock conversion</u>

For British Columbia the theoretical value of the technology can be determined by assuming that all 94 paper and pulp mills in the province host a pyrolysis installation. The total investments and result equals almost 2 billion euros over a 10 years' period.

Table 10 Macroeconomics pyrolysis oil in British Colombia[3]

Paper and pulp mills	94
Total investments (billion Euro)	€1.9
Total turnover (10 years) (billion Euro)	€11.4
Total result (10 years) (billion Euro)	€1.9

[3] Investment, turnover and result calculated by multiplying the amount of paper and pulp mills times the micro-economic information from paragraph 4.1.4.

4.1.3 Microeconomics in the lignocellulosic biomass chain for the Lignol case

Feedstock production

Feedstocks used by Lignol are mainly conventional wood chips sourced from pulp mill operators. The feedstock (chips) used by Lignol are supplied by trucks, and depending on the location, possibly by rail cars. These chips would usually have a normalized moisture content of 45%. The costs of these vary significantly depending on the location from which it is acquired, and would typically range from between $50-70 per tonne. Generally, chips from sawmills tend to be lowest cost while chips from logs harvested from hillsides invariably tend to have the highest costs. Volumes delivered at the plant will depend on the project being undertaken at the time and could range from 1 tonne to 20 tonnes at a time. Similarly, the frequency of supply of the feedstock would also depend on which project is being run and how often the mill is being run in the week. Mill run times could also range from 4 to 5 days around the clock to only 1 or two days.

Feedstock conversion

So far, only basic information is publicly available about the financial feasibility of a Lignol plant. However, the calculation below gives some insight in the costs and revenues of an ethanol and lignin factory.

The main products are ethanol and lignin derived products. The conversion efficiency for lignin and ethanol is respectively 20% and 22% per ton dry weight biomass. It is assumed that the price of wood is 50 euro per ton on dry weight basis, which is the same price as assumed for the pyrolysis case. At the factory the ethanol can be sold for about 553 Euro/ton (Internal information Lignol) and this price fluctuates with world market prices.

The value of lignin depends on its application. Raw lignin for fuel use or as a pellet binder has the lowest value. Other markets could offer higher prices, depending on the product that is replaced. For instance bitumen and phenols have a market value of 500-600 and 1200-1400 Euro/tonne. The price of lignin depends on the price of the fossil products that are replaced, e.g. PF and epoxy resins, which change with crude oil prices. Lignol states that the commercial values for lignin exceed 1500 Euro/ton. Additional upgrading and thus additional investment costs are needed when replacement of high value chemicals is intended. When assuming a useful lignin yield of 20% of the dry biomass with a value of 500-1500 Euro/tonne and a 22% yield of ethanol with a value of 553 Euro/tonne, the total revenues would be 222-422 Euro/tonne biomass. This means that 172-372 Euro per ton dry biomass is left for investments, other production costs and profits. See Table 11.

Table 11 Financial data Lignol

Sales	Euro/ton dry biomass
Lignin	100-300
Ethanol	+ 122
Total revenues	= 222-422
Total costs biomass	- 50
Revenues minus biomass costs	172-372

The investment costs of the Lignol factory are not exactly known. The biorefinery would be expected to operate around the clock, 27/7 except for down-time for periodic maintenance and essential repairs. Typically, a plant like this would operate for 330-350 days per year, allowing for two scheduled one week maintenance shut-downs per year and the occasional unscheduled shut-down for critical repairs. 24/7 operation is required to maximize capital utilization as well as the fact that some unit processes such as distillation need to run continuously for maximum efficiency. A distillation tower might take 24 hours to reach an efficient steady-state following a shut-down.

4.1.4 Microeconomics in the lignocellulosic biomass chain for the pyrolysis case

Feedstock conversion

In the paragraphs and tables below the microeconomics for a typical pyrolysis case is given. The total investments for a 50 MW_{th} pyrolysis factory are estimated at about 21.1 million euros. In Table 12 below the different input costs for the pyrolysis case are summarized.

Table 12 Input costs of the conversion unit for the pyrolysis case study

Production costs	Million Euro/year	Euro/tonne pyr oil	Euro/GJ output
Capital costs	2.9	55.9	3.3
Biomass costs	3.9	76.9	4.5
Labour	0.8	14.7	0.9
Maintenance	1.0	20.6	1.2
Energy	-	-	-
Total	8.6	168.2	9.9

Capital costs

The pyrolysis plant is designed for a capacity of 6.5 tonnes of pyrolysis oil per hour. With 7,884 working hours per year (90% of the year), the total capacity is 51,246 tonnes of pyrolysis per year. The investment costs for a pyrolysis plant are estimated to be 687 €/kW output (pyrolysis oil). With 30.7 MW of output, the total investment is 21.1 million euro. The investment is depreciated in 10 years and the interest rate is assumed to be 6%. This means that the total investment costs are 2.87 million euros per year. With a capacity of 51,246 tonnes and an energy content of pyrolysis oil of 17 GJ/tonne, the capital costs are 55.9 Euro per tonne and 3.3 Euro per GJ of pyrolysis oil.

Biomass costs

In this case, wood is used as biomass source for pyrolysis oil production. The conversion efficiency of this plant is typically 65% ton pyrolysis oil per ton biomass dry ash free (d.a.f). For an annual production of 51,246 tonnes pyrolysis oil, 78,840 tonnes d.a.f. biomass is needed. It is assumed that the price of wood is 50 Euro/ ton d.a.f. It means that the total annual biomass costs are 3.9 million Euro. This is equal to 77 Euro/ton pyrolysis oil and 4.5 Euro/GJ pyrolysis oil.

Labour

The pyrolysis plant requires 16 employees, of which 11 production employees, 2 technicians and 3 administrative employees. See also section 4.2.3 for more information. A production and administrative employee costs respectively 57,926 and 78,121 Canadian Dollars (CAD) per year. The exchange rate is 1.36 CAD/euro, which means 42,593 and 57,442 euro per year for a production and administrative employee (see also Table 13). In this case, a technician earns equivalent as an administrative employee. The total labour costs are 755,729 Euro annually.

Table 13 Input costs of the conversion unit for the pyrolysis case study (Industry Canada, 2010)

Function	Number of workers	Average labour costs in EURO / year
Production	11	42,593
Administrative	5	57,442

Maintenance

The annual maintenance costs are typically 5% of the investment, which is equal to 1.055 million euro's per year. In terms of output, the maintenance costs are 20.6 euro per tonne pyrolysis oil and 1.2 euro per GJ output.

Energy

The pyrolysis process requires heat to keep the hot sand in the reactor at the right temperature and furthermore, incoming biomass need to be dried. Furthermore the plant consumes electricity. Heat (steam) can be produced from the by-products of the pyrolysis process: char and gas. In addition power could be produced for instance by a backpressure turbine. The investments in CHP equipment are included in the cast study, which means that the total pyrolysis plant is energy self-sufficient. Excess heat and power could be supplied to the grid. Furthermore, start-up burners require some fossil fuels. The net external energy costs are set at zero.

Sale of pyrolysis oil, heat and power

When exported to European markets, the pyrolysis oil has a value of about 14 euros per GJ, or 238 euros per tonne when used for CHP production. Pyrolysis oil can be further upgraded. Like in the case of Lignol, the lignin fraction can be extracted and used for the production of phenols. BTG also investigates several other uses like production of bio-asphalt, etc. The total pyrolysis output is 51,246 tonnes per year and – when considering its use for CHP a total income of 12.2 million euros per year is generated. At the pyrolysis factory next to pyrolysis oil, also char and incondensable gases are produced, which can be converted to heat (steam) and electricity. After subtraction of its own heat and electricity demand, the factory can export about 1 MW electricity (depending on the design). These revenues are not taken into account in this model.

Feasibility

In

Table 14 a summary of all variables are given. With these variables, the internal rate of return is determined for three cases (with 50% debt and 50% equity financing):

- Overall: 25.0%

- Dividend: 25.9%
- Equity: 28.4%

With the internal rate of return it can be concluded that a pyrolysis plant of this form is a viable investment. However, it needs to be noted that the input price of biomass and the output price of pyrolysis oil, can vary from case to case and influence the feasibility. Therefore, the internal rate of return can actually be higher or lower.

Table 14 Summary of variables

Technical parameters		
Capacity	6,5	tph
Operation hours	7.884	hours/a
Pyrolysis oil production	51.246	tonnes/a
Biomass consumption	78.840	tonnes daf/a
Cost - revenues parameters		
Pyrolysis oil sales price	14	Euro/GJ oil
Biomass costs	4.5	Euro/GJ oil
Variables		
Biomass costs	50	Euro/ton daf
Investment costs	21,1	Mln Euro
Sales price pyrolysis oil	14,0	Euro/GJ
Labour	16,0	fte
Plant availability	7.884	hours
Pyrolysis oil production eff.	65%	
Maintenance	5%	of investment costs

4.1.5 Summary of measurable units and indicators

- Internal rate of return
- Input costs split per category
- Output revenues split per product

4.2 Employment generation

4.2.1 Employment generation in the lignocellulosic biomass chain in Canada

Feedstock production

Again, this section provides general information about the entire forestry industry, from which feedstock for woody biomass is obtained, usually as a by-product.

Being the world's largest exporter of wood, Canada's forest industry generated some 273,700 direct jobs in 2008 and supported some 300 forest based industries (Poon, 2009). Canada is a net exporter of wood products with a trade surplus of $14.4 billion in 2009. According to the State of Canada's Forest report (2010), wages and salaries paid to the forestry and logging industry alone amounted to 2 billion dollar.

Feedstock conversion

In 2009 the paper and pulp industry employed 45,843 persons in production tasks and 13,236 in administration tasks. However, the sector is in decline due to decreased demand of paper and house construction. During the period 2000 to 2009 the number of jobs in production decreased with 5.1% every year and in administration with 3.9% a year. Between 2008 and 2009 the number of jobs decreased even more than the average number. In this period the production jobs decreased with 9.9% and the administration jobs with 5.9% in a year (Canadian Industry, 2010). Biorefineries like the Lignol plant and pyrolysis plant can contribute to the available jobs in Canada and can help to compensate the decrease of employment in the paper and pulp industry.

In Canada there were a total of 913 pulp and paper mills at the end 2010. When all these paper and pulp mills can house a biorefinery the total amount of jobs created per category is:

- *Direct jobs*: 14,068
- *Indirect jobs*: 5,478
- *Temporary jobs*: 85,822 (see also subsection 4.2.3).

4.2.2 Employment generation in the lignocellulosic biomass chain in British Columbia

Feedstock production

According to the LFS (2009), forest industries provided up to 52,000 direct jobs in British Columbia in 2009. The forestry industry is a major employer in the province, and though forest based employment has declined from some 100,000 to 142,000 jobs in the 1970s to current levels due to the sharp decline in demand and prices of forest products since the 2007s, the industry nevertheless continues to be a major employer in the region supporting workers, their families and the economic and social fabrics of their communities. Data from the State of BC forests, 2010 indicate that in 2008, direct jobs in the forest sector provided some 4.6% of employment in the province whilst together with indirect jobs, they provided some 6.8% of jobs. The province has traditionally been dependent on the forest industry and many First Nations are dependent on forest based employment.

Though the province's economy has grown and become more diversified with overall provincial dependence on forests decreasing, there are still many areas that depend primarily on forest employment and where a high proportion of incomes are obtained from forest employment. According to the state of BC forests, 2010, forest based industries tend to pay very well and the average incomes tend to be around 12% higher than that of all industries. In 2005, direct and indirect forest labour incomes yielded a total of some 6.75 billion dollars or 8.2% of the provincial labour income from all industries.

Feedstock conversion

Around 18,000 people were employed in the renewable market in 2009 (Life Sciences British Columbia, 2009). As could be noted from subsection 3.2.7 the amount of energy in British Columbia from bio-energy is 3%. Assuming that hydro power is also part of renewable energy and all jobs are created evenly between the renewable energy options it could be stated that between 300 and 400 people are currently working in the bioenergy sector in British Columbia[4].

According to industry statistics of Industry Canada (2010) there were a total of 94 paper and pulp mills at the end of 2010 in British Columbia. In theory all paper and pulp mills can house a biorefinery in the form of a Lignol type plant or a pyrolysis plant. In theory the following amount of jobs can be created:

- *Direct jobs*: 1,504
- *Indirect jobs*: 564
- *Temporary jobs*: 3,290 (see also subsection 4.2.3).

However, in theory these amounts can even be higher, due to the fact the abandoned pulp and paper mills are not yet taken into account. Also these sites can house a biorefinery plant.

4.2.3 Employment generation in the lignocellulosic biomass supply chain

Feedstock production

For the assessment of employment in the feedstock production chain, Tembec BC has been used as a case.

The forestry industry and its allied businesses is a leading employer in the British Columbia area. For Tembec BC, there is a public commitment to assist in the creation of long term social, cultural and economic benefits for the people in which the company operates. This has been done through proactively seeking to employ local staff and involve local contractors in its operations. According to the company's Sustainable Forest Management Plan (SFMP) the human resource department maintains copies of all applicants interested in seeking a career with the company for a minimum of one year. These individuals are given priority treatment when a job opportunity comes up, provided that they are qualified and compatible with the position with the possible exception of experience. It is also the BC Division's practice to hire local short term and long term contractors/consultants to support and compliment the FRM group. Although not formally documented, local contractors/consultants are normally considered for hire through a select invite and/or tendering process or direct award. When special and unique services are required and are not available locally, the hiring practice seeks resources beyond the local area.

The following Table represents the total direct employment that includes full-time (staff), hourly (union) and part-time/seasonal staff, in Tembec's Kootenay Operations. Beginning in 2010 all staff (100%) employed by FRM BC Operations are considered to be from the local region and the description between staff and hourly has been further refined.
At the forestry operations level, Tembec employs a total of 33 permanent staff and 1 part time staff. A total of 34 staff are employed in the actual forest management operations. Given that the company has an annual allowable cut (AAC) of 1,133,549 m^3 of wood each year, a total of 0.29 jobs are created per every 10,000 m^3 of wood harvested each

[4] Number of jobs = 18,000 * ((3/(88+3)) * (103.5/(103.5 + 190.1)) = 210

year at the forest resource management level. This does not include the number of contractors that are employed each year. Table 16 indicates that a total of 261 contractors are being engaged in 2011. The list of contractors employed includes loggers, haulers, road builders and consultants. When this is considered, it can be said that up to some 295 jobs are created per annum for the companies AAC. This yields a total of 2.6 jobs per 10,000 m^3 of wood produced.

Table 15 Tembec Employee Summary

Group/ Division	2009			2010			2011 (YTD)		
	Male	Female	Total	Male	Female	Total	Male	Female	Total
FRM[5] Staff	30	6	36	26	6	32	26	7	33
FRM Staff part-time	3	6	37	1	1	1	1	1	1
FRM Hourly	-	-	-	29	1	30	-	-	-
FPG[6] Staff	432	33	465	22	4	26	26	7	33
FPG Hourly	-	-	-	314	18	332	-	-	-
FPG/FRM Cbk Office	-	-		22	23	45	17	19	36
Pulp Staff	240	27	267	57	12	69	54	15	69
Pulp Hourly				242	26	268	245	26	271
Total	**733**	**72**	**805**	**712**	**91**	**803**	**368**	**75**	**443**

Contractor Employment

Using the contractor pensions and other benefit payment schedules that Tembec makes to their logging, hauling, and consulting firms, the following levels of indirect employment can be estimated. In the mid and later part of 2009, Tembec was able to extract the following employment levels from Tembec's contracting community, and they expect to monitor this in future years reporting.

Table 16 Contractor employment

Contractors	2008	2009	2010	2011
Loggers		130	133	138
Haulers		55	55	55
Road builders		32	31	36
Consultants		40	30	32
Total	**347**	**257**	**249**	**261**

<u>Feedstock conversion</u>

The following numbers on job creation are based on the pyrolysis factory. However, the numbers for employment creation for feedstock conversion will be quite similar in the Lignol case as well. A distinction can be made between jobs actually created in operating

[5] Forest Resource Management (FRM)
[6] Forest Products Group (FPG)

the plant and jobs supporting the production process. In operating the plant 11 jobs are created for persons with a technical degree from a community college. These operators work in 3 shifts of 8 hours a day. In addition, 2 persons are present on the plant during normal working hours. These are the jobs of maintenance engineer and E/I technician. These persons should have a technical degree from a community college or university of professional education.

For the supporting activities 3 jobs are created. First, there is a plant manager with a master degree from a university of science. His task is to take care of the daily activities such as human resource management and marketing. In addition, a production assistant will work on site to control the process and to plan the production. This person should have a degree from a university of professional education. Finally, a combined job is created for a controller or administrative assistant. This person should have followed education on a university of professional education or community college.

The plants also create indirect jobs. Often a plant needs a technology manager, a safety officer and some human resource services. In addition, the product created by the plant (ethanol, lignin or pyrolysis oil) should be transported to the customer. Around 6 jobs can be created by these functions. In addition, during plant building 35 temporary jobs are created by the technology developer and local construction companies.

To summarize, each plant can create **16** direct jobs, **6** indirect jobs and **35** temporary jobs (Internal information of Lignol and BTG). See also Table 17 for a summary.

Table 17 Summary generated jobs

Direct Jobs	Indirect Jobs	Temporary jobs
11 operators	1 technology manager	35 construction workers
1 mainteanence engineer	1 safety officer	
1 E/I technician	1 human resource	
1 plant manager	3 transport	
1 production assistant		
1 controller		
16 direct jobs	***6 indirect jobs***	***35 temporary jobs***

4.2.4 Summary of measurable units and indicators

- Number of jobs created for different activities and educational levels.

4.3 Working conditions

4.3.1 Working conditions in the lignocellulosic biomass chain in Canada

<u>**Feedstock production**</u>
Working in the wood production industry demands adequate fitness and endurance. In Canada as in many other countries, workers in forest management tend to spend long hours outdoors usually in forests in isolated and remote locations. They may be required to work from camps and spending extended periods of time outside of home. There is frequent exposure to extreme weather conditions. The work typically includes long hours

of walking and extended working hours during peak seasons. The work also includes operation of heavy duty machinery and typically involves high noise levels and demand adequate physical strength.

Generally considered as one of the most dangerous professions in the world, there is the need for field staff to be adequately protected through the use of personal protective equipment and appropriate health and safety trainings. Given the potential for high risks of injury and fatalities, the forestry industry tends to be have wages much higher than industry average in the country. Annual salaries could range from around $20,000 for forest fire-fighters up to $93,000 for registered professional foresters. Workers are usually entitled to additional benefits including general healthcare and dental care, insurances, pensions, etc.

Feedstock conversion

In Canada there are strict labour laws which should be followed by all employers, including paper and pulp producers and second generation biofuel plants. Due to the fact Canada is a federal state there are two levels of labour laws. There are national and provincial laws. In general, the labour laws are part of the provincial authority, only those activities of national, international or interprovincial nature are covered by a nationwide labour law. Also those operations that have been declared by Parliament to be for the general advantage of Canada are covered by the nationwide laws.

For the second generation biofuel sector no explicit category is listed, meaning that the provincial labour code applies to this sector. However, in the future this can change when the sector is marked as important for the general advantage of Canada. In general, it can be stated the minimum requirements to working conditions are covered by a national labour code. For individual contracts exceptions can be made, but only in advantage of the employee (Human Resources and Skills Development Canada, 2011).

4.3.2 Working conditions in the lignocellulosic biomass chain in British Columbia

As was already stated in the national paragraph the labour code of British Columbia is leading for employment in this province. This labour code is called ‘Employment Standards Act’ in British Columbia. Some of the important points of this labour code are outlined in the box below. This code is – just like the national code – a minimum. Employer and employee can deviate from this code in favour of the employee (LCOG, 2011).

The education level in British Columbia was higher than in the rest of Canada during 2006. Only 12% of the inhabitants had a degree that is lower than high school. Moreover, more than 60% of the inhabitants followed education after high school in the form of community college, a university of professional education or university of science. The younger generation is higher educated than the older generation and women are currently the majority of university graduates. However, only 6% of the women attained a technical grade in a field of study against 44% of the men. For the Lignol and pyrolysis plant this means there are enough high-educated inhabitants in the region. For the plants, most of the technicians will probably be men because women are mostly employed in administrative functions (BC Stats, 2006).

Table 18 Education level in British Columbia

Education	BC	Canada
Less than high school	12%	15%
High school certificate or equivalent	26%	24%
Non-university certificate or diploma	20%	20%
University certificate or diploma below bachelor level	6%	5%
University's bachelor degree or higher	24%	23%
Total	**100%**	**100%**

Minimum wage
€6.94 per hour in 2011. €7.48 per hour in 2012.

Minimum daily pay
At least 2 working hours should be paid, when an employee attends for work.

Meal breaks
An employee may not work more than five hours in a row without a 30-minute unpaid meal break.

Paydays
Employees must be paid twice a month and the pay period cannot be longer than 16 days.

Overtime
1.5 times the hourly pay after 40 hours worked a week and 2 times pay after 12 hours worked a day.

Deductions
An employee cannot deduct any of the employer's business costs from the wages. This includes damage to company property, breakage and cash shortages.

Statutory holidays
There are 9 statutory holidays in British Columbia and employees do not have to work on these days. Payment should, however, continue. When work is performed on these days the employees are paid more.

Annual vacations
An employee is entitled two weeks of vacation each year. After five years the employee is entitled 3 weeks of vacation. The vacation pay is 4 percent or six percent after working 5 years in a row.

Leave from work
Pregnancy and parental leave are just a few possibilities of special leaves available in British Columbia. All these leaves are, however, unpaid.

Employing young people
People under 15 can only be employed by written statement of the parent or guardian. Children under the age of 12 need permission from the Director of Employment Standards.

Collective agreements
Possibilities for collective agreements are possible, but should meet certain rules.

Resolving disputes
Disputes have to be solved by employers and employee. If not they can ask assistance from the director of employment of British Columbia.

Box 1 Employment Standards Act British Columbia (LCOG, 2011)

4.3.3 Working conditions in the lignocellulosic biomass chain at case level

Feedstock production using Tembec as a case

Given the typical working conditions for forest based employment, there is the need for employers to put in place mechanisms that address negative impacts and maximise positive ones. One of the core principles of Tembec's Sustainable Forest Management Plan is to comply with all provincial and federal legislations. These include guidance on health and safety, working hours, employee benefits and staff working conditions in general. Additionally, employees have the right to collective bargaining, there are appropriate grievance resolution mechanisms and staff representation to the company. The company also has a Human Resource Participation Policy that aims at empowering its staff and integrating their concerns into planning and decision making processes.

As a matter of priority, the company ensures that all its employees are well trained not only to execute their duties efficiently, but also on necessary health and safety and working practices. Each staff of the company is entitled to forty hours of training per annum, as a corporate policy. The company hopes to review this upwards to sixty hours. The company has an internal time-table for delivering this and staff are paid their normal rates during the training periods.

Feedstock conversion

Due to the fact the Lignol plant and pyrolysis plant are not yet build, it is impossible to assess the working conditions for these plants in detail. However, something can be said about the paper and pulp sector in Canada, which resembles the two plants.

There are, for example, collective agreements between organizations and employees. These collective agreements make it possible that employer representation within the organization is possible. In these cases two or more full-time or part-time employees are elected to represent the personnel of the organization. During regular working hours these persons are given the opportunity to investigate and process grievances or discuss with the union without the loss of payment. In addition, these collective agreements improve the working hour situation of an employee (extra breaks) and the vacation scheduling (up to 4 weeks of vacation). Moreover, the agreement houses a pension plan, which is both paid for by the employer and the employee (Collective Agreement, n.d.).

The paper and pulp sector and possibly in the future the second generation biofuels sector can have a union. For the paper and pulp sector two examples of unions are 'Communications, Energy and Paperworkers Union of Canada (CEP)' and 'Pulp, Paper and Woodworkers of Canada (PPWC)'. Both unions represent their members and give the opportunity to take education and achieve scholarships. The PPWC, for example, offers the Agnus MacPhee memorial bursary. Members of the union and their family can apply for this $1,000 bursary when they want to study social sciences. Also CEP has a scholarship program, where twelve scholarships of $2,000 are granted each year to union members or their family (PPWC, 2011; CEP, 2011).

4.3.4 Summary of measurable units and indicators

- Minimum regulations by governments
- Presence of unions and their bargaining power
- Employer representation within the organization
- Level of education

4.4 Health issues

4.4.1 Health issues in the lignocellulosic biomass chain in Canada

<u>Feedstock production</u>

Worldwide, the forestry industry is known to be one of the most dangerous professions with a number of adverse health effects and relatively higher rates of accidents and fatalities compared to other industries. Injuries and fatalities result from dangerous situations, equipment failure, cultural attitudes, market and workplace pressures, human , and other factors (fatigue, dehydration, inadequate conditioning, stress, drugs, and alcohol).

<u>Feedstock conversion</u>

See paragraph 4.4.3

4.4.2 Health issues in the lignocellulosic biomass chain in British Columbia

<u>Feedstock production</u>

Forestry is largely considered as one of the most dangerous professions in the world with the potential of accidents and other health issues coming from multiple sources. Aside general accidents that could arise due to the use of heavy duty and fast revolving machinery, bad terrains and adverse weather, there is also the potential for long term health effects when inadequate health and safety precautions are taken and when there is inappropriate personal protective equipment. Compared with most other industries, work in timber-based industries is both physical and dangerous. However, over the past three decades, the annual number of injuries and fatalities in the forest sector of British Columbia has declined. According to the State of BC's forests report, total benefits paid out to for disability and fatalities between 1991 to 2008, inclusive for the forest industry amounted to $130 million, whilst a total of $545 million was paid to all industries altogether.

<u>Feedstock conversion</u>

See paragraph 4.4.3

4.4.3 Health issues in the lignocellulosic biomass chain at case level

<u>Feedstock production using Tembec as a case</u>

Given the nature of forestry operations and the high risks of injury, accidents and long term health effects, it is essential for forestry operations to have enforceable health and safety procedures that are rigorously followed to minimise the incidence of accidents and fatalities. Tembec has an Occupational Health and Safety Policy that aligns with the BC forest council initiative and aims at eliminating all fatalities within its operations. Available data from Tembec indicate that there have not been any fatalities of its direct employees since 2007. Additionally, no medical aid and lost time accidents have been recorded in a number of years. However, there is a comparatively higher levels of accidents and medical aid within the company's contractors, with one fatality being recorded in 2010. Table 19 presents a representation of safety records between 2007 and June 2011.

Table 19 Safety records between 2007 and June 2011 (Sustainability Report 2011, unpublished).

	2007	2008	2009	2010	2011	Total Cummulative
Employees						
Medical Aid (off-site)	4	0	1	1	0	6
Lost time accidents (LTA)	0	2	0	1	0	3
Fatalities	0	0	0	0	0	0
Contractors						
Medical aid (off-site)	11	2	6	5	3	27
Lost time accidents	8	8	7	7	9	39
Fatalities	0	0	0	1	0	1

Feedstock conversion

The Lignol and pyrolysis plant can be compared to every industry using machines and chemicals. It also deals with the same issues, for example noise, fire and gas emission issues. However, in Canada there are all kinds of regulations the plants have to meet. Due to these regulations and internal measures taken, the health and safety issues are reduced to a minimum. A few examples are outlined below.

A problem which can arise in the plant is noise from the engines. Some engines produce noise which lies above the legal threshold. A research for a typical pyrolysis plant shows that when proper measures are taken, the factory can meet an acceptable sound level. An engine can for example be enclosed in a noise-reducing case. Outside of the factory there can also be problems with noise. The shredder of the biomass and the vehicles transporting the biomass make noise. For a typical pyrolysis plant the average long-term sound level is 10 to 28 db(A) depending on the distance to the plant. The noise level is quite constant during the day. So noise can be a problem only if the right countermeasures are not taken.

Another health and security risk is the chance of a fire outbreak. The biomass can, for example, start scalding increasing the chance of fire. In addition, wood dust and air can give a dust explosion in the right concentrations. Another fire threat are the storage tanks of ethanol or pyrolysis oil and other stored flammable gasses. The risk of fire can, however, be reduced by taking the right precaution measurements. By installing the right fire fighting equipment, making materials fire retardant and by developing sufficient escape routes the risk of fire can be reduced.

In addition, the emission of gasses in- and outside the plant can be a health and safety risk. Examples of gasses are NO_2, SO_2 and CO. Also pyrolysis vapour can escape when the installation is under maintenance. These risks are overcome by wearing a personal CO detector, installing gas detectors in the plant and by training the personnel. Emission outside of the plant can be reduced to a minimum by using several techniques. Cyclones can be used to filter ash and dust. A fabric filter can save small dust particles and the afterburner will burn the toxic gasses. Accidents with toxic gasses can happen within the plant, but can be reduced to a minimum by taking the necessary precaution measurements.

In general, it can be stated there are several health and safety hazards in the Lignol and pyrolysis plant, but that they can be compared to every other (chemical) plant in the world. By installing software, hardware, personal or mechanical protection and security most of these issues can be reduced to a minimum. The actual figures can only be determined when the plants are actually operating.

4.4.4 Summary of measurable units and indicators

- Health and safety threats in plant
- Possibility of precaution measurements in different forms (hardware, software, personal etc.)
- Health programs by organizations or governments.

4.5 Food issues

4.5.1 Food issues in the lignocellulosic biomass chain in Canada

Feedstock production

Land use planning in most places have usually considered forestry and large scale commercial agriculture to be two mutually exclusive processes. Commercial agriculture has in most cases implied forest conversion, and the two have not co-existed, except in agroforestry schemes. However, given the permanent forest estate of Canada, it is not anticipated that there would be any conversion of forest vegetation to food crop production. Unlike other feedstock sources for biofuel production, the forestry industry barely has any direct competition with food crops. That notwithstanding, forests also serve as a place for gathering numerous non-wood forest products, some of which can be used as food. Likely food products obtainable from forests include mushrooms, honey, and game. In some other cases, forests may serve as forage grounds for livestock. The nature of forest management may permit or restrict access to these products and services that forests provide in terms of provision of food resources.

In Canada, maple syrup, mushrooms and berries are the major non-wood forest products extracted from the forests. Though the exact value of all non-tree forest products (NTFPs) from Canada's forests are not known, it is estimated that traditional NTFPs have the potential to contribute up to 1billion dollars to the economy. Mushroom exports have been estimated to potentially contribute some $115 million to the Canadian economy, with pine mushrooms alone selling for some $400 per kg.

Feedstock conversion

See paragraph 4.5.3.

4.5.2 Food issues in the lignocellulosic biomass chain in British Columbia

Feedstock production

Forests in British Columbia also serve as an important source of non-timber forest products used as food. The most common types being pine mushrooms, chanterelles and morels. These species have the best-established commercial markets, ranging from local restaurants to commercial operations, where harvesters pick the mushrooms for grading and shipping to markets across Canada and internationally, notably Europe and Asia. In Japan, the pine mushroom is a delicacy, known for its aromatic odour and its texture and taste, and can command a price of about $400 per kilogram. Forest management in the province has in most cases tried to allow for multiple use of the resource, allowing the sustainable extraction of the food based non-timber forest products. Data on extraction levels are not readily available.

Feedstock conversion

See paragraph 4.5.3.

4.5.3 Food issues in the lignocellulosic biomass chain at case level

Feedstock production using Tembec as a case

As mentioned above, the operations of forestry industries including Tembec in British Columbia are carried out on clearly defined forestry lands that are not meant to be used for agricultural practices. That notwithstanding, there is still the potential for local communities to carry out small scale exploitation of food resources from the forested areas. This includes mushroom gathering, hunting and fishing.

As part of its strategy to protect biodiversity in its forests, Tembec has employs various measures including access restriction into its areas to regulate the level of hunting and exploitation of other non-timber forest products. The status of biodiversity in the forests is also monitored on regular basis to serve as a basis for implementing appropriate interventions where necessary. As part of its efforts to protect water bodies, the company also has a buffer zone policy that also targets the protection of fish habitats and fishery resources both within the company's forests and beyond.

Feedstock conversion

The Lignol and pyrolysis plant do not compete with food, because they use lignocellulosic biomass from well managed forests. The Lignol plant even solves part of the energy versus food discussion for ethanol production. Currently, ethanol is mainly produced from agricultural crops such as potatoes, sugar cane and corn. These products are cultivated on farmland which could also be used for food production. Ethanol production in the Lignol plant does not originate from agricultural products, but from lignocellulosic biomass instead. Therefore, there is currently no competition with farmland used for food production.

In the future lignocellulosic energy crops could be planted on farmland. However, with a large surface being covered with woods and a lot of grassland still available in British Columbia and Canada, it will not be likely that this will be a problem in the future. For other countries with smaller surfaces covered with wood and grassland this can give a problem. This also applies to pyrolysis oil production.

4.5.4 Summary of measurable units and indicators

- Amount of surface taken by biomass for second generation biofuels

4.6 Land use competition and conflicts

4.6.1 Land use competition and conflicts in Canada

Feedstock production

Canada has a well-established land use system with a permanent forest estate that has been fairly constant over the decades. As leaders in sustainable forest management, the country's integrated land-use planning process seeks to balance the economic, social and cultural opportunities in a specific area of forest with the need to maintain and enhance the health of the area's forest. It is a process whereby all interested parties come together to make decisions about how the land and its resources should be used and managed, and to coordinate their activities in a sustainable fashion. It holds that maintaining the integrity of the ecosystem is the primary consideration[7].

Though the land ownership and land-use categorisation has been fairly constant over the years, it is also worth observing that there is an increasing amount of forests coming under Aboriginal jurisdiction as land issues are settled.

Feedstock conversion

See paragraph 4.6.3.

4.6.2 Land use competition and conflicts in British Columbia

Feedstock production

Like the rest of Canada, the province of British Columbia has a fairly permanent forest estate. Given low population density and the large forest estate, there is minimal pressure to convert the permanently dedicated forest estate. However, what has changed slightly within the decades is the percentage of land ownership by various land owners. Currently, there is about 22 million hectares of timber harvesting land base (THLB) in BC. THLB refers to publicly owned lands on which timber harvesting is both feasible and permitted. This is complemented by some 2 million hectares of privately owned forests that are suitable for timber harvest. Of this, only 0.4% of the total forest area (or 0.8% of the area suitable for harvesting) is harvested each year.

Feedstock conversion

See paragraph 4.6.3.

[7] http://www.sfmcanada.org/english/topics-land.asp

4.6.3 Land use competition and conflicts at case level

Feedstock production using Tembec as a case

As indicated in previous sections, land use planning in Canada is clearly defined and the forestry industry does not compete with other industries. However, there is the issue of First Nations rights over forestry resources that are currently being addressed through various initiatives.

The entire area covered by Tembec BC's Kootenay operations is within the traditional territory described by the Ktunaxa/Kinbasket Tribal Council. The Ktunaxa-Kinbasket Tribal Council has entered into the BC Treaty Process and is currently at the fourth stage of that process (Agreement in Principal stage). They are currently completing a Land Use Planning exercise that will identify areas of specific cultural value in their territory.

As an FSC certified Forestry Company, Tembec is expected to identify all social and cultural High Conservation Value (HCV) areas within its management areas. In 2006, the company began working with the local community to identify all the Ktunaxa cultural interests throughout its territory. Working together with Tembec, the Ktunaxa identified and mapped known cultural landscapes that overlap with Tembec's management and tenure. Additional mapping of other cultural and social values have carried on with other First Nations living in close proximity to Tembec's management areas.

As part of its sustainable forest management plan (SFMP), the company strives to maintain a relationship with First Nations based on 'respect, openness and integrity'. This is achieved through active engagement and participation of First Nations in both strategic planning and operational level activities. Currently, most of Tembec's Kootenay operations are on Crown lands. The company also manages some areas belonging to First Nations on their behalf. The company has a dispute resolution mechanism that seeks the participation of local stakeholders in ensuring meaningful, culturally appropriate and scientifically sound resolution of disputes within the landscape. In the 2008 fiscal year, the company did not encounter any situation that warranted the engagement of the dispute resolution mechanism.

Though rare, there are also cases where other resource users (mineral explorations, range, etc) are given permission by government to operate within areas that overlap with Tembec's management. The company's internal resolution systems may be engaged when necessary, but in all cases, the other land users are informed of the presence and locations of High Conservation Values where these are contained in the permit areas

Feedstock conversion

There is no land use competition for the Lignol or pyrolysis plant if they are situated on the same site as an operating pulp and paper mill. This site was already allocated to industrial purposes and will not give any problems. The plant owner only has to apply for renewed permissions, such as a building and environmental permit.

When the Lignol or pyrolysis plant is built on the site of an abandoned pulp and paper mill there is also no land use competition. By building the plant here the site gains a higher value and provides employment and added value for the region again. However, one can think that some inhabitants around the renewed site are not happy with a new plant, because it can give some nuisance. This negative effect will, most certainly, be small, because a lot of small towns in British Columbia depend on a paper and pulp mill. This also more or less also applies to new plants outside of operating or abandoned pulp and paper sites.

4.6.4 Summary of measurable units and indicators

- Availability of a coherent land ownership structure
- Availability of treaties on land use issues with native local stakeholders

4.7 Gender issues

4.7.1 Gender issues in the lignocellulosic biomass chain in Canada

Feedstock production and conversion

The Canadian Charter of Rights and Freedoms of 1982 settled the gender equality of men and women in employment, public life and education. Moreover, the Canadian Human Rights Act and the Multiculturalism Act were introduced to – especially - protect the rights of aboriginal women and foreigners. It could therefore be stated that – in theory – men and women are equal in Canada (Wikigender, 2011).

In practice, there is still some gender inequality in Canada. This can be noted from the wage gap between men and women. Until 2000 the hourly rate of women was 30% lower than the hourly rate of men with the same profession. During the years this wage gap decreased to around 13% in 2011. Women are now making, on average, 21.09 Canadian dollars and men earn 24.33 Canadian dollars (Statistics Canada, 2011).

The labour employment gap is, however, rather low in Canada with 10%. This means that there are 10% less women on the labour market than men. There is, however, a large difference between professions. Women are overrepresented in humanities, arts, education, health and welfare. On the other hand, women are underrepresented in jobs like engineering, computer science and other technology-related fields. In Canada women do become the higher educated class in the future, with changes in professions as a result (Wikigender, 2011).

Women on the labour market are also represented by several organizations. A federal government organization called ‘Status of Women Canada’ (SWC) does work together with federal agencies so gender issues are taken into account in the development of policies. In addition the private organization ‘Gender Equality Incorporated’ (GEI) does work with the government and private organizations to commit them to gender equality (Wikigender, 2011).

4.7.2 Gender issues in the lignocellulosic biomass chain in British Columbia

Feedstock production and conversion

Around 5 to 10 years ago there were some developments on gender issues in British Columbia. Especially due to cutbacks at the public services a lot of female workers were fired. The cutbacks also indirectly affected feminine work areas such as childcare, leading to fewer jobs for this group. In addition, changes in the 'Employment Standards Act' in British Columbia affected job opportunities for women. A reduction of the minimum shift length made it more difficult for women to find suitable part time jobs. Also farm workers are exclude from regulations related to hours of work, overtime and statutory holiday pay. Because during harvesting time 61.5% of the work is performed by women, they are not protected by this law (CCPA, 2004).

No recent report could be found on gender issues in British Columbia. Therefore, it could be that the position of women on the labour market became better over the years.

4.7.3 Gender issues in the lignocellulosic biomass chain at case level

Feedstock production using Tembec as a case

The forestry industry is a traditionally male dominated field. According to Martz et al., 2006, the representation of women in the forestry sector account for only 15.2%. Diverse reasons gave been given for this low representation. This includes the fact that the primary forestry industry is physically demanding, has a relatively higher levels of accidents and in most cases require long periods of stay in camps with little flexibility in working times.

In Tembec BC, the total number of females employed in its operation in east Kootenay is given in the table below. As can be seen from the table, the total number of women employed has grown from 9.1% in 2009 through 11.3% in 2010 to 16% in 2011 YTD. Though gender issues are not mentioned or addressed in the company's SFMP and the annual reports, there is a growing percentage of female employees in all aspects of the company's work. It is however evident that a greater proportion of the female staff are based in the FRM/FPG offices. Female staff based in these offices accounted for 51% and 53% of office staff in 2010 and 2011 respectively.

Table 20. Male and female staff.

	2009	2010	2011YTD
Number of male workers	733	712	368
Number of female workers	72	91	75
Total number of workers	805	803	443
Percentage of female workers	9.1%	11.3%	16%

Feedstock conversion

Due to the fact that the Lignol or pyrolysis plant is not build yet, no conclusions can be drawn on gender issues. However, some general comments can be made. As could be noted from the previous paragraphs most women are employed in the social sciences and not as technicians or engineers. Therefore, it will be most likely that most of the operators actually working at the site will be men. On management and administrative level probably more women will be employed.

4.7.4 Summary of measurable units and indicators

- Wage gap between men and women
- Employment of sexes in different working categories
- Presence of organization for women's rights
- Women participation policy of local, provincial and national governments

5 EVALUATION OF THE MEASURABLE UNITS AND INDICATORS

5.1 Relevance of impacts

The production of second generation products like lignin, ethanol, pyrolysis oil and upgraded products using forest residues and pulp wood can generate economic benefits and employment in the forestry sector that suffers from the declining demand for paper and timber. These impacts are important on national and regional level, but even more on a local level. Villages and communities are often highly dependent on the nearby paper mill or saw mill and the decline of these sectors have hit these communities hard.

On micro-economic scale, for each biorefinery, the challenge is to produce sufficient added value materials at low costs. For instance, ethanol is produced elsewhere in bulk and ethanol prices are not very high. Some fractions have high added value but are only available as small shares of the total output. These fractions are often similar but not equal to their fossil substitutes, meaning that marketing can be challenging. Furthermore, the complexity of the process adds to the costs. For these reasons it is difficult to predict when the widespread dissemination of biorefineries will take place with the estimated economic and employment impacts on regional and national level.

Working conditions are not likely to deviate from the existing practices in the forestry sector (biomass supply) and chemical industry (biomass conversion). In both sectors, health and safety are important issues that need to be taken care of by following and implementing the regulations that are in place.

Food issues are limited to the use of forest products like maple syrup, mushrooms and berries. Impacts seem to be limited, but can occur in case of land use conflicts. Land use conflicts are a relevant topic in Canada with its population of First Nations. These conflicts are tried to be solved through treaties on province level.

The forestry sector and processing industries typically employ male workers. Field work in the forestry sector is physically demanding, while offices have a 50% share of female employees. The wage gap between male and female workers is decreasing in Canada, but still exists.

5.2 Determination of thresholds

For economic issues, the determination of thresholds does not seem to be useful. Investors use thresholds on IRR, NPV, payback time and perceived risks before making an investment decision, but there is no ground to provide specific thresholds in the frame of this case study.

In the Employment Standards of British Columbia various thresholds for labour conditions can be found, related to minimum wage, minimum daily pay, meal breaks, paydays, overtime, deductions, staturary holidays, annual vacations, leave from work, employment of young people and disputes, etc. See also Box 1 in section 4.3.2.

Related to safety issues, safety records are kept, but it is hard to provide thresholds: each accident is simply one too much.

Regarding gender issues, some countries have minimum shares of women present in the board, but most countries don't. Of course, wage gaps between women and men are not acceptable on company level, but are however found in statistics.

5.3 Impact mitigation options

The production of renewable biofuels and bio-products is perceived as an environmentally friendly green activity. Generally, this green image also raises expectations related to socio-economic conditions. Working conditions in the biomass supply sector should meet all relevant standards. Biomass supply is expected to be extracted from forests that are managed sustainably, and meet standards like FSC or PEFC. The company should have an active policy on equal treatment and payment of women and encourage their participation.

5.4 Impact and biomass certification

Existing biomass certification schemes do not cover biomass conversion. The biomass production and supply is covered by forest certification schemes. There are a number of possible certification systems that are available for forest management. The most widely used systems being the FSC and the PEFC certification schemes.

In 2001, Tembec committed to certification under the Forest Stewardship Council as a step towards improving its operational activities and assuring its client base about the sustainability of their forestry operations. In 2008, the company achieved FSC certification for all its forestry operations (an area totalling more than 9.7 million hectares across Canada. Additionally, all of the company's pulp and paper, solid wood and chemical operations achieved FSC Chain of Custody Certification. The company continues to pursue FSC certification for new areas that come under its management.

As an FSC certified entity, there is the requirement for the company to ensure that its operations are socially acceptable, environmentally sound and economically viable. To meet its certification requirements, the company has carried out a number of assessments (including High Conservation Value Assessments) to identify the impacts of its operations on the surrounding environment and communities. Various stakeholders including First Nations and experts have been involved in the identification of social and environmental values and in the prescription of appropriate management interventions as well as the monitoring of these interventions.
Following its commitments under certification, the company has also moved to implement grievance and dispute resolution mechanisms as well as introduce various policies aimed at eliminating discrimination and ensuring fair treatment and representation of worker interests.

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6 CONCLUSION

This report presents the Global-Bio-Pact Case Study for 2nd generation biofuels and products from lignocellulosic material in Canada. Two different technologies were selected as cases: lignin and ethanol production with the Lignol process and pyrolysis oil production with the BTG process. Although these technologies are different, their socio-economic impacts are very similar. The biomass supply chain is similar: both technologies can use pulp wood, forest residues, saw mill residues, waste wood, etc. Especially when biomass is extracted from forests, socio-economic issues like land ownership and conflicts are relevant. The conversion side has also many similar characteristics: both processes are in the demonstration phase, have the challenge to sale new bio-products with potentially high added value, but with the challenge of selling these products in a fossil dominated market. Also their factories will have a quite similar general outline and need of technical and operational personal. Working conditions, health and gender issues are expected to be similar to those found in the forestry sector (biomass supply) and the chemical industry (biomass conversion). The processes are expected to have environmental benefits and the products will be marketed as being ‘green’. This image as green=good, needs to be supported by proper measures to ensure that proper socio-economic conditions in the field of labour conditions, health and gender equality, etc. are created and sustained.

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A. LIST OF CASE STUDIES

Name of company	Plant locations	Technology	Description justification	Contacts
Dynamotive Energy Systems Corporation	West Lorne, Ontario Guelph, Ontario	Fast Pyrolysis	Dynamotive converts residual cellulosic biomass from forestry and agriculture into bio-oil and bio-char using the fast pyrolysis technology. They also have a facility for further refining the bio-oil into transport grade liquid hydrocarbon fuels (this is yet to be commercialized)	+ 1 604 295 6800 http://www.dynamotive.com/
Ensyn Technologies Inc	Renfrew, Ontario	Rapid Thermal Process (pyrolysis)	Ensyn currently provides the world's only rapid thermal process (RTP) that operates on a long-term commercial basis. The company's plant at Renfrew has the capacity to process 100 tonnes of dry residual wood per day into bio-fuels that can be used in power generation and also in transportation fuels if processed further.	+1613-248-2257 http://www.ensyn.com/
PyroMax	Ontario	Fast pyrolysis	PyroMax works with small and medium sized private power generation companies to incorporate renewable fuel capabilities in power generation using a fast pyrolysis of wood waste, forest slash and logging residues into bio-fuels.	+1647 408 3148 asaf@pyromax.ca http://www.pyromax.ca/
Iogen Energy	Ottawa, Ontario	Cellulose to ethanol using enzyme technology	A biotechnology firm specializing in the conversion of cellulose (from agricultural residues) to ethanol. Commercial production is yet to start and the company has recently received some investment from Royal Dutch Shell to commercialize the production of cellulosic ethanol.	Mandy Chepeka +1 613 733-9830 http://www.iogen.ca/
Lignol Innovations	Vancouver, BC	Cellulose to	Lignol is in the process of commercializing its	+ 1 604 222 9800

		ethanol using enzyme technology	integrated cellulose to ethanol process technology for biorefining ethanol, pure lignin and other co-products from forestry residues.	http://www.lignol.ca/
Greenfields Ethanol	Edmonton, Alberta	Cellulose to ethanol using gasification and enzyme technology	Greenfields is currently undertaking research to produce cellulosic ethanol from agricultural waste, forestry residues and municipal solid waste.	http://www.greenfieldethanol.com/home
Tembec	Temiscaming Quebec	Hemicellulose to ethanol	Tembec produces up to 15 million litres/year of ethanol as one by-product of a sulphite pulping process that produces specialty cellulose. The ethanol is not used as fuel ethanol, but is supplied to industrial markets such as vinegar production industry. (*Tembec is the only known pulp mill in North America that produces commercial ethanol*)	+1 819 627-4252 http://www.tembec.com/public/home.html
Enerkem	Westbury, Quebec	Cellulose to ethanol through gasification and catalytic synthesis	Enerkem processes sorted municipal wastes and forestry and agricultural residues into ethanol through gasification and catalytic synthesis. Production of ethanol at the Westbury commercial demonstration plant is anticipated to start in late 2010. Main products being produced now are syngas, acetates and methanol.	+1 514-875-0284 http://www.enerkem.com/en/home.html