CANADA’S ABILITY TO DEVELOP AND SUSTAIN A COMPETITIVE ADVANTAGE IN THE GLOBAL WOOD PELLET MANUFACTURING INDUSTRY

by

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ABSTRACT

In recent years, there has been increasing interest in sustainable energy production across the globe. This has led to increased export opportunities for North American bioenergy producers. The production of wood pellets in Canada is one industry that has greatly benefited from the increased demand for renewable energy. This paper uses analytical tools outlined by Michael Porter in his 1979 paper “How Competitive Forces Shape Strategy” as well as his 1990 paper “The Competitive Advantage of Nations” to examine the wood pellet manufacturing industry. These tools include Porter’s “5 Forces Model” as well as his “Diamond Model.” These models are used to define the competitive forces in the domestic market that provide competitive advantages / disadvantages as well to define the attributes of Canada as a nation that give it its competitive advantages / disadvantages in the global market. The overall outcome of the analysis shows that Canada can be competitive on the basis that it has abundant resources and established related and supporting industries; however there are many challenges to overcome to improve its competitive position. These challenges are associated with the access to raw materials, transportation costs and labor availability to name a few. Government can play a role to improve Canada’s position by implementing programs to improve domestic access to raw materials, infrastructure and knowledge resources. Government can also play a role to open up new markets internationally. The overarching uncertainty with regards to the long term sustainability of the wood pellet manufacturing industry pertains to emerging technologies. These new technologies will either shore up the wood pellet manufacturing industry or serve as more economical and renewable substitutes.

Keywords: wood pellets, bioenergy, forestry.
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My project supervisor, Dr. Ajit Dayanandan for his time and expertise.
CHAPTER I

INTRODUCTION

Over the past decade, there has been increasing interest in sustainable energy production across the globe. Energy security, global warming and utilization of local resources are driving factors for using biomass as an alternative energy source (Sultana, Kumar and Harfield 2010). This interest gained much of its momentum in Europe when the European Commission committed to doubling the financial contributions to renewable energy to 12% in 2010. A number of environmental benefits would result from such a contribution including the reduction of conventional pollutants such as carbon dioxide (CO₂), nitrogen oxides (NOx) and sulfur dioxide (SO₂) (See Table 1-1). Wood pellet energy systems are considered a major component of European plans to reduce Green House Gas (GHG) emissions. The availability of advanced boilers and burners and building of new wood pellet production plants and combined heat and power plants have made bioenergy from wood a fast growing industry and a viable alternative to fossil fuel based energy systems.

Table 1-1: Emissions of Pellet Stoves and Oil Furnaces:

<table>
<thead>
<tr>
<th>Emissions</th>
<th>Pellet Stove</th>
<th>Oil Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO₂</td>
<td>11 g/kWhₘₜ</td>
<td>295 g/kWhₘₜ</td>
</tr>
<tr>
<td>NOₓ</td>
<td>1.49 g/kWhₘₜ</td>
<td>3.6 g/kWhₘₜ</td>
</tr>
<tr>
<td>SO₂</td>
<td>0.043 g/kWhₘₜ</td>
<td>0.1 g/kWhₘₜ</td>
</tr>
<tr>
<td>Dust</td>
<td>0.45 g/kWhₘₜ (PM₁₀)</td>
<td>0.09 g/kWhₘₜ</td>
</tr>
</tbody>
</table>

(BIOCAP 2008, pg 36)
Biomass has low energy density and low yield per unit area resulting in high biomass delivery costs which in turn leads to high processing costs (Sultana, Kumar and Harfield 2010). In addition, it contributes to unattractive efficiencies for the consumer in terms of heating value and energy efficiency. Pelletization is the process of converting this biomass into pellets. Converting the raw wood to wood pellets improves upon these attributes and enhances the heating value and burning efficiency (Spelter and Toth 2009). This is achieved through reducing the moisture content and increasing the energy content thereby making wood pellets one of the more attractive forms of biomass based energy (Sultana, Kumar and Harfield 2010). Wood Pellets are a type of wood fuel that is typically manufactured from residual sawmill material (Junginger, et al. 2010). This material is typically composed of residual fibre not utilized in the manufacture of other wood products (i.e. lumber). It primarily consists of sawdust, shavings, bark, wood chips and low grade roundwood. To produce wood pellets, this residual fibre is compacted into a homogeneous cylindrical product that facilitates more efficient transportation, handling and usage (Spelter and Toth 2009). Wood Pellets can be used on multiple scales ranging from combustion in stoves for household heating to co-firing in plants for electricity production (Junginger, et al. 2010).

In recent years, the Mountain Pine Beetle (MPB) epidemic and the search for more renewable energy sources has created conditions where there has been great interest in wood pellet markets. The increased availability of fibre due to increased harvest levels in light of timber being damaged by MPB has triggered investment in wood pellet manufacturing facilities in British Columbia (B.C.) to meet the world's renewable energy demands. Wood pellets are in many instances considered the product of choice for excess biomass in the forest industry as opposed to converting wood to electricity, oil or ethanol. These other
options are either considered too expensive or the technology still isn’t at a level where the manufacturing process is commercially viable. Wood pellets have several advantages over other fuel sources, including a consistency in size and shape that makes them easy to transport, a lack of artificial or toxic ingredients making them completely safe to handle and eliminates the possibility of toxic spills, more efficiency and offer a net carbon reduction if they displace non-renewable fuels (Schrier 2009).

Wood pellets are considered a source of renewable energy and carbon neutral because new tree growth recaptures carbon released from burning them (Spelter and Toth 2009). Energy policies endorsing the use of renewable energy in Europe and Asia are leading to increased international demand for wood pellets. Coal–fired power plants produce over half of the electricity in the United States (Spelter and Toth 2009) as well as significant proportion of electricity in Asia and coal is the primary target for carbon dioxide mitigation (Spelter and Toth 2009). Over the past decade, there have been rapid increases in the production and consumption of wood pellets, and predictions on its increased future demand have led to a competitive global market (Mobini, Sowlati and Sokhansanj 2013). The total global consumption of wood pellets in 2011 was 14.4 million tonnes, from which about 80% were consumed in Europe (Mobini, Sowlati and Sokhansanj 2013). European, North American and Asian demand is expected to grow as a result of legislative supports and greenhouse gas reduction policies and could potentially reach to 20–50 million tonnes per year by 2020 in Europe alone (Mobini, Sowlati and Sokhansanj 2013). The wood pellet industry as well as the use of wood pellets as energy is in its relative infancy in North America (Spelter and Toth 2009). This study examines the feasibility of the wood pellet industry in Canada becoming a global leader in the supply of fossil fuel free energy sources.
not only in Canada but also in the world. The framework of Michael Porter’s Five Forces model which he developed in his famous article titled “How Competitive Forces Shape Strategy” in Harvard Business Review in 1979\(^1\) is used (Porter 1979). Here he outlines the five factors to be considered for assessing the competitive position of the firm/industry in a global environment. This along with Michal Porter’s diamond model provides the enhanced analytical framework to examine the determinants of competitiveness position of the wood pellet market in Canada at the global level (Porter 1979). This study will consider the extent to which wood pellets can be produced in B.C. and Canada, whether this capacity can be matched by local demand, what the market potential is in Europe and Asia and what barriers exist to entering these markets and for exporting pellets from B.C. and Canada. The study is organized as follows:

Chapter 2 reviews the existing literature on the biomass industry; chapter 3 provides an overview of data and methodology; chapter 4 considers the analytical and empirical results of the study; Chapter 5 will summarize the findings and provide recommendations for continued sustainable competitive advantage in the industry.

---

2 Conversion factor for kilotonne of solid wood waste to terajoules of coal is 18 according to Stats Canada 2011.
3 “Stumpage” is a fee paid to the provincial government for the timber resources extracted.
4 “Cut control limit” is a measure of the balance between the amount harvested and the amount that is available for harvest over a given time period under a particular harvesting license. For example, a license may have an
CHAPTER II
REVIEW OF LITERATURE

This chapter provides an overview of the literature pertaining to the global wood pellet manufacturing industry. It outlines the environmental benefits of using wood pellets for energy compared to fossil fuels and comments on the domestic, European and Asian markets.

As of 2010, the global wood pellet production was 14.3 million tons (Cocchi, et al. 2011) and North American production was just less than 6 million tons (Walker 2010).

Chart 2-1: North American Wood Pellet Production

Wood Pellet Production – North America
Million short tons

(Walker 2010, pg 3)
2.1 Environmental Benefits of Wood Pellet Based Electricity Generation

The worldwide use of coal is responsible for 25% of global GHG emissions and substitution with biomass is considered a viable option to significantly reduce this contribution (Zhang, et al. 2010). In 2010, the European Commission doubled the financial contribution to renewable energy creating the potential for a reduction of 230-260 million metric tonnes of CO₂ equivalent emissions (Magelli, et al. 2009). A number of environmental benefits would result from replacing fossil fuels with wood pellet based energy. Among these benefits are the reduction of GHG emissions such as carbon dioxide (CO₂), nitrogen oxides (NOx) and sulfur dioxide (SO₂) (See Tables 2-1 and 2-2) (Magelli, et al. 2009). 100% pellet utilization would reduce GHG emissions in generating stations by 91% relative to coal and 78% relative to natural gas combined cycle systems. If 10% co-firing were to be implemented in the United States and Canada in all coal generating stations, electricity generation from biomass would make up approximately 4% of the two countries annual electricity generation and reduce GHG emissions by 170 million metric tonnes per year (Zhang, et al. 2010). When factoring in the production of wood pellets in western Canada and transporting them to Europe, the use of wood pellets can lead to more than a 50% reduction in net CO₂ emissions (Magelli, et al. 2009).

Table 2-1: Emissions of Pellet Stoves and Oil Furnaces:

<table>
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<th>Emissions</th>
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<th>Oil Furnace</th>
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<tr>
<td>CO₂</td>
<td>11 g/kWhₘₜ</td>
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<tr>
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<td>1.49 g/kWhₘₜ</td>
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<tr>
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<td>0.043 g/kWhₘₜ</td>
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<td>0.45 g/kWhₘₜ (PM₁₀)</td>
<td>0.09 g/kWhₘₜ</td>
</tr>
</tbody>
</table>

(BIOCAP 2008, pg 36)
<table>
<thead>
<tr>
<th></th>
<th>Wood (Gasification)</th>
<th>Coal</th>
<th>Natural Gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
<td>0.1-0.5 g/kWh</td>
<td>0.4-0.75 g/kWh</td>
<td>0.08-0.75 g/kWh</td>
</tr>
<tr>
<td>SO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>~0 g/kWh</td>
<td>0.6-1.5 g/kWh</td>
<td>0.002 g/kWh</td>
</tr>
<tr>
<td>Dust (PM&lt;sub&gt;10&lt;/sub&gt;)</td>
<td>&lt;0.01 g/kWh</td>
<td>&lt;0.1-0.3 g/kWh</td>
<td>~0 g/kWh</td>
</tr>
<tr>
<td>VOC</td>
<td>Like Natural Gas</td>
<td>0.016 g/kWh</td>
<td>0.0003 g/kWh</td>
</tr>
<tr>
<td>CO&lt;sub&gt;2&lt;/sub&gt;</td>
<td>0 g/kWh</td>
<td>800-1,000 g/kWh</td>
<td>380-450 g/kWh</td>
</tr>
</tbody>
</table>

(BIOCAP 2008, pg 29)

### 2.2 Benefits and limitations of biomass compared to other renewables

Other renewable generating options have the disadvantage of being intermittent making the use of biomass more applicable to areas without significant wind, solar or hydropower (Zhang, et al. 2010).

While using biomass to co-fire with coal has higher fuel costs than pure coal, it requires lower capital expenditures than other sources because it is applicable to almost all types of utility coal boilers meaning that existing facilities can be used (Zhang, et al. 2010).

The main limitations of wood energy include the availability of woody biomass, fuel moisture content and transportation costs (Roos and Brackley 2012). There is often uncertainty in the availability of long term supply of raw materials due to access restrictions or high reliance on the viability of suppliers businesses. It is costly to dry the fuel to the desired moisture content before it can be pelletized as well as transport the raw materials and pellets large distances.

### 2.3 Uses for wood pellets

As of 2008, approximately 10% of wood pellets manufactured in Canada were used domestically compared with 80% in the US (Spelter and Toth 2009). In North America, wood pellets are mostly used in residential heating systems. The higher usage of wood pellets in the US compared to Canada can be attributed to the heating costs of pellets vs.
firewood. Table 2-3 below shows a cost breakdown for residential heating in the US. As shown, there isn’t a large cost gap between the three least expensive fuel types (i.e. Seasoned firewood, natural gas and premium wood pellets). In Canada however, 53.8% of the total area is forested (Natural Resources Canada 2011) and the majority of forested lands are public as opposed to those in the US, meaning that the 20% of Canadians living in rural areas (Stats Canada 2006) have access to relatively inexpensive firewood. This makes firewood considerably less expensive than wood pellets in rural Canada as opposed to the US where a lot of firewood is presumably purchased from private landowners. However, in North America firewood stoves still exceed wood pellet stoves in number despite being less convenient, more polluting and their use can be prohibited in some locations during times of unfavorable atmospheric conditions (Spelter and Toth 2009). This would suggest an opportunity for the residential segment of the wood pellet market to grow in North America whereby wood pellets can provide a reasonable substitute to firewood.

Table 2-3: Example of Annual Home Heating Costs in the US Using Various Fuels:

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Gross Heating Value</th>
<th>Efficiency (%)</th>
<th>Net heating value</th>
<th>Fuel Required for 1 Million Btu of useable heat</th>
<th>Average Cost / Unit</th>
<th>Total Annual Fuel Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>1.03 million BTU/1,000 ft³</td>
<td>80</td>
<td>0.82 million Btu/1,000 ft³</td>
<td>1,220 ft³</td>
<td>$7/1,000 ft³</td>
<td>$854</td>
</tr>
<tr>
<td>Propane</td>
<td>91,200 Btu/gal</td>
<td>79</td>
<td>72,000 Btu/gal</td>
<td>13.86 gal</td>
<td>$1.25/gal</td>
<td>$1,730</td>
</tr>
<tr>
<td>Fuel Oil # 2</td>
<td>138,800 Btu/gal</td>
<td>83</td>
<td>115,000 Btu/gal</td>
<td>8.68 gal</td>
<td>$1.40/gal</td>
<td>$1,220</td>
</tr>
<tr>
<td>Seasoned firewood</td>
<td>20 million Btu/cord</td>
<td>77</td>
<td>15.4 million Btu/cord</td>
<td>0.065 cord</td>
<td>$115/cord</td>
<td>$747</td>
</tr>
<tr>
<td>Electricity</td>
<td>3,413 Btu/kWh</td>
<td>98</td>
<td>3,340 Btu/kWh</td>
<td>299 kWh</td>
<td>$0.08/kWh</td>
<td>$2,390</td>
</tr>
<tr>
<td>Premium wood pellets</td>
<td>16.4 million Btu/ton</td>
<td>83</td>
<td>13.6 million Btu/ton</td>
<td>0.0373 ton</td>
<td>$120/ton</td>
<td>$882</td>
</tr>
</tbody>
</table>

(USDA US Forest Service 2004, pg 2)

Wood pellets can also be used as fuel in power generation (Spelter and Toth 2009). Policy incentives both domestically and globally have created incentives to utilize biomass as a substitute for coal in power generation. For instance, the Alberta Government is requiring coal power plants to increase their use of renewable feedstock (e.g. wood biomass, char from wood) (Stennes, Niquidet and van Kooten 2009). Studies have shown that up to 15% of the
total energy input in coal fired power plants can be substituted with biomass without incurring major equipment or modification costs as long as the coal boilers meet specifications that are not likely to cause flow problems in the fuel-handling equipment or result in incomplete burns (Spelter and Toth 2009). According to (Spelter and Toth 2009), such use of pellets has become widespread in Europe and is only beginning to emerge in North America. As of 2009, 61% of the electricity produced from coal in Canada is converted to electricity (Stats Canada 2009). Assuming the conversion factor for wood pellets to terajoules of coal is at least as good as that for solid wood waste to terajoules of coal, at least 6.96 million tonnes of wood pellets could be substituted for coal in coal fired plants assuming that all the Canadian coal fired plants meet boiler specifications. That’s almost 70 times the current domestic demand for pellets. In the US, this potential is even larger with coal – fired plants producing over half the electricity (Spelter and Toth 2009).

Table 2-4: Potential Amount of Biomass that Can Replace Coal:

<table>
<thead>
<tr>
<th>Coal Production a (terajoules)</th>
<th>Coal Transformed to Electricity a (terajoules)</th>
<th>% of Coal to be Substituted with Biomass</th>
<th>Amount of Coal to be Substituted (terajoules)</th>
<th>Conversion Factor a</th>
<th>Amount of Biomass Replacing Coal (kilotonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,361,322</td>
<td>835,776</td>
<td>15 %</td>
<td>125,366</td>
<td>18</td>
<td>6,965</td>
</tr>
</tbody>
</table>

aData obtained from (Stats Canada 2009)

2.4 Wood Pellet Markets

Demand for wood pellets primarily depends on the cost for using it. These costs are partially a result of political decisions (Monteiro, Mantha and Rouboa 2012). As of 2013, global wood pellet consumption is 24.5 million tons (Wood Pellet Association of Canada 2011).

2 Conversion factor for kilotonne of solid wood waste to terajoules of coal is 18 according to Stats Canada 2011.
The ensuing sections describe wood pellet markets in North America, Europe and Asia.

### 2.4.1 North America

The North American wood pellet market started in the 1970s for use by industrial, commercial and institutional sectors for heating and then began to enter the residential heating market for use in pellet stoves (Roos and Brackley 2012). The recent growth of the wood pellet industry in the United States is due to increased costs of fossil fuel energy, legislative support for bio-based fuels and policies aimed at reducing GHG emissions (Lu and Rice 2011).

In the US, the Biomass Crop Assistance Program (BCAP) reduced the cost of fibre to US pellet plants giving them a $50/tonne feedstock advantage over Canadian suppliers resulting in the Northeastern US market for Canadian pellets drying up (Cocchi, et al. 2011). Although this BCAP incentive ended in 2010 and the US market opened up again (Cocchi, et al. 2011), events such as this one stresses the importance for the added security of a domestic market in Canada and more diversified international markets. To add to this, economic forces overseas also add to the importance of a stable diversified market (Cocchi, et al. 2011). For example, pellet export contracts to Europe are in Euros and the collapsing Euro in 2010 led to decreasing profits for Canadian pellet exporters making the Canada’s largest export market unattractive (Cocchi, et al. 2011) (See Chart 2-2). A weak Euro will continue to put pressure on profit margins for North American pellet producers (Walker 2010). Despite this, Canada anticipates utilizing its vast forest resources to build capacity for export but expects an increasing amount will be used domestically especially since reductions in the
value of the Euro relative to the Canadian dollar has been affecting profits (Cocchi, et al. 2011).

Chart 2-2: North American Export Prices. Pellet Prices in Canadian $:

(Cocchi, et al. 2011, pg 112)

Currently, the domestic market for pellets in Canada is very small, estimated at 100,000 tonnes annually (Cocchi, et al. 2011). This is equivalent to the annual production of one average sized pellet plant in Canada (Murray 2010). This is minor compared to 1.3 million tonnes being exported and by 2020, the domestic demand could reach 2.3 million tonnes leaving 3.5 million tonnes of export potential (Cocchi, et al. 2011). As of 2011, there were 39 pellet plants operating with a total capacity of 3.2 million tonnes and 11 of these plants with more than half of Canada’s capacity were in B.C. (Cocchi, et al. 2011). Below is a map of wood pellet manufacturing facilities in North America as of 2010.
As of 2011, 62% of Canada's production comes from B.C. and 36% comes from eastern provinces and with planned expansions, proposed new plants, and future unannounced plants, capacity in Canada could reach 5.8 million tonnes by 2020 (Cocchi, et al. 2011). Below is a chart showing current and expected exports from North America.

(Walker 2010, pg 4)
Atlantic Canadian exports come from Nova Scotia, New Brunswick, and exports are soon expected from Montreal while capacity is also building in the southeastern United States (Cocchi, et al. 2011). Canada has long exported from B.C. to Europe through the Panama Canal (Cocchi, et al. 2011). There are many proposals for new plants in Ontario and Quebec that have the potential to create reduced rail costs to the ports along the St. Lawrence River opening the region up as a new export corridor, only 5000 km from European markets (Cocchi, et al. 2011). This sets Canada up to export larger volumes to Europe from the East coast and higher proportions of pellets to Asia instead of Europe from the west coast.

Only 20% of the U.S. wood pellet production is exported with most of the pellet production consumed domestically primarily for residential heating (Roos and Brackley
2012). The use for wood pellets in residential heating has grown in North America in recent years along with their use for commercial applications such as heating for schools, theatres and manufacturing facilities (Lu and Rice 2011). Much of this demand is driven by the price of oil (Lu and Rice 2011) which is used in higher proportions for heat in eastern North America than in the west. Wholesalers and retailers are the primary customers for wood pellet manufacturing facilities in the residential market accounting for approximately 83% of the market share (Lu and Rice 2011).

2.4.2 Europe

The European wood pellet market got an early start in the 1970s when equipment was developed for converting oil boilers to wood pellet heaters and rapidly expanded in the 1990s when European countries implemented taxes on fossil fuel usage (Roos and Brackley 2012). These policies along with the Kyoto Protocol and the European Biomass Action Plan in 2005 promoted research and development and increased utilization of biomass energy further contributing to increased demand for wood pellets (Roos and Brackley 2012).

The European Union Target to supply 20% of its energy needs from renewable sources by 2020 led to increased demand for wood pellets in Europe and firms began looking to North America as a source for pellets to reduce their domestic pressures (Spelter and Toth 2009). It is expected that The Russian Federation will increasingly play a role in supplying wood pellets to Europe as they have the largest forest area in the world and an estimated production capacity of 3 million tons of which 1 million tons is actually produced (Cocchi, et al. 2011).
In Europe, the wood pellet market contains both the electric power generation and the heating segments (Roos and Brackley 2012). There is an estimated 400 wood pellet manufacturing facilities in Europe, many of which are small operations with limited output and as of 2009 the European wood pellet consumption was around 11 million metric tons while 2 to 3 million metric tons were imported (Lu and Rice 2011). The European market is expected to grow to between 35 and 45 million tons by 2020 (Wood Pellet Association of Canada 2013).

(Cocchi, et al. 2011, pg 146)
2.4.3 Asia

According to Roos and Brackley (2012), most wood pellets in Asia are consumed for co-firing in coal-fired power plants and Japan is currently the largest importer. *Japan’s Renewable Energy Portfolio Standard Law* enacted in 2003 set the target to increase renewable energy to 16 billion kilowatt hours by 2014 (Roos and Brackley 2012). Japan has an established wood pellet industry producing 60,000 metric tons domestically in 2008 and importing 49,000 metric tons in 2009, an amount that is still growing (Roos and Brackley 2012). The Japanese market is expected to grow to 8 million tons by 2020 (Wood Pellet Association of Canada 2013).

South Korea is striving to increase the proportion of renewable energy it uses through the pursuit of an energy policy aimed at reducing fossil fuel consumption by 22% and increasing renewable energy use by 8.6% from 2007 levels by 2020 (Roos and Brackley 2012). This policy coupled with South Korea’s economic growth may mean huge potential for North American wood pellet exports to South Korea whose imports are still relatively small (Roos and Brackley 2012). As of 2009, South Korea produced 20,000 metric tons domestically and imported 10,000 metric tons and by 2020 the total pellet market is expected to be 5 million metric tons (Roos and Brackley 2012).

China is the largest consumer of energy in Asia but already has an established wood pellet manufacturing industry meaning minimal need for Canadian wood pellet exports to China (Roos and Brackley 2012). However, that doesn’t mean that there isn’t potential for wood pellet exports from Canada to China. While China’s wood pellet consumption currently relies on domestic production, they are still the second largest energy consumer in the world of which coal provides 70% of its energy needs (Roos and Brackley 2012). This
may mean that there is potential for large amounts of wood pellet exports to China given China’s proximity to the Port of Prince Rupert, the appreciation of the Chinese currency against the dollar and the increased focus of China on ensuring more of their energy be generated from renewable energy sources. Due to its strong economy, growing energy demand and pursuit of substituting renewable energy for coal, China has the potential to become the largest wood pellet market in Asia (Roos and Brackley 2012).

There is limited literature about any sort of wood pellet trade with India. However there may be potential for wood pellet exports to India. India is one of the world’s top 5 contributors to carbon emissions (Gopinathan and Sudhakaran 2009). According to a Bloomberg article published in the spring of 2013, India is Asia’s second largest energy consumer where coal fired power stations provide 59% of India’s electricity. The nation is expected to need 730 million tons / yr by 2017 meaning coal imports are expected to increase. At the same time, India’s cleaner burning natural gas (India’s main alternative) supplies are falling at the quickest rate in Asia (Katakey 2013). Based on India’s current planning of energy mix, its heavy dependence on coal will make it impossible to mitigate projected carbon emissions (Gopinathan and Sudhakaran 2009). Power is essential for India’s long-term growth and problems are expected with the rate at which power will become available (The Economist 2012). India’s power capacity must increase by 5 times by 2031-2032 and pursuit of all available fuel options and forms of energy is required to meet this capacity (Gopinathan and Sudhakaran 2009). Based on this, one could assume that there is enormous potential for the use of wood pellets (or agropellets) for co-firing with coal in power plants in India. India’s current trend is not sustainable and the nation is bound to face
serious international pressures to reduce carbon emissions (Gopinathan and Sudhakaran 2009).
CHAPTER III
DATABASE AND RESEARCH METHODOLOGY

This chapter discusses the database and methodology used in the study. Section 1 discusses the database and section 2 presents the theoretical framework.

3.1 Database

The study uses data on wood pellet prices (which is an outcome of supply and demand for this product) in Canada and abroad to bring out supply-demand imbalances at home and abroad. The price difference between Canada and abroad is taken as a representation of price advantage/disadvantage of Canadian wood pellet manufacturers.

3.2 Methodology

To determine the extent to which wood pellets can be produced in B.C. and Canada and whether Canada can play a sustainable competitive role in the domestic and international wood pellet industry, this project will utilize the framework of Michael Porter’s Five Forces model as well as his Diamond model.

Michael Porter presented his Five Forces Model in his is famous article titled “How Competitive Forces Shape Strategy” in Harvard Business Review in 1979. In this article, Porter suggests that competition in an industry is entrenched in its underlying economics, and that competitive forces are present that surpass the established competitors in a particular industry. As shown in the figure below, Porter says the five forces are 1) threat of new
entrants, 2) buyer power, 3) supplier power, 4) threat of substitutes and 5) degree of rivalry.

Below is a summary of how Porter describes these five forces.

**Force #1) Threat of New Entrants**

New entrants to an industry may bring new capacity, potential to gain market share as well as substantial resources. Whether or not the threat of entry is serious depends on the barriers present and on the competitor's expected reaction. The barriers to entry come from six major sources;

1. **Economies of scale** – New entrants into an industry have to confront economies of scale enjoyed by already established industry participants. They can act as hurdles in distribution, utilization of the sales force, financing and nearly any other part of a business.

2. **Product differentiation** - New entrants have to spend greatly to overcome customer loyalty to existing industry participants.

3. **Capital requirements** - The need to invest large financial resources to compete especially if the capital is required for unrecoverable expenses. This can act as a barrier to entry.

4. **Cost disadvantages independent of size** – Existing companies may have advantages not yet available to rivals. These advantages may have stemmed from learning curves, proprietary technology, and access to the best raw materials, etc…

5. **Access to distribution channels** - The more limited the distribution channels are and the more existing participants have them tied up, the more difficult entry into the industry will be.
6. Government policy - Government can restrict or exclude entry into industries with regulations such as license requirements and limits on access to raw materials.

Force # 2) Buyer Power

Buyers can force down prices, demand higher quality or more service, and play competitors off against each other thereby eroding industry profits. In instances where the majority of the product is exported, this buyer power is on the behalf of foreign users. Where the product is used domestically, buyer power can exist among domestic end users and wholesaler distributors.

Force # 3) Supplier Power

Suppliers can exert bargaining power over producers by raising prices or reducing the quality of purchased goods and services thereby squeezing profitability out of an industry that is unable to recover cost increases in its own prices.

Force # 4) Threat of Substitutes

Substitute products or services limit the potential of an industry by placing an upper limit on prices it can charge. Participants in an industry may need to upgrade the quality of the product or differentiate it somehow to prevent loss of earnings and growth.

Force # 5) Degree of Rivalry

Rivalry among existing competitors requires the use of tactics such as competition, product introduction and advertising competitions in attempts to jostle for position. Intense rivalry is related to the presence of numerous competitors equal in size and power, slow industry growth due to competition for market share, lack of differentiation or
switching costs; high fixed costs; perishable products creating temptation to reduce costs; large increments of capacity augmentation; high exit barriers; and high diversity in strategies, origins and eccentricities amongst rivals.

Chart 3-1: Porter's 5 Forces Model Adapted from (Carpenter, Sanders and Harling 2012).

Michael Porter's Diamond Model concludes that there are four broad attributes of a nation that individually and as a system constitute a diamond of national advantage (Porter 1990). Below is a summary of how Porter describes these attributes in his paper titled "The Competitive Advantage of Nations."
Attribute # 1) Factor conditions

These conditions have to do with a nation’s position in factors of production such as land, labor, natural resources, capital and infrastructure. Of particular importance is how effectively nations create, upgrade and deploy these factors of production.

Attribute # 2) demand conditions

These conditions have to do with the nature of the domestic market demand for an industries product. The composition and character of the domestic market usually has a disproportionate effect on how companies perceive, interpret and respond to buyer needs. Nations gain competitive advantage in industries where the domestic demand gives their companies a clearer or earlier depiction of emerging buyer needs and where demanding buyers pressure companies to innovate faster and achieve more innovative competitive advantages than their foreign rivals.

Attribute # 3) related and supporting industries

These conditions have to do with the presence or absence of supplier industries and other related industries that are internationally competitive. These conditions create advantages in downstream industries by delivering cost effective inputs in an efficient, early, rapid and preferential way. These related and supporting industries provide advantages based on close working relationships where suppliers and end users in close proximity to each other can take advantage of short lines of communication, efficient flow of information and ongoing exchanges of ideas and innovations.

Attribute # 4) firm strategy, structure, and rivalry.
These conditions have to do with the circumstances and contexts within a nation that govern how companies are created, organized, and managed as well as the nature of domestic rivalry. Management practices and organizational manners favored in a country converge to increase competitiveness in a specific industry. Nations differ in the goals that companies and individual strive to achieve. Success can depend on the types of education talented people choose, where they choose to work and where they focus their commitments and efforts. The values set for individuals and companies, the goals of a nation's institutions and the prestige attached to certain industries guide the flow of capital and human resources. Nations tend to be competitive in activities that people admire and depend on.

The presence of strong domestic rivals encourages the creation and persistence of competitive advantage. Amplified by domestic concentration, it creates pressure to innovate and improve.

Porter shows that each of the attributes affects or depends upon other attributes. Of these, domestic rivalry and geographic concentration are the essential drivers of the diamond as a system. Rivalry promotes improvement in all other determinants and geographic concentration elevates and magnifies the interaction of all the attributes (Porter 1990).

This paper utilizes the Porter theories to analyze the industry for wood pellets domestically and internationally and to assess whether the industry has a sustainable competitive advantage in the global market. Based on his theories, recommendations will then be put forward for ways to improve the competitiveness of the industry.
To add to the Porter model, environmental sustainability can be considered a condition contributing to competitive advantage. This can take into account many considerations including the environmental track records of the nation or industry or the environmental benefits of the products with which the industry deals. This environmental sustainability includes the nature of the end products as well as the manner in which the raw materials are sourced for producing the products.
CHAPTER IV
APPLICATION OF THE PORTER THEORIES

This chapter presents the results of the application of the Porter (1979) framework to examine the feasibility of enhanced access to the growing world markets for Canadian wood pellet products. First, the aspects of the Canadian wood pellet industry as they apply to the 5 pillars of the Porter (1979) model are discussed. Then the aspects of the nation as they apply to the 4 attributes of the Porter (1990) diamond model are discussed.

4.1 Five Forces

4.1.1. New Entrants

On the basis of access to raw materials, it may be difficult for new entrants to enter the wood pellet manufacturing industry in Canada. Existing manufacturers have cost effective supply agreements in place with nearby sawmills for waste wood residues and have relationships with primary harvesters for supply of the raw material from the chipping of roadside residue or harvesting of standing timber. Due to the transport cost constraints of extending beyond 60 km from a manufacturing facility, there isn’t much localized capacity in terms of labor and raw material supply to support additional manufacturing facilities. However, that doesn’t exclude opportunities in areas where no present manufacturing facilities already exist.

In the case where no present manufacturing facilities exist however, a new entrant would be disadvantaged because of the learning curves associated with the supply of raw materials. There is a great deal to learn about costs associated with transportation and labor.
Harvesting is a highly specialized business. In addition, gaining legal access to the raw material is also specialized. B.C. currently does not have many bioenergy tenures awarded and obtaining such tenure involves much government collaboration and navigation of bureaucracy. Such tenures are usually not economical without some sort of access to higher value sawlog material to supplement costs. Benefits from such access would require business to business relationships with local sawmills. This relationship would not only involve the sharing of sawogs, but also residual supply.

Economies of scale are an important factor in the forest industry. Existing bioenergy facilities have supply agreements with large forestry corporations who have their own economies of scale. This means that large companies like Pinnacle Pellet may have fibre supply contracts with multiple West Fraser and Canfor sawmills where all available material is already being supplied. Also multiple facilities that are part of a larger corporation have a further reach when it comes to the supply of raw materials, making access for new entrants even more challenging.

It should be noted however that barriers to entry for existing lumber manufactures into the wood pellet manufacturing industry are lower relative to greenfield renewable energy companies. As mentioned earlier, sawmills generally already have existing efficiencies when it comes to the supply of raw materials (the highest cost phase of the wood pellet production cycle). For instance, they have;

1. Timber harvesting contracts and a long history of collaboration with harvesting contractors.
2. Established infrastructure such as off-highway road systems leading to their manufacturing facilities enabling higher volumes of transport per trip.

3. Knowledge resources when it comes to navigating government policies and land use objectives as well as managing contractors.

4. An interest in minimizing the buyer power of bioenergy facilities when it comes to disposing of their residual waste.

5. A significant portion of the raw material is already on site in the form of residual waste.

6. Economies of scale in terms of harvesting capacity allowing them to harvest lower grade forested sites to source additional sawlog material in conjunction with bio fuel.

7. Existing tenure agreements allow sawmills access to raw materials and through the stumpage appraisal system have a means to recover costs associated with building additional access infrastructure.

8. Lower labor costs in terms of administration and manufacturing because they can source from their existing labor pools.

9. Adding wood pellets to the lumber industry’s product mix would contribute to a shift in their industry life cycle curve from a place in which they are in a mature state to a place where they are part of a growing industry (See Chart 4-1)
Outside of the realm of raw material supply, there are other barriers to entry. Starting a new facility involves large capital investments. For example, Pinnacle Pellet’s plant in Burns Lake, B.C. was initially forecasted to cost $30 million (Pinnacle Pellet: MFLNRO; 2010). New entrants looking to establish economies of scale comparable to existing participants will need to make capital investments at least as high as Pinnacle Pellets’. Existing firms have learning advantages when it comes to dealing with suppliers (i.e. sawmills) and distribution authorities. For example, how will they source rail cars for transport of their products; how will they gain access to storage silos at ports; how will they ensure rail cars and storage silos do not contain contaminated materials?

4.1.2. Suppliers

The main suppliers of material to North American wood pellet producers are sawmills who despite being obligated to find alternative means of disposing of their waste wood material, still have a relatively high amount of supplier power. The Wood Pellet Association
of Canada claims that just a few large tenure holders have monopolized regional control over the majority of B.C.’s public forests and that they simply dictate prices and terms on a take it or leave it basis, feeding fibre to pellet producers on a hand to mouth basis, using their monopoly to keep the majority of the economic value for themselves (Wood Pellet Association of Canada 2013). This would be possible for the proportion of the fibre that is sourced from road side debris and not sawmill residues. In part, this is the result of the sawmilling industries inability to quantify the cost / benefit of selling the road side debris or burning it. Selling it requires sorting the material and maintaining access and liability over the forest sites. The Sawmilling industry is required by law to remove the roadside debris in a timely fashion as a means of fire hazard abatement and to gain access to the soils underneath for reforestation. Allowing wood pellet manufacturers’ access requires a level of risk acceptance for use of the infrastructure and timely removal of the residues.

4.1.3 Buyers

Large-scale pellet consumers are now looking for medium to long term supply agreements with well-defined volumes and prices that mirror their domestic feed-in tariffs and this is conflicting with the volatile supply situation caused by insecure raw material supply (Cocchi, et al. 2011). Investing in making higher proportions of their plants producing renewable energy requires large capital investments on behalf of buyers so it is in their best interest to require long term supply security before making investment decisions.

4.1.4 Substitutes

For residential heating, natural gas, oil, firewood and electricity are common substitutes to wood pellets. Wood in its raw form is not always cost effective as a main fuel source if consumers have to purchase it rather than collect it themselves. It has a low energy
density, low bulk density and high moisture content (Katers, Snippen and Puettmann 2012). This is a drawback for raw wood for residential heating. When pelletized, the energy content per unit volume almost doubles and allows for more economical transportation, handling and combustion (Katers, Snippen and Puettmann 2012) making wood pellets more cost effective.

Cocchi, et al. (2011) commented on the use of many substitutes to wood pellets. Below is a summary of their comments on the alternatives. *Agropellets* are produced from agricultural residues such as straw, hay and husks and are becoming prominent for bioenergy use. Other resources for agropellets include different types of grains and grasses, olive kernels, rape cake and coffee husks. While some European countries have minor markets for agropellets relative to wood pellets, many countries do not yet have a market. Countries with distinct agriculture sectors and little forested areas qualify for a development and expansion of an agropellet market. Agropellets are currently mainly used for co-firing with coal in power plants. Their use in small scale heating systems is not an option at this time. As technology improves the demand for agropellets for this type of use will likely increase.

*Pyrolysis oil* is a dark brown liquid made from plant material and can be stored, pumped and transported like petroleum products and can be combusted directly in boilers, gas turbines and slow to medium speed diesel engines for heat and power. It is also CO2 neutral. It provides the same heating value as wood pellets at more than twice the density meaning lower shipping costs. It is only available in commercial scale in Canada and one manufacturer announced in 2010 a partnership with a forest products company in northern Alberta where the oil would be used to make power and to heat the sawmill operation with excess power fed into the power grid.
Although not really considered a substitute, the quality of wood pellets will likely be refined through a process called torrefaction. Through this process the physical and chemical properties of both woody and herbaceous biomass is changed so that it becomes hydrophobic and therefore can be stored in the open air and is easier to dry. The process also increases the energy density of the biomass leading to drastic reductions in logistical costs and allows for increased proportions for co-firing with coal.

**Bio-Coal** is a torrefied wood product that is not pelletized. It is simply added to coal in proportions specified by the customer and employs existing coal supply chains. Vancouver’s Global Bio-coal Energy is a company developing 2 bio-coal plants in B.C. They claim that B.C. can support 30 similar facilities. Bio-coal can be made from almost any woody substance including bark, industrial wood and forest residue.

**Agricultural wastes** can be used as a substitute for wood pellets. According to Bioenergy Consult, India’s current biomass power plants are based mostly on agricultural wastes. Supply chain challenges exist because agricultural biomass supply is not certain through the entire year because of the 2-4 month harvesting period (Gupta 2013). 86% of rural households and 20% of urban households in India use traditional biomass fuels such as gathered wood, agricultural residues and animal waste for cooking emissions (Gopinathan and Sudhakaran 2009).

See table 4-1 below for variety in some fuels suitable for biomass co-firing.
4.1.5 Rivalry

See section 4.2.4.

4.2 Diamond Model

4.2.1 Factor conditions

According to Mobini, Sowlati and Sokhansanj (2013), the wood pellet supply chain consists of sourcing, transporting and storing raw materials, densification of biomass, grading, packaging and distribution. The ability of domestic wood pellet producers to maintain or increase capacity depends on their ability to address each of these supply chain aspects.

4.2.1.1 Labour (quantity, skills, and cost of personnel)

In 2009, 25.9% of bioproduct firms said that access to skilled labor was of high importance when deciding where to locate a facility (Rothwell, Khamphoune and Neumeyer 2011). However, most wood pellet manufacturing facilities are automated and few employees are required (Lu and Rice 2011). However, some trades people are still required.

Table 4-1: Variety in fuels Suitable for Biomass Co-Firing.

<table>
<thead>
<tr>
<th>Moisture Content (% wt)</th>
<th>Wood Pellets</th>
<th>Torrefaction Pellets</th>
<th>Wood</th>
<th>Charcoal</th>
<th>Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>7 - 10</td>
<td>1 - 5</td>
<td>30 - 45</td>
<td>1 - 5</td>
<td>10 - 15</td>
<td></td>
</tr>
<tr>
<td>Lower Heating value (MJ/kg)</td>
<td>15 - 18</td>
<td>20 - 24</td>
<td>9 - 12</td>
<td>30 - 32</td>
<td>23 - 28</td>
</tr>
<tr>
<td>Volatile Matter (% db)</td>
<td>70 - 75</td>
<td>55 - 65</td>
<td>70 - 75</td>
<td>10 - 12</td>
<td>15 - 30</td>
</tr>
<tr>
<td>Density (kg/l) (bulk)</td>
<td>0.55 - 0.75</td>
<td>0.75 - 0.85</td>
<td>0.2 - 0.25</td>
<td>-0.20</td>
<td>0.8 - 0.85</td>
</tr>
<tr>
<td>Energy Density (GJ/m³) (bulk)</td>
<td>7.5 - 10.4</td>
<td>15.0 - 18.7</td>
<td>2.0 - 3.0</td>
<td>6 - 6.4</td>
<td>18.4 - 23.8</td>
</tr>
<tr>
<td>Dust</td>
<td>Limited</td>
<td>Limited</td>
<td>Average</td>
<td>High</td>
<td>Limited</td>
</tr>
<tr>
<td>Hydrousic Properties</td>
<td>hydrophillic</td>
<td>hydrophilic</td>
<td>hydrophobic</td>
<td>hydrophobic</td>
<td>hydrophobic</td>
</tr>
<tr>
<td>Grindability</td>
<td>Poor</td>
<td>Good</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Handling</td>
<td>Special</td>
<td>Good</td>
<td>Special</td>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Quality Variability</td>
<td>Limited</td>
<td>Limited</td>
<td>High</td>
<td>Limited</td>
<td>Limited</td>
</tr>
</tbody>
</table>

(Koppejan, et al. 2012, pg 9)
There are challenges in the northern rural areas obtaining skilled tradespeople to work in pellet mills. The living conditions are less desirable and the mining, oil and gas and forestry industries compete for skilled trades' people and have higher profit margins allowing them to pay higher wages. Table 4-2 below shows the factors that affect firms' access to labor in Canada.

Table 4-2: Factors Affecting Firms’ Efforts to Fill Bio-product Related Job Vacancies, Canada, 2009

<table>
<thead>
<tr>
<th>Factor</th>
<th>Low (%)</th>
<th>Medium (%)</th>
<th>High (%)</th>
<th>N/A (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compensation Requirements by Candidates too High</td>
<td>39.2</td>
<td>33.2</td>
<td>7.2</td>
<td>20.4</td>
</tr>
<tr>
<td>Candidates Unwilling to Relocate</td>
<td>45.9</td>
<td>12.5</td>
<td>14.4</td>
<td>27.1</td>
</tr>
<tr>
<td>Capital / Resources insufficient to Attract Candidates</td>
<td>19.0</td>
<td>31.1</td>
<td>22.9</td>
<td>27.1</td>
</tr>
<tr>
<td>Lack of Highly Qualified Candidates</td>
<td>30.3</td>
<td>26.2</td>
<td>25.2</td>
<td>18.3</td>
</tr>
<tr>
<td>Lack of Bioproduct Specific Education Available</td>
<td>40.7</td>
<td>27.2</td>
<td>8.9</td>
<td>23.1</td>
</tr>
<tr>
<td>Sector Instability / Insecurity</td>
<td>23.6</td>
<td>27.7</td>
<td>21.2</td>
<td>27.5</td>
</tr>
<tr>
<td>Other</td>
<td>0.0</td>
<td>2.1</td>
<td>0.0</td>
<td>97.9</td>
</tr>
</tbody>
</table>

(Rothwell, Khamphoune and Neumeyer 2011, pg 18)

Canada’s aging workforce and issues associated with a mismatch of skills also contribute to difficulties accessing labor. This will be discussed in more detail in section 4.2.4.

4.2.1.2 Raw Materials (abundance, accessibility, cost)

The supply of raw materials is the most costly of all the supply chain aspects, accounting for nearly 40% of the total cost of producing pellets (Monteiro, Mantha and Rouboa 2012). Challenges within this supply chain include impacts associated with the MPB epidemic in B.C., access costs, changing energy costs and competitive pressures from other regions (Stennes, Niiquidet and Van Kooten 2011).
The extent to which wood pellets can be produced in B.C. depends on the availability of raw materials (i.e. Timber Supply). Availability, quality, and cost of these raw materials have decisive effects on the business viability and design of the supply chain (Mobini, Sowlati and Sokhansanj 2013). Raw materials for wood pellet production are available in 3 forms: (1) Sawmill wood waste consisting of sawdust, chips, shavings and bark; (2) roadside wood waste that is usually grinded and hauled to the manufacturing facility; (3) Standing timber that is available for harvest (Industrial Forestry Services Ltd, M.D.T. Ltd, Murray Hall Consulting Ltd. 2011). Chart 4-2 below shows the projected available raw material supply by type.

Chart 4-2: Available Raw Material by Type:

(Industrial Forestry Services Ltd, M.D.T. Ltd, Murray Hall Consulting Ltd. 2011, pg 3).

Timber killed by the MPB is expected to surpass $10^9$ m³ within the next two decades, an amount that exceeds what can be salvaged for traditional uses, meaning higher proportions of standing dead timber will be available for non-traditional uses (Stennes, Niquidet and van
Additionally, over time, the physical condition of this dead timber will deteriorate to the situation where rot and cracks will render the wood unsuitable for dimensional lumber, further diminishing the use of salvaged wood for traditional products. The loss of such timber volume from future timber supplies could mean that many forestry-dependent communities may no longer be able to rely on traditional logging to support their economies. Any means to add value through the intensification of timber use or expansion of the extensive margin could be viewed as potentially minimizing future economic damage (Stennes, Niquidet and van Kooten 2009).

Due to their small particle size, low ash content and low moisture content, shavings and sawdust are the most desired raw material for wood pellet manufacturing (Mobini, Sowlati and Sokhansanj 2013). These materials are usually obtained from sawmills nearest to wood pellet manufacturing facilities who traditionally disposed of the majority of the materials as waste in bee hive burners. B.C. has legislated these burners to be gradually phased out in recent years. Hence, sawmills have been looking for new ways to dispose of their waste making much of it available as biomass for wood pellets. Although the availability of sawmill wood waste (the lowest cost fuel category) in B.C. is significant, it is widely scattered and whether it alone can sustain a reasonably sized plant may vary throughout the Province (Industrial Forestry Services Ltd, M.D.T. Ltd, Murray Hall Consulting Ltd. 2011). Industry consensus in Northern B.C. suggests that road side residue resulting from traditional logging practices is only economically feasible within 60 km of a wood pellet manufacturing facility under the current pricing regime. Again, the availability of this source is often geographically constricted and in many cases may not be able to sustain a reasonably sized pellet plant. When compared to standing timber, net road side
residues are much less expensive. In order to gain access to standing timber, a wood pellet producer would have to hire contractors with appropriate machinery to fell, skid and process the trees as well as to build access roads. There would also be administration costs associated with obtaining the required permits as well as stumpage to be paid to the Crown. These are all activities that add additional costs over those associated with accessing residual roadside debris and sawmill waste residues. In the cases of both harvesting standing timber and collecting roadside debris, there are still additional costs over those associated with using sawmill waste residues. Grinding has to occur to convert the material into a form that can be used to produce pellets. The material has to be then transported to the wood pellet manufacturing facility. This reiterates the fact that access to sawmill residual material is the most financially feasible access to raw materials for wood pellet production making business to business relationships between traditional forest product companies and wood pellet manufacturers essential. Business to business relationships can allow traditional forest product companies to supplement their costs by selling either sawmill residues or roadside debris and also allow them to harvest stands that were traditionally not economically feasible. Through these relationships, they can harvest stands that are further away from their manufacturing facilities and that are of lesser quality for sawlog production. This makes more raw materials available for both traditional uses and wood pellet manufacturing.

Also, a more recent government policy put in place to appease the U.S. as a result of the Softwood Lumber Agreement has inadvertently created incentives for the business to business relationships discussed above. Before 2008, the majority of dead pine stands harvested in B.C. were available as scale based sales, meaning stumpage was paid on volume.

3 "Stumpage" is a fee paid to the provincial government for the timber resources extracted.
once it was delivered to the manufacturing facilities. There was no stumpage to be paid for unsuitable sawlog material remaining at the road sides once the primary harvesting activities were completed. Currently, the majority of these stands are available as cruise based sales, meaning that each stand is priced as a whole and stumpage is paid on all the estimated merchantable volume within the stand. Therefore, a business to business relationship whereby more volume within the stand is utilized helps companies in effect recuperate stumpage costs. Otherwise, volume remaining at the roadside that was paid for by the primary harvesting company would not be utilized. This is of particular importance since roadside debris piles are becoming larger due to the deteriorating condition of the MPB killed timber.

This deteriorating condition of timber has caused forest companies to reevaluate the way they process logs in the forest to maximize log quality prior to transport. Many companies are utilizing a cut to length system where logs are bucked into required lengths for standard lumber production prior to transporting them to manufacturing facilities. This system means more debris for wood pellet manufacturing is left at the road side and less is available at sawmills. This practice is becoming more and more popular in the B.C. interior.

The extent to which sawmill residuals are available in the future is uncertain. In recent years, there has been an inflated harvest level in B.C. due to the MPB epidemic. When harvest levels decline, it is uncertain how much raw material will be available for wood pellet production. Sawmills may be running at reduced capacities meaning there will be less sawmill residue and roadside residue available for wood pellet production through business to business relationships. Some sawmills may shut down, which would completely remove any opportunity for access to raw materials through business to business relationships.
There are already signs of this occurring. In October, 2013 both Canfor and West Fraser announced they will be trading timber rights and each closing mills in Quesnel and Houston B.C, both of which are in close proximity to wood pellet manufacturing facilities.

Given that the low density of forest residues is the main limiting factor for its transportation, its transport over short distances is crucial (Monteiro, Mantha and Rouboa 2012). Standing timber and roadside residues are less likely to be available in close proximity to manufacturing facilities due to impacts from the economic downturn. During this time, most of the province was operating under minimum stumpage payment to the Crown meaning there were no cost allowances for harvesting further away from manufacturing facilities. As a result, many companies liquidated most of their closest timber to minimize costs.

The cost of raw materials is a definite hurdle to be addressed. Given that sawmill residues and roadside debris are the two lowest cost sources for raw materials, suppliers of these raw materials have increased supplier power. The current structure of the industry requires that wood pellet manufacturers rely on business to business relationships to survive, meaning suppliers can presumably set the price. This will become even more of an issue as less of these raw materials become available from sawmills.

The wood pellet industry is looking for ways of improving their security around the supply of raw materials. One thing they are looking for is bioenergy tenures that allow access to raw materials. There are many questions as to what these tenures would look like. The BC Ministry of Forest Lands and Natural Resource Operations (MFLNRO) conducted a study in fall 2007 to estimate the potential tenure opportunity for bioenergy in BC using
forest stewardship requirements, available low-grade timber, and available Allowable Annual Cut as guiding principles. This study was intended to assess the availability of standing timber for bioenergy tenures. The study showed that almost 1.6 million m³ of annual harvest opportunity existed for standing timber in the BC interior (MFLNRO 2007). Since allowing access to competitive timber for sawlog production threatens the traditional forest industry, many licenses offered to bioenergy producers are for timber that is below the lower merchantability limits for sawlogs and below what is used to calculate AAC levels in the province of BC. With these licenses, the question remains as to how this volume will be valued and measured in terms of stumpage payments to the Crown and deductions from cut control limits⁴. Timber below the lower merchantability limits traditionally isn’t measured or timber valuation or cut control deductions and is therefore not subject to stumpage payments.

So in the past, the Crown received no revenue for this material. Going forward in a bioenergy tenure structure, it would be reasonable to assume that since this material will be used for producing a product, the Crown will be expecting some kind to stumpage payment.

Some bioenergy producers have also put forward that they would be willing to accept liability obligations that traditionally are the responsibility of traditional licensees in order to remove the requirement for business to business relationships. This would remove the reluctance of primary harvesters to cooperate with bioenergy producers and reduce the risk to bioenergy producers for being subject to supplier power. In this instance, to gain access to road side debris, bioenergy producers could assume; liability for reforestation of the roadside work areas; liability for mitigating fire damage should any remaining debris contribute to a

⁴ "Cut control limit" is a measure of the balance between the amount harvested and the amount that is available for harvest over a given time period under a particular harvesting license. For example, a license may have an AAC of 100,000 m³ per year and have a cut control period of 5 years meaning that within a 5 year period, 500,000 m³ is available for harvest. If by the 3rd year, only 200,000 m³ is harvested, then the licensee has 2 years to harvest 300,000 cubic meters.
forest fire; liability for any resource roads and their associated stream crossing structures in place to access the road side debris. Tenures of this sort could remove these liabilities from existing tenure holders and place it on the bioenergy producers. However, the question of revenue to the crown still exists. To date, forms of tenure have been developed to provide access to raw materials but they are short term and do not address all of the issues. For example, licensees are still responsible to plant the areas underneath the debris piles within a reasonable time frame.

There are purpose-grown sources of wood biomass being considered near biomass users. Approximately 2500 ha are being established annually with scale-ups planned in Ontario and the Prairies (Cocchi, et al. 2011). OSB and Pulp and Paper producers have been experimenting with this in Alberta for a number of years. Alberta Pacific Ltd. near Athabasca, Alberta has been growing hybrid poplar trees on private land surrounding their manufacturing facility. These trees are genetically selected to yield higher volumes of wood at a faster rate and have allowed Alberta Pacific to increase their production capacity. In Canada, 8 – 16 million hectares of land has the potential to be used for this application where establishment costs are 50-70% of the total delivery costs (Cocchi, et al. 2011).

In Canada, raw material costs have increased 3-4 fold since the early 2000s, requiring export contracts to increase 30-40% in price in order to sustain financial viability for pellet mills (Cocchi, et al. 2011). The wood pellet sectors primary customers are larger power utilities who are holding back on investment decisions due to B.C.’s regulatory and fibre supply uncertainty forcing pellet producers to demonstrate fibre security before the power utilities commit to biomass conversion (Wood Pellet Association of Canada 2013).
4.2.1.3 Knowledge resources (scientific, technical, market)

Canada has significant knowledge resources when it comes to the nation's ability to create, upgrade and deploy factors of production. Almost every province has at least one major university and numerous technical schools. Table 4-3 below shows the number of employees in Canada's bio-products industry with various scientific or technical skills. See section 4.2.4 for more information on knowledge resources.

<table>
<thead>
<tr>
<th>Number of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientific Research and Development (e.g. Scientists, R &amp; D Managers)</td>
</tr>
<tr>
<td>Engineers</td>
</tr>
<tr>
<td>Laboratory Technicians</td>
</tr>
<tr>
<td>Management / Marketing / Finance</td>
</tr>
<tr>
<td>Production / Operators</td>
</tr>
<tr>
<td>Others</td>
</tr>
</tbody>
</table>

(Rothwell, Khamphoune and Neumeyer 2011, pg 17)

4.2.1.4 Amount and cost of financing

There are several types of financing available for bioenergy projects in B.C. (BIOCAP 2008). BIOCAP (2008) summarizes some of them as follows:

Banks - Most funding for commercial projects usually comes from banks. Interest rates are usually low compared to other sources. Banks are risk adverse and may require further assurances from other stakeholders and may require that other parties co-finance projects.

Risk Capital – Some technology investors and venture funds are available. The investors typically desire 15-20% returns on their investments making this type of financing expensive.

Investment Funds – Some companies have investors that are specifically interested in profiting from the renewable energy market. Creststreet, the Clean Power Income Fund or the
Algonquin Power Income Fund are examples of sources of this type of financing. These investments may come from tax deductible savings and investment plans. These investors typically want to own all or part of a facility and will want to be part of their operation.

**Federal Funding Sources** – Several government programs or private foundations may be able to assist with funding bioenergy initiatives or projects. Some of them are listed below:

1. Sustainable Development Technology Canada (SDTC) - provides grants for up to one-third of the capital cost of pre-commercial technology projects.
2. Technology Early Action Measures (TEAM) - funds new technologies to be demonstrated.
3. Canadian Biomass Innovation Network (CBIN) - funds research and development of biomass technologies.
4. Natural Resources Canada’s ecoENERGY Technology Initiative - funds biomass energy projects at the demonstration stage.
5. Canada Strategic Infrastructure Fund - only available for large-scale projects with costs of over $75 million.
7. Northern Development Initiative Trust – their mandate covers issues related to mountain pine beetle and is available for local governments, not-for-profit societies, and First Nations.
8. There are many more sources but the list is too long to provide here.

**Income and incentive sources** – The following provide for additional revenue or lower costs
1. Emissions Credits
2. Renewable Energy Certificates
3. ecoENERGY for Renewable Power
4. Accelerated Write-off: Federal Income Tax Act states renewable energy systems can be written off faster
5. Standing Offer Program

In 2009, 78% of bioproducts firms said that financial incentives such as Government programs were of high importance when deciding where to locate a facility (Rothwell, Khamphoune and Neumeyer 2011). Table 4-4 shows the sources of capital funds raised for bio-product activities in Canada in 2009.

Table 4-4: Capital Funds Raised for Bioproduct Activities in Canada, 2009

<table>
<thead>
<tr>
<th>Private Sources</th>
<th>Thousands of Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Canadian Based Private Venture Capital</td>
<td>35,657</td>
</tr>
<tr>
<td>American Based Private Venture Capital</td>
<td>0</td>
</tr>
<tr>
<td>Other Private Venture Capital</td>
<td>2,575</td>
</tr>
<tr>
<td>Banks, Cooperatives, Credit unions</td>
<td>x</td>
</tr>
<tr>
<td>Angel investors / Family</td>
<td>17,599</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Government Sources</th>
<th>Thousands of Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>Government Loans (e.g. BDC, FCC, EDC, STDC)</td>
<td>47,460</td>
</tr>
<tr>
<td>Matching Funds</td>
<td>2,218</td>
</tr>
<tr>
<td>Grants (e.g. IRAP)</td>
<td>60,493</td>
</tr>
<tr>
<td>Other</td>
<td>3,794</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Other Sources</th>
<th>Thousands of Dollars</th>
</tr>
</thead>
<tbody>
<tr>
<td>IPO / SPO</td>
<td>0</td>
</tr>
<tr>
<td>Private Placements</td>
<td>x</td>
</tr>
<tr>
<td>Other</td>
<td>F</td>
</tr>
</tbody>
</table>

(Rothwell, Khamphoune and Neumeyer 2011, pg 25)
4.2.1.5 Infrastructure (type, quantity and cost)

When considering the shipment of wood pellets internationally, availability of suitable vessels and meteorological conditions (e.g. winter time in Scandinavia and Russia) need be considered (Junginger, et al. 2010). Shipping rates have gone from fluctuating wildly in 2007 and 2008 to steadily rebounding from an all-time low in most recent years (investenttools.com 2014). Availability of vessels is closely linked to international shipping rates of dry bulk and shipping rates determine a large percentage of the total costs delivered to the end user internationally.

Harbor and terminal suitability to handle large biomass streams can hinder the import and export of biomass to certain regions (Junginger, et al. 2010). Different ports have wide variation in their efficiencies, which can be reflected by dock facilities, connections to inland transportation lines, harbor characteristics (channel depth and tidal movements), congestion level, etc. The efficiency of a Port could be an important determinant of shipping costs (Yifei and McDow 2013). Couple this with insufficient volumes of biomass to achieve low shipping costs through economies of scale because of the shear space required for storage necessitates investment in biomass handling (Junginger, et al. 2010). Pinnacle Pellet has recently completed a wood pellet receiving, storage and shipping facility on the west coast of Kaien Island in Prince Rupert B.C. (Golder Associates Ltd. 2012). This provides them more control over the whole port aspect of their supply chain as they no longer have to compete for space with other bulk transporters (i.e. coal shipments) and they no longer have to deal with inadequate cleaning and contamination issues. Junginger, et al. (2010) noted in their survey that many port facilities are designed for the handling of high value goods and bulk commodities such as coal and wood pellets have a lower value, and are difficult to handle
and manage without proper infrastructure. Pinnacle Pellet’s efforts in Prince Rupert are intended to solve some of these issues. The port of Prince Rupert is considering new storage silos to accommodate increased volumes, improvements to enable completely filling handymax ships, a better loader to limit dust and preserve pellet integrity, and new rail siding for efficiency. The port of Vancouver is also considering improvements (Cocchi, et al. 2011).

To increase control over rail transport, Canadian pellet producers often lease rail cars from CN rail for transport of their pellets. These rail cars are of the same style as those used for bulk agricultural transport. By having this control over the rail cars, pellet producers are able to ensure there is no contamination of the product and there are sufficient numbers and types of rail cars available when they need them.

Canada’s west coast is in a strong position to supply Asia with wood pellets, drawing on both timber supply and proximity to Asian markets (Roos and Brackley 2012). The expansion of the Port of Prince Rupert is of particular importance. It boasts competitive advantages of being North America’s closest port to key Asian markets by up to three days (Prince Rupert Port Authority 2014).
It is favorable when the end user's facility is close to the harbor avoiding additional transport by trucks. Transportation by truck or train (both in biomass exporting and importing countries) is a high cost factor, which can impact the overall energy balance and total biomass costs. Growth of transport of wood pellets from within B.C. to the ports of Vancouver and Prince Rupert by train may be seriously hampered by limited logistical infrastructure (e.g. single rail tracks) (Junginger, et al. 2010).

4.2.1.6 Production Costs

Pellet production is a combination of sequential steps including processing, drying, grinding, pelletizing, cooling, screening and bagging (Monteiro, Mantha and Rouboa 2012). Biomasses low bulk density and high moisture content of raw materials contributes significantly to transportation costs and hence to the final cost of wood pellets (Mobini, Sowlati and Sokhansanj 2013). The drying phase of the manufacturing process represents the major portion of the electricity consumption and that is the main source of maintenance
costs (Monteiro, Mantha and Rouboa 2012). The combined raw material costs and drying costs account for over half of the total production costs (Lu and Rice 2011). Personnel costs can be relatively low. A typical plant requires one maintenance person, an administrative person, and five employees for every working shift (Monteiro, Mantha and Rouboa 2012).

According to Koppejan, et al. (2012), a recently developed economic assessment model based on a manufacturing facility located on the southeast coast of North America assumed the costs in tables 4-5 and 4-6 below in their cost analysis.

Table 4-5: Cost from Facility to End User

<table>
<thead>
<tr>
<th>Facility to Port</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Truck Transport 100 km to Port ($/mt/100km)</td>
<td>10</td>
</tr>
<tr>
<td>Storage in Port ($/mt/day) for 45 Days</td>
<td>0.14</td>
</tr>
<tr>
<td>Loading ($/mt)</td>
<td>2.86</td>
</tr>
<tr>
<td>Deep Sea Shipment ($/mt)</td>
<td>35</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Port to Utility</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Loading ($/mt)</td>
<td>2.86</td>
</tr>
<tr>
<td>Storage ($/mt/day) for 14 Days</td>
<td>0.14</td>
</tr>
<tr>
<td>Barge / Truck / Railway Transport ($/mt/100km)</td>
<td>5.6</td>
</tr>
<tr>
<td>Loading ($/mt)</td>
<td>2.86</td>
</tr>
</tbody>
</table>

Adds up to $411 / GJ

Adopted from (Koppejan, et al. 2012)

Table 4-6: Total Product Cycle Costs ($/GJ)

<table>
<thead>
<tr>
<th>Cost Components</th>
<th>$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Biomass</td>
<td>4.28</td>
</tr>
<tr>
<td>Cost of Electricity</td>
<td>0.60</td>
</tr>
<tr>
<td>Cost of Labour</td>
<td>0.47</td>
</tr>
<tr>
<td>Financial Costs</td>
<td>3.01</td>
</tr>
<tr>
<td>Other Costs</td>
<td>0.40</td>
</tr>
<tr>
<td>COST PRICE AT PRODUCTION SITE</td>
<td>6.76</td>
</tr>
<tr>
<td>Inland Logistics from the Plant to Port</td>
<td>1.12</td>
</tr>
<tr>
<td>Deep Sea Shipment</td>
<td>2.04</td>
</tr>
<tr>
<td>Inland Logistics from Port to Utility</td>
<td>0.94</td>
</tr>
<tr>
<td>COST PRICE DELIVERED AT THE UTILITY</td>
<td>10.87</td>
</tr>
<tr>
<td>Extra costs at the Power Plant</td>
<td>1.93</td>
</tr>
<tr>
<td>TOTAL COSTS OF COAL REPLACEMENT</td>
<td>12.80</td>
</tr>
</tbody>
</table>

(Koppejan, et al. 2012, pg 29)
Charts 4-4 and 4-5 below show a depiction of the average variable costs of pellet mills in the U.S. and export costs from the U.S. and Canada.

Chart 4-4: Average Variable Cost for Domestic Pellet Mills

Average Variable Cost
Domestic pellet mills – 2012
USD/ton

(Walker 2010, pg 6)

Chart 4-5: Wood Pellet Export Costs

Wood Pellet Export Costs -2012
USD/tonne

(Walker 2010, pg 12)
Table 4-7 below shows the costs of wood pellet production from base case situations in North America. These costs are based on annual production of 45,000 tons. It is assumed that there would be economies of scale with the average larger North American plant that would reduce production costs (Mani, et al. 2006).

Table 4-7: Costs of Wood Pellet Production

<table>
<thead>
<tr>
<th>Pellet Process Operations</th>
<th>Capital Cost ($/t)</th>
<th>Operating Cost ($/t)</th>
<th>Total Cost ($/t)</th>
<th>Cost Distribution (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Material</td>
<td>0.34</td>
<td>19.39</td>
<td>19.73</td>
<td>39.02</td>
</tr>
<tr>
<td>Drying Operation</td>
<td>2.46</td>
<td>7.84</td>
<td>10.30</td>
<td>20.37</td>
</tr>
<tr>
<td>Hammer Mill</td>
<td>0.25</td>
<td>0.70</td>
<td>0.95</td>
<td>1.88</td>
</tr>
<tr>
<td>Pellet Mill</td>
<td>1.43</td>
<td>1.88</td>
<td>3.31</td>
<td>6.55</td>
</tr>
<tr>
<td>Pellet Cooler</td>
<td>0.13</td>
<td>0.21</td>
<td>0.34</td>
<td>0.67</td>
</tr>
<tr>
<td>Screening</td>
<td>0.11</td>
<td>0.05</td>
<td>0.16</td>
<td>0.32</td>
</tr>
<tr>
<td>Packing</td>
<td>0.56</td>
<td>1.37</td>
<td>1.93</td>
<td>3.82</td>
</tr>
<tr>
<td>Pellet Storage</td>
<td>0.07</td>
<td>0.01</td>
<td>0.08</td>
<td>0.16</td>
</tr>
<tr>
<td>Miscellaneous Equipment</td>
<td>0.42</td>
<td>0.33</td>
<td>0.76</td>
<td>1.50</td>
</tr>
<tr>
<td>Personnel Cost</td>
<td>0.00</td>
<td>12.74</td>
<td>12.74</td>
<td>25.19</td>
</tr>
<tr>
<td>Land Use and Building</td>
<td>0.21</td>
<td>0.95</td>
<td>0.26</td>
<td>0.51</td>
</tr>
<tr>
<td>Total Cost</td>
<td>5.99</td>
<td>44.58</td>
<td>50.57</td>
<td>100</td>
</tr>
</tbody>
</table>

(Mani, et al. 2006) (page 424)

4.2.2 Demand Conditions

According to Michael Porter, demand conditions in the domestic market generally help build competitive advantage when a particular industry segment is larger or more visible in the domestic market than in foreign markets (Porter 1990). In the case of wood pellet manufacturing, the industry segment is smaller and less visible in the domestic market than in European markets and therefore may not receive as much attention from Canadian companies as European companies would pay to their market segment. In the case of co-firing with coal, the technology has not yet been utilized in Canada while it is being utilized in Europe and the United States where in some cases 100% biomass utilization in former coal
generating stations has also been successfully implemented (Zhang, et al. 2010). However, increased attention could be paid to the wood pellet market in Canada by the sawmilling industry as a means to sustain its own competitive advantages. Canada has a very advanced sawmilling industry making it more visible in the domestic market and hence the pellet market may become more visible by association.

Michael Porter also says that a nation’s companies gain competitive advantages if domestic buyers are the worlds most sophisticated and demanding buyers for the product. This provides a window into advanced customer needs (Porter 1990). This is an indication of further challenges for Canadian wood pellet manufacturers. In Canada, wood pellets are primarily used for residential heating whereas the majority of the products used in other countries are for co-firing with coal and in more sophisticated wood pellet heaters.

4.2.2.1 Quality and Sustainability Criteria

According to Junginger, et al. (2010), technical standards have not been noted to hamper trade, but there is the potential to do so should technical standards one day become more important. The European Union currently has biomass standards describing all forms of solid biofuels in Europe. The wood pellet standard (CEN/TS 14961) divides wood pellets into various classes based on size, ash content and mechanical durability. In addition, various EU countries have developed their own quality standards aimed for use for non-industrial applications like residential heating as well as different standards for use in co-firing with coal (Junginger, et al. 2010). The Pellet Fuel Institute in the United States designed a set of standards for wood pellet fuel grading (Roos and Brackley 2012) (See table 4-8).
The survey conducted by Junginger, et al. (2010) of bioenergy market players indicated that 50% of experts believe that establishment of an internationally accepted technical industrial wood pellet standard would be a major step to enhance the global trade. In other words, while the multitude of technical quality standards is not perceived to hamper global wood pellet trade, a single internationally accepted standard would enhance it (Junginger, et al. 2010).

Sustainability criteria and certification systems also exist for the trade of wood pellets. Among these there are voluntary standards endorsed by non-governmental bodies in the private business to business sector. Examples include the Green Gold Label by Control Union, the GDF-SUEZ / Electrabel label by SGS, Laborelect and the Sustainability Policy for Biomass by Drax. There are voluntary government initiatives such as the Roundtable on Sustainable Biofuels (RSB) and the Global Bio-energy Partnership (GBEP). There are also regulations which make the eligibility of a biomass product dependent on certification (Junginger, et al. 2010).

The International Organization for Standardization is developing a new standardization in the field of sustainability criteria for production, supply chain and

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### Table 4-8: Pellet Fuel Institute Standards

<table>
<thead>
<tr>
<th>Fuel Property</th>
<th>Premium Grade</th>
<th>Standard Grade</th>
<th>Utility Grade</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bulk Density</td>
<td>40.0 – 46.0</td>
<td>38.0 – 46.0</td>
<td>38.0 – 46.0</td>
</tr>
<tr>
<td>Diameter (inches)</td>
<td>0.230 – 0.285</td>
<td>0.230 – 0.285</td>
<td>0.230 – 0.285</td>
</tr>
<tr>
<td>Diameter (mm)</td>
<td>5.84 – 7.25</td>
<td>5.84 – 7.25</td>
<td>5.84 – 7.25</td>
</tr>
<tr>
<td>Pellet Durability Index</td>
<td>&gt;= 96.5</td>
<td>&gt;= 95.0</td>
<td>&gt;= 95.0</td>
</tr>
<tr>
<td>Fines (% at mill gate)</td>
<td>&lt;= 1.0</td>
<td>&lt;= 1.00</td>
<td>&lt;= 1.00</td>
</tr>
<tr>
<td>Inorganic ash %</td>
<td>&lt;= 1.0</td>
<td>&lt;= 2.00</td>
<td>&lt;= 6.0</td>
</tr>
<tr>
<td>Length (% &gt; 1.5 inches)</td>
<td>&lt;= 1.0</td>
<td>&lt;= 10.0</td>
<td>&lt;= 1.0</td>
</tr>
<tr>
<td>Moisture % (wet basis)</td>
<td>&lt;= 6.0</td>
<td>&lt;= 6.0</td>
<td>&lt;= 10.0</td>
</tr>
<tr>
<td>Chloride (parts per million)</td>
<td>&lt;= 300</td>
<td>&lt;= 300</td>
<td>&lt;= 300</td>
</tr>
</tbody>
</table>

(Roos and Brackley 2012, pg 5)
application of bioenergy. This standard will include terminology and aspects related to the sustainability (e.g. environmental, social and economic) of bioenergy. The new standard will be called ISO 13065 and is scheduled to be published April 30, 2015 (ISO 2014).

Sophisticated industries involving natural resources already have quality and sustainability standards for their products. Sawmills for example have quality standards for lumber that is internationally recognized and enables them to obtain premium or discounted prices based on these standards depending on where their product is being shipped. In addition they belong to environmental certification organizations that guarantee a certain portion of their raw materials come from environmentally sustainable sources. It is reasonable to assume that as the wood pellet industry matures globally, there will also be an internationally recognized set of standards that will enable firms to attract premium prices for products that have a proven chain of custody from environmentally sustainable sources. In North America, the majority of these sources are already certified as a result of the forest products industry. Already in B.C., Pinnacle Pellet boasts on their website that they are members of the following accreditations and associations: Certified Green Gold Label Supplier (Control Union Certifications); Participant of community air shed quality improvement forum; Meet the requirements of the Drax Power Limited Sustainability Criteria; Collaborative partner at the UBS Biomass & Bioenergy Research Group; Meet the net energy at net carbon requirements of the supply of wood pellets to Europe; and over 90% of fibre used in the wood pellet production is sourced from sustainable forest as certified by FSC, SFI or CSA (Pinnacle Renewable Energy Group 2010-2011).
4.2.2.2 Commodity Prices

High oil prices and strong GHG emission reduction policies are important for determining demand for wood pellets. In particular, Junginger, et al. (2010) found that high coal prices were seen as an opportunity for wood pellets since about half of the global wood pellet production is used to replace coal in power plants. Also, high prices for natural gas could affect the demand for wood pellets for residential heating as consumers will be looking for a lower cost alternative to heat their homes.

As of Feb 13, 2013, prices of wood pellets delivered to Amsterdam-Rotterdam-Antwerp were at $166.65/ton. Export prices in North America ranged from $132/ton to $168/ton (Argus Biomass Markets 2013). Charts 4-6 and 4-7 below show the prices for North American wood pellets at home and shipped abroad. The trends show increasing prices over the last 5 years indicating increasing demand relative to supply. When compared to export costs from section 4.2.1.6 above, it is evident that profit margins are not that high. For instance, in 2012 total cost of production and shipping was $180 / tonne and the Chart 4-7 shows a price of $190 to $200 / tonne in the same period.
Chart 4-6: Wholesale Pellet Prices

RISI and PFI Pellet Manufacturing Survey
Wholesale Pellet Prices (fob mill)
USD/ton

(Walker 2010, pg 7)

Chart 4-7: Average Pellet Prices of North American origin

Average Prices CIF EU USD/tonne
North American Origin

(Walker 2010, pg 11)
4.2.2.3 Government Support

Junginger, et al. (2010) found that strong policy support for electricity and heat from wood pellets was deemed a very important condition for further growth of international wood pellet trade. Asian countries are striving to increase their usage of renewable energy. A consistent factor in China, Japan and South Korea is that their governments are promoting renewable energy, leading to policies that are driving demand for wood pellets (Roos and Brackley 2012). In Ontario where 18% of the electricity is generated from coal, the provincial government has committed to eliminating the use of coal for electricity generation by December 31, 2014 (Zhang, et al. 2010). The United States has a Renewable Energy Production Tax Credit that provides a 2.2 cent-per-kilowatt-hour tax credit for renewable energy production (Roos and Brackley 2012). In 2009 at the Copenhagen climate change summit, United States president Barak Obama committed to reducing GHG emissions in the range of 17% by 2020, and by more than 80% by 2050 (The Huffington Post 2010). The United States has since made attempts at introducing climate change policy with the proposal of The American Clean Energy and Security Act as well as The American Power Act which called for 20% and 17% reductions in GHG emissions from 2005 levels respectively (Roos and Brackley 2012).

In 2009, Ontario introduced the Green Energy Act which allowed for a feed in tariff program (Zhang, et al. 2010). This program allows homeowners, business owners and private developers to sell renewable energy they generate to the province at a guaranteed price for a fixed contract term (Ontario Ministry of Energy 2013). Programs such as these entice nations to start up renewable energy industries.
4.2.3 Related and Supporting Industries

British Columbia's introduction of the *Wood Burner and Incinerator Regulation* in 1995 required sawmills to shut down waste-wood beehive burners as an incentive to reduce air pollution creating a need for sawmills to have an alternative means of disposing of their wood waste (Wood Pellet Association of Canada 2013). This in turn led to the need for a related and supporting industry to the sawmilling industry. Sawmills serve as suppliers to the wood pellet manufacturing facility. They are generally in close proximity, have knowledge of harvesting and efficient transportation infrastructure, access to fibre, and relationships with contractors. Business to business relationships with traditional forest products companies is essential for success of wood pellet manufacturers. Also related to and supporting the wood pellet manufacturing industry are activities associated with construction as well as other forest product industries. Construction machinery is used for building access roads to raw materials for biomass and chip trucks normally used for transport of raw material for pulp can be used to transport raw materials for wood pellets. There are also various dealerships and auction houses that enable buyers and sellers of machinery to gain access to equipment.

4.2.4 Firm Strategy, Structure, Rivalry.

The rivalry among existing competitors is currently low. There are not a lot of competitors in Canada; any impediments to growth are not based on competition for market share; and there is not high diversity among rivals. However, as the industry grows and technology for wood pellets as well as substitutes improves, there is potential for rivalry especially between wood pellet manufacturers and producers of other renewable energy products made from biomass. These firms will be competing for market share based on the
differentiation of their products and low switching costs for the consumers. They will also be competing for raw materials.

Canada has an aging workforce with significant proportions of the labor force coming of retirement age within the next 10 years. This along with its increasing participation in the global economy has reinforced the need for Canada’s proactive immigration policy. Immigrants are expected to account for all of Canada’s net labour force growth in the next few years and 80% of population growth by 2031 (Allies 2014). This is in part due to Canada’s understanding that maintaining a global competitive advantage involves building better international networks, increasing diversity awareness and improving relationships with global suppliers (Allies 2014). Canada’s skilled immigrants can contribute international skills, experience, and languages to the benefit of its exporting industries, and aid with the nations global goals (Allies 2014). Skilled immigrants are valuable resources for understanding customer needs in ethno-specific markets (Allies 2014). As a result, Canada’s labor force will look considerably different in the coming years and higher proportions of Canadian firms will be ethnically diverse. This diversity will come with increased skills. In 2007, 54% of immigrants between the ages of 25 and 54 who arrived from 2002 to 2007 held at least a bachelor’s degree, compared to 22% for their Canadian-born counterparts (Allies 2014) meaning immigration is leading to a more educated workforce. However, this won’t solve all of Canada’s labor shortage problems. The majority of these immigrants locate themselves in urban areas away from areas where skills are needed like the north (Sorensen 2013).
Chris Sorensen at Maclean’s wrote an article titled “The Future of Jobs in Canada” in 2013. In his article, Sorensen outlines many of the conceptions about the Canadian labor force. Below is a discussion of his article.

Many of the people in Canada perceive the trades to be a low paying, dead end career choice. However that doesn’t appear to be a realistic perception. As discussed earlier, Canada will be facing labor shortages as baby boomers retire and economists say the nation is facing a skills mismatch. The nation needs engineers, health care workers and skilled tradespeople while students continue to pursue degrees in the arts and humanities. The article suggests that Canada will be facing high unemployment rates alongside serious labor shortages. Up to one-fifth of Canada’s labour market already suffers from insufficient qualified workers, particularly in the health care, mining, business services and manufacturing sectors.

The article also says that colleges instead of universities are well-suited to bridging the divide between academics and training because they work closely with industry to develop their programs. Many companies offer apprenticeships where combinations of work experience and training earn candidates credentials towards certification. However, many companies are becoming weary of entering into such processes for fear of only training an employee to go work for someone else.

To summarize, Canada promotes a culture of high expectations in terms of wages in the industry due to its labor shortages and its talented people choose to be educated in the arts and humanities meaning that is where the desired work is rather than in the trades or
engineering. While Canada recognizes the problem, immigration will only solve part of the issue.

Currently, the industry is not all that concentrated and firms within it have a traditional organizational structure. Labor shortages will place pressures on this system and will force industry participants to come up with innovative ways to deal with the issue.

4.2.5 Environmental Sustainability

The burning of wood pellets is considered to be carbon neutral and therefore a form of renewable energy because no more CO₂ is emitted than what is absorbed through natural processes. The environmental benefits of wood pellets compared to fossil fuels were outlined in the literature review and will not be discussed in detail here. However it should be mentioned that there has been much debate over whether or not the burning of wood pellets should be considered a form of renewable energy mostly due to the fossil fuel energy required to produce and transport them. Wood pellets classification as a source of renewable energy is crucial to maintaining and growing the industry. Without this classification, energy policies will no longer drive their use and players in the export market will look to alternatives to meet their renewable energy needs.
CHAPTER V

SUGGESTIONS FOR SUSTAINED COMPETITIVE ADVANTAGE

To grow or maintain the wood pellet industry in Canada and to ensure Canada as a nation is competitive in the global market, the barriers to production seen in table 5-1 should be addressed. This table shows how important bioproduct firms believe the barriers of production are to their businesses. As shown in the table, the big hitters are the cost of biomass (i.e. price, transport costs), difficulty entering the commercial marketplace, lack of financial capital, cost and timeliness of regulatory approval and ongoing regulatory costs and requirements. Some of these important barriers to production will be discussed in this section.

Table 5-1: Canadian Barriers to Production of Bio-products, Canada, 2009

*Percentage of Respondents who rated barriers to production as Low, Medium, High, N/A

<table>
<thead>
<tr>
<th>Degree of Importance</th>
<th>Low (%)</th>
<th>Medium (%)</th>
<th>High (%)</th>
<th>N/A (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unreliable Quantity of Biomass</td>
<td>43.4</td>
<td>21.7</td>
<td>17.9</td>
<td>17.0</td>
</tr>
<tr>
<td>Unreliable Quality of Biomass</td>
<td>39.2</td>
<td>26.2</td>
<td>17.4</td>
<td>17.2</td>
</tr>
<tr>
<td>Cost of Biomass (e.g. Price, Transport Cost, etc.)</td>
<td>14.2</td>
<td>33.5</td>
<td>41.6</td>
<td>10.8</td>
</tr>
<tr>
<td>Difficulty in Entering Commercial Marketplace</td>
<td>15.4</td>
<td>33.3</td>
<td>34.1</td>
<td>17.3</td>
</tr>
<tr>
<td>Cost of Developing Environmental Indicators</td>
<td>28.7</td>
<td>27.2</td>
<td>12.4</td>
<td>31.7</td>
</tr>
<tr>
<td>Lack of Skilled Human Resources</td>
<td>32.9</td>
<td>37.5</td>
<td>9.3</td>
<td>20.3</td>
</tr>
<tr>
<td>Lack of Financial Capital</td>
<td>9.1</td>
<td>26.1</td>
<td>53.0</td>
<td>11.9</td>
</tr>
<tr>
<td>Cost and Timeliness of Regulatory Approval</td>
<td>15.7</td>
<td>21.0</td>
<td>50.3</td>
<td>13.0</td>
</tr>
<tr>
<td>Ongoing Regulatory Costs / Requirements</td>
<td>26.2</td>
<td>26.4</td>
<td>29.3</td>
<td>18.1</td>
</tr>
<tr>
<td>Lack of Adequate Product Standard Certification</td>
<td>46.6</td>
<td>31.7</td>
<td>6.4</td>
<td>15.2</td>
</tr>
<tr>
<td>Other</td>
<td>0.0</td>
<td>2.5</td>
<td>10.8</td>
<td>86.7</td>
</tr>
</tbody>
</table>

(Rothwell, Khamphouune and Neumeyer 2011, pg 15)
Based on the findings of this report, expansion on some of Porter's suggestions for policies that government and companies should pursue is warranted. For example, government should act as a catalyst and challenger, but not get involved directly in competition (Porter 1990).

Much of Governments involvement could pertain to the availability of raw materials. According to the Wood Pellet Association of Canada, B.C.'s pellet industry growth has stalled due to the lack of access to long term cost effective and predictable fibre supply and this has become the biggest threat to the continued viability and growth of B.C.'s pellet industry (Wood Pellet Association of Canada 2013). On June 26, 2012, the B.C Government announced regulatory changes that provide access to logging slash and wood waste fibre needed by biomass users (Ministry of Forests, Lands and Natural Resource Operations 2012). According to the administration manual for these tenure types, the access is in the form of tenures that provide access to logging debris piles that result from primary harvesting activities. These new fibre recovery tenures are to be used when a business to business relationship cannot be established and the secondary user must have made reasonable attempts to enter into a business to business relationship prior to issuance (Forest Tenures Branch 2012). The Wood Pellet Association of Canada claims that this approach requires bioenergy producers to prove that a major tenure holder is uncooperative and sets the stage for an adversarial relationship. They also claim that these types of tenures are too small and short term to provide meaningful fibre (Wood Pellet Association of Canada 2013). While these tenures require primary users to say they have no further use for the debris piles and place responsibility for fire hazard and abatement on the bioenergy users, they do not remove primary users from the silviculture obligations underneath the debris piles. During the time it
takes for the secondary user to prove to the government that they cannot reach an understanding with primary users and obtain a license, the primary users go ahead and burn the debris piles because they don’t want to miss the late fall burning windows to be able to plant trees in the spring. Therefore, this type of tenure doesn’t appear to be effective in helping bioenergy users gain access to fibre. This situation could be helped in the following ways;

1. Government could issue long term licenses without stipulation of a business to business relationship and relieve primary licensees of silviculture obligations underneath the debris piles. There could be an appraisal allowance add on for cutting permits with a bioenergy utilization chance to compensate primary licensees for additional risks associated with unutilized debris piles. Once debris piles are utilized, the appraisal dollars can be paid back to the Crown; if not then the primary user gets to keep the allowance and can burn the piles. (Not a preferred option because primary gets paid either way. Burning or selling the piles. Primary may not care what happens).

2. Government could issue long term licenses for standing bioenergy fibre. Licenses should be restricted to sites with forest health issues so that high quality fibre is not harvested too soon and forest health improves. These licenses will encourage collaboration between sawlog users and biolog users where small proportions of the bioenergy stands could be used for sawlogs and the waste from sawlog stands can be used for bioenergy. This increases the availability of raw materials for all users. Since not harvesting the bioenergy stands would mean the material would never be utilized, government should only worry about collecting minimum stampage for this
material. Developing such tenures should involve input from all potential users of the material so that the logistics of the processes involved could be simplified.

Governments can play a role in simplifying regulatory approval processes and reducing ongoing regulatory costs and requirements. This applies not only to the sourcing of raw materials, but also the processes involved in constructing and maintaining facilities and transportation infrastructure. Both the federal and provincial governments should look for ways to simplify these processes so as not to discourage investment in the industry.

More primary users of the raw material should pursue their own bioenergy licenses to gain additional access to sawlogs as well as to renew their positions on the industry life cycle to a growth position with the addition of bioenergy to their product mixes. This can be done either on their own or by gaining learning advantages of process technologies through partnerships. Through partnerships, both parties bring knowledge resources. Raw material supply knowledge on behalf of the sawmills and process technology knowledge on behalf of wood pellet producers.

Nations gain competitive advantage in industries where the domestic demand gives their companies a clearer or earlier image of emerging buyer needs (Porter 1990). More feed in tariffs and commitments to reduce the reliance on coal for power in Canada would also generate innovation and investment in the wood pellet manufacturing industry at home. This would pressure companies to innovate and gain learning advantages from the home market. It could improve the availability of financial capital from domestic sources and reduce logistical costs associated with transport of the finished product.
To further contribute to the availability of financial capital, Cocchi, et al. (2011) proposes that a *Bio-trade equity fund* be created to aid with investment in logistical infrastructure and enable development in new biomass supplies, reduce risk by investing in the whole supply chain, secure fibre supply contracts, efficient ground transport, large conversion plants, efficient ports and safe off take agreements. Federal funding helped build much of transportation infrastructure in Canada that most exporting industries have benefited from. However, it is difficult for wood pellet manufacturing facilities to compete within some of this infrastructure so they haven’t received the same benefits from it (i.e. competing for storage silos with coal manufactures at shipping ports). This has forced wood pellet manufacturing facilities such as pinnacle pellet to construct their own storage silos at huge capital investments. Federal funding or a *Bio-trade equity fund* would aid with such investments. Policy makers may be able to play a role in overcoming logistical obstacles (e.g. by building better roads and other infrastructure) (Junginger, et al. 2010).

Promotion in advancement of technology would also contribute to the long term competitiveness of the nation in the wood pellet industry. As of December 2012, there were 40-50 torrefacation initiatives identified between Europe and North America that intend to demonstrate the technical and economic feasibility of torrefication (Koppejan, et al. 2012). Promotion of such technology could come in the form of capital investment or programs encouraging industry players and education facilities working to together for faster innovation and advancement of technology. Advances in technology such as torrefacation opens up the doors for many other cost advantages within the industry. For example, torrefacation allows for the use of a broader range of products as a source of biomass. In the wake of reduced harvesting levels after salvage of mountain pine beetle staads is complete,
other species could be included in the biomass mix including hardwoods. There would be opportunity to plant hybrid popular plantations on private land adjacent to manufacturing facilities thereby reducing transportation costs. Also, due to the density of pellets, fewer raw materials are required to make pellets from high density hardwoods than lower density softwood (Lu and Rice 2011). This would lead to a reduction in raw material and manufacturing costs.

Michael Porter says that factors leading to competitive advantage are advanced, specialized and tied to specific industries or industry groups (Porter 1990). Specialized apprenticeship programs, research efforts in universities connected with industry are among the mechanisms that create these factors (Porter 1990). Polytechnics Canada is an alliance of Canada’s leading research intensive, publically funded colleges and institutes of technology (Polytechnics Canada 2014). Among recommendations they put forward to Canada’s federal Government are: more government support for applied research and commercialization programs; more focus on apprenticeship and pre-apprenticeship programs; and a requirement that bidders on government contracts create apprenticeship positions as a condition of their bids (Sorensen 2013). This government support, when directed at issues associated with development of industries related to renewable energy along with investment from the private company sector, would contribute to the overall competitiveness of the nation in the wood pellet manufacturing industry. It would also help the nation deal with issues associated with labor and innovation gaps.

With wood pellets in Asia primarily being used for co-firing in coal power plants, business development strategies in collaboration with governments and associations should be focused on developing relationships with coal power plants (Roos and Brackley 2012).
With Asia being an emerging economy, renewable energy use on the rise and Canada being in close proximity to Asia, this is the primary opportunity for a wood pellet industry in Canada. The potential in India should be explored as well. There is not a trade industry with India for wood pellets currently but literature shows between 300 and 400 million people in rural areas not connected to power grids and an oncoming energy crisis in terms of the availability of coal and natural gas. India is an emerging economy and with emerging economies comes wealth. More people will be connected to power grids, the existing power grids will eventually be upgraded to prevent power failures. India will be looking for sources of renewable energy in addition to the potential sources they already have and they will be looking for sources that can supplement their use of coal. India warrants a business development strategy in collaboration with industry, governments and associations to break down some of the political and logistical barriers to this potential large market.
CHAPTER VI

CONCLUDING OBSERVATIONS

The study examines the role and competitiveness of the wood pellet industry in Canada. The wood pellet industry in Canada has witnessed substantial growth in recent years. In the framework of Porter's international competitiveness model, it has all the credentials to become a competitive international product- it has a low carbon footprint, it is competitive vis-à-vis its national competitors (like US), wood pellets possess strong demand outside the country (especially in Europe), it has strong links with lumber industry etc. Being an industry dominated by a few players (oligopoly), it faces strong competition internally (in Canada), low margins and high transport costs (to their desired destinations). Being an industry that is evolving and faced by technological and consumer taste changes, it is faced with an uncertain future. For e.g., pyrolysis oil- driven from wood has immense potential because of its heat and power attributes; it also possess a low carbon footprint.

The industry is dependent on external entities like government and chance to enhance its competitiveness. In global trade, promotion of the product across borders requires a substantial role for government especially to remove tariff and non-tariff barriers. Chance attributes like innovation and exchange rates will also play an important role. Whether or not wood pellets are an industry of the future or just a short term solution to the call for renewable energy will depend upon the advancement of technologies in the renewable energy field. Industrialized renewable energy is still a relatively new field and much advancement in wood pellets, biomass substitutes as well as other sources are yet to be seen. Canada faces
issues with labor, a cyclical forest industry, and heavy regulatory barriers pertaining to the supply of raw materials. It is up to government to work with industry to come up with innovative ways to deal with these issues so that the wood pellet manufacturing industry can remain competitive.
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