Swedish University of Agricultural Sciences
*Faculty of Forest Sciences*

Department of Forest Products, Uppsala

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– a study about the production environment and international competitiveness of wood pellets from British Columbia

*Träpelletsexport från British Columbia*
*– en studie om förutsättningar för produktion och den internationella konkurrenskraften av träpellets från British Columbia*

Anders Johansson

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**Keywords:** Wood pellets, British Columbia, export, competitiveness, sea freight, Europe, South Korea

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# Sammanfattning

Den internationella marknaden för träpellets har haft en kraftig tillväxt de senaste åren som en följd av Kyoto-protokollet samt de incitament som skapats av den Europeiska Unionen för att gynna förnyelsebara energikällor. Den globala konsumtionen av träpellets uppgick år 2010 till 13,5 miljoner ton och ett flertal experter har uppskattat att konsumtionen kommer stiga till 35-50 miljoner ton tills år 2020. I och med dessa uppskattningar väcks frågor vilka regioner som kommer kunna tillhandahålla all denna träpellets och vilka förutsättningarna är för produktion på olika platser runt om i världen.

Denna studie syftar till att utvärdera förutsättningarna för träpelletsproduktion i British Columbia, på Kanadas västkust, genom att fokusera på den nuvarande industri strukturen, tillgång på råmaterial samt distributionskedjan. Konkurrenskraften avseende pris för träpellets från British Columbia kommer också utvärderas samt framtida utmaningar för sektorn kommer identifieras. Denna studie har grundats i fallstudie-metodik och datainsamlingen har skett genom flera typer av källor, som litteratur studier, seminarier samt semistrukturerade intervjuer.

Produktionskapaciteten för träpellets i British Columbia har växt med cirka 4000 % från år 1996 till år 2010 (50 000 ton till nästan 2 miljoner ton). En stor del av denna kapacitetsökning har skett under de senaste åren och mellan 2010-2011 tillkom ungefär 800 000 ton. Nästan 95 % av all träpellets som produceras i British Columbia skeppas till den europeiska marknaden. Respondenterna i de intervjuer som genomförts i denna studie har ansett att tillväxten i produktionskapacitet i British Columbia kommer trappas ner och att vi kommer få se en mer måttlig tillväxt framöver. Den största anledningen till detta är att den tillgängliga råmaterialen för fortsatt utbyggnad är dyrare. I provinsen finns stora mängder insektsdödade träd till följd av härjningarna av Contortabastborre (Mountain pine beetle). Ungefär 700 miljoner kubikmeter dödades mellan åren 1998 och 2010 men det har visat sig att det är dyrare att producera träpellets direkt från rundved än om traditionellt råmaterial såsom sågspån och andra restprodukter från träförädlingsindustrin används. En typ av råmaterial som är mer trolig att stå för en ökad andel i pelletsproduktionen i framtiden är avverkningsrester.

Träpellets från British Columbia har hitintills till största del använts av europeiska bulk-konsumenter. Den sydkoreanska marknaden har dock identifierats som en stor framtida importör som ett resultat av nyligen införda krav på användning av förnyelsebara energikällor i landet. British Columbia ligger långt iväg från både EU och Sydkorea och därför är konkurrenskraften för träpellets från British Columbia till stor del beroende av fluktueringarna i skeppningskostnader. Priset för träpellets i Vancouver har nyligen legat mellan €95 till €118/ton (FOB). Skeppningspriserna har varit fluktererat ganska kraftigt under de senaste åren och år 2001 kostade det €19/ton att skeppa till EU medan det 2007 kostade hela €75/ton. Denna studie har visat att priset för närvarande ligger på cirka €25/ton till Nederländerna vilket resulterar i ett levererat pris av träpellets från British Columbia i EU på mellan €120-143/ton. Priserna för bulkpellets i EU har senaste tiden fluktuerat kring €115-145/ton vilket visar att träpellets från British Columbia är konkurrenskraftig på den europeiska marknaden.

Kostnaden att skeppa träpellets till Sydkorea från Vancouver har beräknats till €18/ton. Detta resulterar i ett leverarat pris av träpellets mellan €113-136 /ton. Priset för träpellets på den Sydkoreanska marknaden har nyligen flukturerat mellan €91 till €116/ton. Detta åskådligör att träpellets från British Columbia har svårigheter att konkurrera avseende pris på den Sydkoreanska marknaden. Den framtida utvecklingen för kanadensisk träpellets på denna

marknad är därför beroende av hur mycket träpellets eller liknande produkter som kan levereras av länder i Sydkoreas närområde vilka förnärvarande kan leverera till lägre pris.

Ett flertal framtida utmaningar för fortsatt framtida träpelletsexport har identifierats i denna studie. Det är för närvarande endast en terminal som hanterar träpellets för export i British Columbia och det endast ett tågföretag som transporterar träpellets från fabrikerna i inlandet till hamnen i Vancouver. Mer konkurrens inom dessa tjänster skulle kunna påverka kostnaderna för distribution . En annan framtida utmaning är att utveckla metoderna för att producera torrifierade pellets på ett kostnadseffektivt och säkert sätt. Detta skulle kunna potentiellet kunna stärka konkurrenskraften för träpellets från British Columbia eftersom torrifierade pellets har teoretiskt sett bättre förutsättningar för långväga transport. Detta eftersom energidensiteten är högre i torrifierad pellets samt att de inte kräver lika varsam förvaing på grund av att fuktkänsligheten är lägre.

***Nyckelord***: *Träpellets, British Columbia, export, konkurrenskraft, sjöfrakt, Europa, Sydkorea*

## Preface

There are many people that have contributed and helped me during the process of writing this thesis. First of all I would like to thank all the interviewed actors and other people that have helped me in finding answers to my questions. Secondly, I am grateful for the help I got from Mark Boyland at Canadian Forest Service which has given me many recommendations during the initial stage of the study.

Finally, I would like to thank my supervisor at the Swedish Univeristy of Agricultural Sciences in Uppsala, Dr. Folke Bohlin and my supervisor at the University of British Columbia, Dr. Gary Bull.

*Anders Johansson*

Uppsala, Sweden 25 May 2012

## Summary

The global wood pellet market has seen a rapid growth after the adoption of the Kyoto protocol and the renewable energy incentives created within the European Union. The global consumption of wood pellets reached 13,5 million tonnes in 2010 and several experts estimate the consumption to be between 35-50 million tonnes by 2020. These forescasts raise the questions which regions that can supply this vast amount of wood pellets and what the conditions are for producing it.

This study evaluates the conditions for wood pellet production and export from British Columbia, on Canada's west coast, focusing on existing industry structure, raw material supply and the distribution chain. The price competitiveness of British Columbian wood pellets export will also be examined and future challenges identified. The study is based on case-study research method with several sources of data collection such as literature studies, seminar proceedings and semi-structured interviews.

The production capacity for the wood pellet industry in British Columbia has grown with about 4000% from 1996 to 2011 (50 000 tonnes to almost 2 million tonnes). A large part of this capacity has been added during recent years with 800 000 tonnes increased production capacity in 2010-2011. About 95% of the wood pellets produced in British Columbia are shipped to the European market. The general opinion expressed by the interviewed actors is that the rapid growth in production capacity will slow down and we will see a more moderate growth in the near future. The major reason for this is that the available raw material for increased production is more expensive. There exists a vast amount of mountain pine beetle killed trees in the province, about 700 million $m^3$ of pine have been killed from 1998 to 2010, but the price of using whole trees for wood pellet production has been found more expensive than the traditional raw material for pellet production; mill residues. A raw material source that is more likely to contribute to an increased production in the near future is harvest residues.

The wood pellets exported from British Columbia to date has mainly supplied the European market, and mainly bulk consumers. The South Korean market has been identified as a future market due to their newly introduced renewable energy targets. The price competitiveness of wood pellets from British Columbia has been found to a large extent be dependent on the price fluctuation for the cost of sea freight. The price in Vancouver port has recently been fluctuating from €95 to €118/tonne (FOB). The shipping market has been rather volatile during recent years and the price of shipping from Vancouver to Rotterdam has fluctuated between €19 to €75/tonne between 2001 and 2007. The current price for shipping has been estimated to be €25/tonne to the Netherlands which result in a delivered price from 120 to 143€/tonne for British Columbian wood pellets in Europe. The bulk prices in European ports have during the last years fluctuated between €115-145/tonne. This makes wood pellets from British Columbia price competitive in Europe and can explain why Europe is the major market for British Columbian wood pellets.

The current shipping price of wood pellets from Vancouver to South Korea has been estimated to be €18/tonne. This would result in a delivered price in South Korea of €113-136 /tonne. The price for wood pellets on the South Korean market has recently fluctuated from €91 to €116/tonne. This reveals that British Columbian wood pellets currently have difficulties to be cost competitive on this market. A future success for British Columbian wood pellets on the

South Korean market is dependent on how much wood pellets or similar biomass based products that can be delivered from Asian countries which currently have a lower price level.

Several future challenges for the future wood pellet export have been identified in this study. There is currently only one terminal that is handling wood pellets for bulk export in British Columbia and only one rail company that transports the pellets from the production facilities to the port. An increased competition on this market is likely to affect the price of distribution. Another interesting area for the future development is if torrefied pellets can be produced in a cost efficient and safe way. Torrefied pellets have theoretically better properties for long distance shipment due to higher energy density and does not have the same demand for storage facilities as regular wood pellets.

**Keywords**: *Wood pellets, British Columbia, export, competitiveness, sea freight, Europe, South Korea*

# Contents

**Glossary**

| | |
|---|---|
| AAC | Annual Allowable Cut |
| AEBIOM | European Biomass Association |
| BDI | Baltic Dry Index |
| Bdt | Bore dry tonnes |
| CEN | European Committee for standardization |
| CHP | Combined Power and Heating Plant |
| DH | District heating |
| DWT | Dead weight tonnage |
| EU27 | The 27 member countries of the European Union |
| GHG | Green House Gas |
| IEA | International Energy Agency |
| ISO | International Organization for Standardization |
| MDF | Medium density Fiberboard |
| Mt | Million tones |
| NGO | Non-Governmental Organization |
| Odt | Oven dry tonnes |
| RH | Residential Heating |
| RPS | Renewable Portfolio Standards |

# 1 Introduction

## 1.1 Background

One of the most rapidly growing commodities on the European energy market has during the last decade been wood pellets. There are several reasons to why wood pellets have become one of the most traded bioenergy products. First of all it has relatively high energy content compared to other solid biomass fuels. (Junginger, et al. 2008) Secondly it has been proven that wood pellets are relatively easy to handle when transported over long distances because of its good flowability. (Peng, et al. 2010) Just as other biofuels the increased trade with wood pellets can also be explained by the renewable energy incentives that have been created by several countries after the adoption of the Kyoto protocol. During the same time the price of alternative fuels, such as heating oil, has risen. (Junginger, et al. 2008)

The Kyoto Protocol, which is a legally binding agreement to reduce GHG-emissions, was adopted in 1997 and it entered into force in 2005. The binding targets of the protocol are addressed to 37 industrialized countries and the European community. The US has announced that they do not have the intention to ratify the protocol while Canada ratified it in 2002 but withdrew in December 2011. (UNFCCC 2012)

The European Union adopted further targets in 2007. These targets are set until 2020 with the goal to reduce GHG-emissions by 20 percent (compared to 1990 levels), increase the share of renewable energy to 20 percent and make 20 percent improvement in energy efficiency. (European Commission 2011) The renewable energy target has led to the creation of different incentive schemes within EU to promote renewable energy. This has made the region a driver in the international trade with bioenergy commodities such as wood pellet, ethanol and biodiesel. (Junginger, et al. 2008) Figure 1 below shows the major trade routes for the mentioned bioenergy commodities. Europe is a large importer and wood pellets are mainly imported from Canada, US and Eastern Europe. Trade within EU is not displayed in this figure.

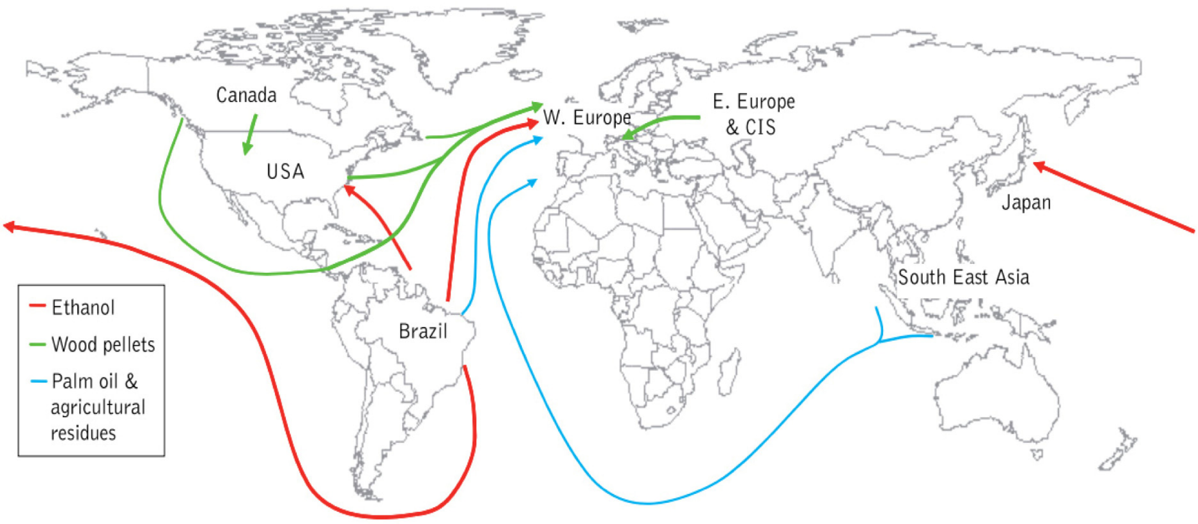


*Figure 1. The map shows the main international trade routes for biomass based fuels used in the energy sector. (IEA Bioenergy 2009)*

The global consumption of wood pellets was about 13,5 million tonnes in 2010. Forecast analysis from Pöyry estimates that the consumption will increase to about 45 million tonnes in

2020. Europe is estimated to continue to be the largest wood pellet consumer, but East Asia is another region that is forecasted to have a large growth in consumption. (IEA Bioenergy 2011) A question that many people ask is which regions that will be able to cover the rapidly growing demand for wood pellets. Because of the rising demand it is crucial to know to what prices different regions can produce and transport wood pellets to the expected markets.

The province of British Columbia in western Canada has been shipping wood pellets to international destinations for 15 years. It is one of the regions that have been addressed as one of the future suppliers of the increased demand of wood pellets.  For this reason it has been chosen as a case in this study. The objectives for the study have been chosen after discussions with knowledgeable people in the wood pellet sector. The study will focus on the environment for wood pellet production in British Columbia and challenges that is facing the wood pellet industry to remain competitive in a global context.

## 1.2 Objective and scope

Objectives

This study has a two-folded objective which aims to:

1. Evaluate the conditions for wood pellet production and export from British Columbia, focusing on existing industry structure, raw material supply and the distribution chain.
2. Examine the competitiveness of British Columbian wood pellets export and identify future challenges.

Scope

The markets that will be studied are the European market, which currently is a large importer of Canadian wood pellets, and the impending South Korean market. The latter market has been assumed to be a large future importer of British Columbian wood pellets by the Wood Pellet Association of Canada.

# 2 Theoretical framework

## 2.1 Comparative advantage

One explanation to international trade can be found in the theory of comparative advantage. The theory explains that a country should produce those goods that it has a comparative advantage in producing. This is goods that other countries value at a higher relative price than the producing country. By producing these goods, and buying goods that other countries sell at a relatively lower cost, a country can maximize its wealth. Even more simplified it can be said that trade can make both importing and exporting countries wealthier simultaneously. This term is also true even though a country cannot produce any good at the cheapest rate. It can still benefit from specialization and the goods that should be produced depend on the relative production cost compared to other goods. (Wessels 2006)

The theory of comparative advantage can also explain how countries with a lack in natural resources can achieve economic development (Grant 2005) Resources that a country can benefit from are financial, physical, legal, human, organizational, informational and relational. (Hunt and Morgan 1995) Several countries in East Asia such as South Korea, Singapore and Taiwan have been able to achieve rapid economic growth with virtually no domestic natural resources. Instead they have been relying on education, technology, and communication and transportation infrastructure. Another way to achieve national strength in certain sectors is the creation of clusters of industries that are closely related. An example of this is computers, computer software and semiconductors in the US. This also creates competition between domestic companies which is likely to be a driving force in innovation and improving the national advantage. Domestic competition is often more direct and personal compared to only competing with foreign companies. (Grant 2005)

For management teams in companies it is crucial to recognize and understand which comparative advantages that the firm can rely on when they are implementing new strategies. By doing this they can yield a marketplace position of competitive advantage which in the end will lead to higher profits and superior financial performance compared to the competitors. The competitive advantage can be achieved in a markets segment or several segments. For a region or economy a good marketplace position is a powerful motivation for an efficient use of the existing resources but also for the creation of new ones to sustain the competitive advantage. This can lead to that a market-based economy can get more efficient and more innovative over time. Figure 2 summarizes the linkages between comparative advantage, competitive advantage and how they affect the success of firms and whole economies. (Hunt and Morgan 1995)


*Figure 2. This flowchart shows how a comparative advantage can lead to a competitive advantage which can affect the success for single firms or whole economies. (Hunt and Morgan 1995)*

## 2.2 Competitive advantage in production markets

Competitive advantage occurs when a firm can earn, or has the potential to earn a higher profit than its competitors. A company can achieve higher profits than competitors by either producing an identical product to a lower cost or supplying a product that is differentiated. These two strategies can be applied to attract customers in an industry wide context. The product that is differentiated has to be valued higher by the customer and the value has to exceed the additional cost of differentiating. (Grant 2005) A third strategy to achieve an advantage can be to serve a particular target very well. The target can be a buyer group, a geographic market and the strategy is known as *focus strategy*. It can combine the cost or differentiating strategy or achieve one of them in its specific targeted market. When applying one of those strategies successfully it creates defenses for potential competitive forces and increases the competitiveness of the company. (Porter 2004) In some industries the cost advantage is the dominate source to create a competitive advantage. As an example, in commodity industries, such as steel and textiles, it is often difficult to create an advantage other than focusing on costs. (Grant 2005)

The globalization has led to more internationally traded commodities. When companies produce to an international market instead of only domestically they have to adjust their strategy to be internationally competitive. Four of the most important factors that differ from only produce to the domestic market to produce to an international are; potential factor cost differences among countries, different circumstances in foreign markets, different roles of governments in foreign markets and the ability to monitor competitors and their goals and resources which may change. (Porter 2004)

The different circumstances on the international market makes it crucial for companies that compete internationally to find different sources to their competitive advantage compared to industries that only operate domestically. Domestic based companies achieve their competitive advantage by matching their internal strengths in company resources and capabilities to successful factors in their specific industry. A company that operates on the international market, on the other hand, is dependent on the conditions of the national environment compared to other nations. (Grant 2005)

Figure 3 below summarizes the factors that affect the competitive advantage for a company that competes internationally and how the advantage can be created. This study will focus on cost advantage as the strategy to achieve higher profits in wood pellet markets. This is justified by the fact that *cost advantage* is the major driver in commodity markets.

Within the national environment five important factors can be identified which affect the company's competitive advantage. The factors are: national resources and capabilities, domestic market conditions, government policies, exchange rates, related and supporting industries. The national resources and capabilities can be further defined as raw materials, national culture, human resources, transportation, communication and legal infrastructure that the country possesses. All these factors are important to take into account when a company decides where to locate their production or manufacturing. The transportability of the product is a crucial factor to be able to locate the production away from markets. A production within the market is favored when the transportation costs are high or when customers prefer local products. Barriers to trade created by governments can also favor local production.

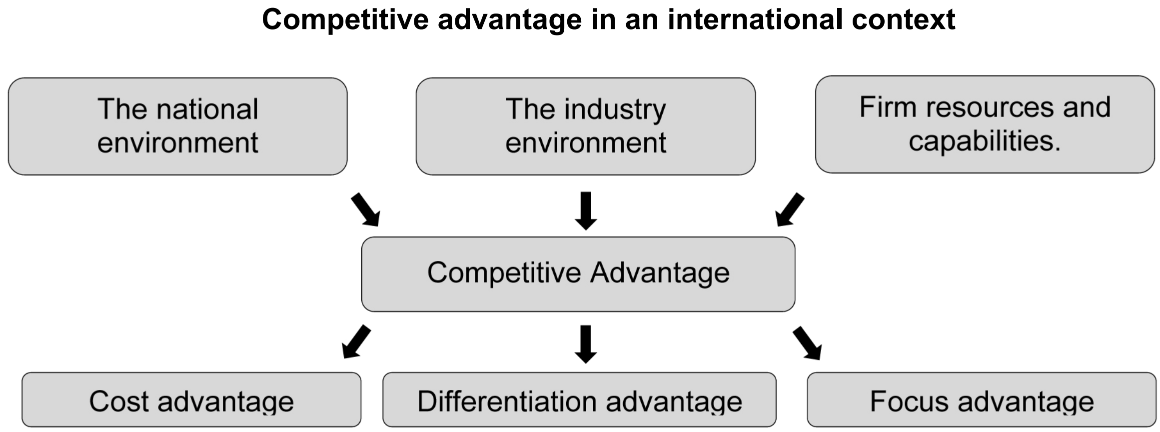


*Figure 3. This figure summarizes the factors that affect a company's competitive advantage if it produces goods to an international market. It also presents in which way companies can achieve competitive advantage, either by focusing on costs, differentiation or focus strategy. (Grant 2005) (Porter 2004)*

If a nation has competitive advantage in a certain industry and wants to remain competitive it is crucial to also create a dynamic advantage. This includes innovation and upgrading of products which will enable a broadening of the competitive advantage. (Grant 2005) Barney (1995) further defines how a single firm can sustain its competitive advantage. To remain competitive a firm constantly has to evaluate if their different resources and capabilities: -add value to their business, -if they are rare among competitors, -if they are difficult to imitate and –if the resource or capability can be fully exploited with the current organization. If a resource or capability fulfills all of these requirements it can have potential to contribute to the competitive advantage of the firm and should be taken into account when the firm evaluates their future strategy. (Barney 1995)

## 2.3 Challenges in emerging markets

This theory section will link to objective number 2 where future challenges are aimed to be identified for the wood pellet export from British Columbia. There are several factors that are likely to constrain growth in emerging industries. Some of them are related to the production and industry while others are related to the market environment. These factors are further described below and summarized in Table 1.

One of the most common challenges in emerging markets is the fact that expansion in production often leads to severe shortages in raw materials or components. (Porter, Competitive Strategy - Techniques for Analyzing Industries and Competitors 2004) This reveals the importance of first-mover advantage, which typically is defined as the ability of pioneering firms to earn positive economic profit. It can be a result of either possessing unique resources, foresights, or just because of luck. The resources that the firms possess can include raw materials but also retailing or manufacturing locations. First-movers can also gain an advantage from a market perspective by selecting the most attractive niches within the market. (Lieberman and Montgomery 1987) An example of gaining first-mover advantages by securing resources was shown in a study by Main (1955) about in the Canadian nickel industry. The first company to secure rights in an area with high concentration of nickel could control the world market for decades. (Main 1955)

Firms operating in emerging markets can also create an advantage by developing other resources which can make it more difficult for additional firms to enter the market. Wernerfeldt (1984) define this as resource position barriers, which can be exemplified by production experience, customer loyalty and technological lead. (Wernerfeldt 1984) Porter also emphasizes the importance of, in an early stage, achieving a unique competitive position within emerging industries. By doing this the risk of imitation eases and the company will have higher chance to earn profits. (Porter 1996)

Emerging industries can also be limited by actions taken by threatened entities. This can include lowering of prices for substitutes or marketing actions taken by the competing industries. (Porter 2004)

Emerging markets are also often characterized by absence of other vital factors for further growth. Such factors may include infrastructure, such as distribution channels, service facilities or trained personnel. The absence of technical standardization is also something that can limit trade and create confusion among customers. Other factors that can be confusing for customers are claims and counterclaims by competing companies that promise things about the products. The lack of standardization is usually a result of technological uncertainty with the emerging products and it can also lead to erratic product quality. (Porter 2004)

New technologies can also be affected by the fact that potential customers predict that the current products soon will be considered obsolete due to the promising forecasts for second and third generation products. This can prevent customers from buying the current product lines since they predict a cost reduction and technology progress. This can sometimes require companies to price their products very low because the customers know that the efficiency of the production will increase.

*Table 1. The list below sums up the different types of challenges discussed above which is likely to occur in emerging markets. The challenges are divided in challenges that can occur on the market and in the industry (Porter 2004)*

| **Industry challenges** |
| --- |
| *- Inability to obtain enough raw materials and rapid escalation of price* |
| *- Response of threatened industries* |
| *- Erratic product quality* |

| **Market challenges** |
| --- |
| *- Absence of Infrastructure* |
| *- Customers' confusion* |
| *- Perceived likelihood of obsolescence* |
| *- Absence of product standardization* |
| *- High Costs* |

# 3 Methodology

## 3.1 General description

The methodology in this study is based on case study research method with several sources of data collection. The data collection has included literature studies, attending seminars and semi-structured interviews. The aim for the data collection has been to achieve a triangulating data collection to be able to validate facts from multiple sources of information.

## 3.2 Case-study research method

There are several methods for carrying out research projects. In social science are *experiments, surveys, archival analyses, histories* and *case studies* the most common methods. In this study the case-study method has been used because it is suitable to use when the researcher tries to achieve a deep, but often narrow, exploration of a particular phenomenon. Case studies have historically been used in different research areas such as psychology, political science and business. They can also be used in economics when a certain industry, economy or region may be investigated. (Yin 2009) The studied phenomenon in this case has been the wood pellet export from British Columbia.

A case study can, just as other research methods, be explanatory, descriptive or exploratory. The chosen type of case study depends on which type of question the researcher tries to answer. A typical categorization for different types of research questions are: “who”, “what”, “where”, “how” and “why”. The objectives in this study have been defined as “what” questions since they tries to answer “*what the production environment looks like*” and “*what the competitiveness situation looks like*”. Yin (2009) proposes that, when those types of questions are asked in case-studies, an exploratory research approach should be preferred. (Yin 2009) One of the major drivers for exploratory studies is to gain a better understanding of the studied phenomena and exploratory studies almost always yield new insights into the studied topic. (Babbie 2007) The studied area (*wood pellet export*) has been found to be in rapid change which made an approach that is used for gaining better understanding and insights most suitable.

Case studies are associated with a specific type of research process. The process can be divided into six phases which include: *planning, designing, preparing, collecting, analyzing* and finally *sharing.* Figure 4 below shows how this procedure can be displayed. The logic solution is to follow this procedure when dealing with case studies. However, it can be necessary to redesign the study when more knowledge is being gained throughout the study.

The initial phase of this study has involved defining which area to study and the objectives. To narrow down which case to study certain variables have been considered. First, the access to potential data, e.g. to interview people, review documents or make observations, shall be evaluated. This process was initiated during the planning phase of the study and resulted in the decision on which objectives the study should have.

**The process of case studies**

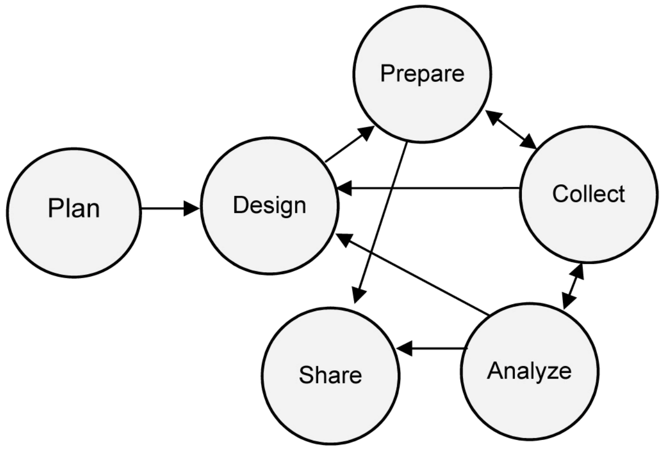


*Figure 4. The working process in case-study research method. (Yin 2009)*

Other important features for a case study are that there will be many more variables of interest than data points and that the result relies on multiple sources of evidence. Therefore, a data collection with triangulating fashion from several types of sources is suitable to be able to understand the studied phenomena. (Yin 2009) This study includes interviews, research publications, seminar proceedings and studies of public data as sources of evidence. The aim with this has been to get a more realistic and complete understanding of the studied area.

Case study research approach is often combined with grounded theory research approach. By doing this the researcher can find new theoretical concepts or models which can explain the findings in the study. This study will not deal with generating new theories and the theoretical framework will therefore only refer to existing theories. By doing this the study is aiming to uncover patterns and linkages to existing theories. This method is also known as *theory-based generalization.* (Daymon and Holloway 2011) The analyzing part in this study is therefore based on existing theoretical propositions and the collected data is linked to these theories in chapter 6.

## 3.3 Data collection

Research and its data collection can be qualitative or quantitative. The characteristics of quantitative research are that it tends to be associated with a pre-determined research design and the instruments used for collecting data are not influenced by the researcher. The research methods associated with quantitative data can be questionnaires and observations and the collected data can take the form of numbers.

In qualitative research, on the other hand, the researcher often has a more influential role in collecting the data. Instead of numbers, the data take the form of words or pictures and the data collection is performed through interviews, written documents or observations. (Denscombe 1998) The data in case studies can include both quantitative, qualitative or a mix between the two as evidence. (Yin 2009)

The chosen methods for collecting data in this study have been primary data in the form of interviews and observations from seminar proceedings as well as secondary data from literature. The data collection has been aiming answer the objective for the study in a complete way and aiming to increase the validity by using data from several sources. The collection is further described in the following sections.

### *3.3.1 Literature study*

The most important objective with including studies of literature in case studies is to be able to verify data from other sources. If contradictions are found between the sources a further inquiry is needed in order to find conclusions. The strengths in using documentation are that it can be reviewed repeatedly, have a broad coverage and contains exact references and details. The weaknesses, on the other hand, are the risk of biased selectivity of publications and risk of bias within the chosen documents. (Yin 2009)

The literature that has been studied in this work has been derived from research publication databases or organizations who have published data related to the topic. Many of these publications are available online which is indicated in the list of references. Information has also been derived from seminar proceedings and PowerPoint-presentation from these sources are available online which also is indicated in the list of references. Moreover, advice for suitable literature has been given by the people that have been interviewed and contacted during the study. The literature that has been recommended by the interviewed actors has both been published data and unpublished data from their own organizations.

### *3.3.2 Interview study*

Interviews can either take the form of structured, semi-structured or open interviews. Structured interviews can be defined as interviews which have predetermined questions and follow a strict order of topics to be discussed. Semi-structured interviews give the interviewee more possibility to interact and present his/her own ideas and thoughts. The interviewer may have a list of questions or list of areas that are aimed to be discussed, but it is important that the interviewed actor is able to talk about aspects that he or she consider important. (Trost 2005) As a result, the interviews can be considered as guided conversations rather than structured queries. (Yin 2009) Open interviews are even less standardized and structured. In this form of interviews, both the interviewee and interviewer can direct the conversation to topics and issues they find suitable. (Trost 2005)

The interviews conducted in this study can be considered as semi-structured interviews and the areas that have been discussed during the interviews are listed in Appendix 1. Semi-structured interviews were chosen to be able to maximize the understanding of the studied areas by welcoming the interviewed actors own ideas and thoughts. Three of the interviews were conducted via phone meetings and the rest face to face. All of them were about one hour in length.

Interviews are usually one of the most important sources of information in case study research. The reasons to this are that interviewees can provide important insights as well as recommend other relevant sources. Risks when using interviews include the possibility of a biased group of people that been interviewed and risk for poor recall. There is also a risk for inaccurate articulation by the interviewee. This is another reason why several sources of information should be preferred in case studies. (Yin 2009) Notes were taken during the interviews to reduce the risk for poor recall of the perspectives given by the interviewees.

The areas of interest that have been discussed during the interviews are listed in Figure 5 below. Most of the interviewed actors have specific knowledge in one or a few of the areas. This made some interviews more focused on the area in which the actor was knowledgeable.

The areas that have been covered in the interviews are; *raw material for wood pellets*, *industry structure, domestic transportation, terminal handling*, *overseas transportation.* The areas have been chosen because they have been assumed to be the most important factors which affect the price for exported wood pellets from British Columbia. Appendix 1 further describes the discussed areas.

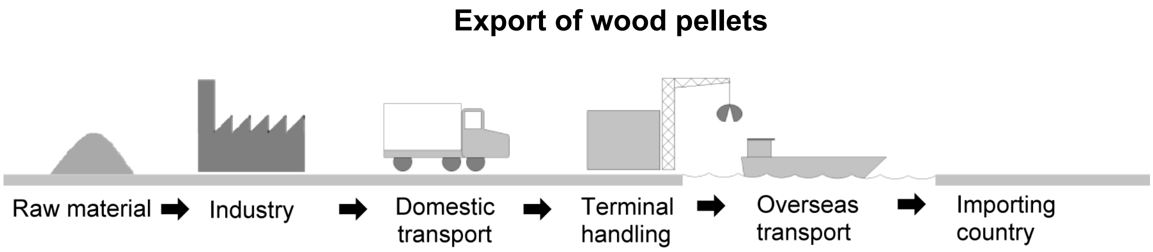


*Figure 5. This figure shows the parts of the process of exporting wood pellets that have been examined in this study.*

### *3.3.3 Sample*

The interviewed people have been chosen because of their knowledge in areas that are related to the objective of this study. The snowball sampling method has been used, to get in contact with suitable interviewed actors. When using this method the sample emerges through a process where one person refers to one or a few persons that can be contacted to enlarge the sample. This method has been found effective for small-scale research projects to get in contact with respondents. (Denscombe 1998) The interviewed actors have represented the research sector (3 respondents), transportation (2 respondents), consulting (2 respondents), wood pellet organization (1 respondent) and in total eight interviews have been conducted. The respondents active in the transportation sector has answered question on both domestic and overseas transportation. The respondents areas of knowledge are listed in the end of the list of references.

## 3.4 Validity and reliability

Validity is a term that refers to the degree to which the collected data reflects the studied phenomena in a good way. The expression covers both the research data collected and the methods used to obtain the data. Considering qualitative interviews it is important that the right questions are asked and the interviewed actors are the most appropriate for the research objective. (Trost 2005) Moreover, data triangulation is very important to be able to construct a study with high validity. It can also be appropriate to have key informants to the study review a draft of the final report to minimize the risk of misunderstandings. (Yin 2009)

The author plays an important role when analyzing the data to achieve validity within a case study. This can be performed by addressing rival and matching explanations in the data analysis. By doing this the reader will get a broader understanding of the studied areas. (Yin 2009)

The meaning of reliability, when discussing research data, is the degree of consistency of the data. A good reliability is achieved if a new data collection would give the same results as the first. (Trost 2005) If a change is discovered, when an exact similar study is performed a second time, it should be caused by the phenomenon being measured and not by the research instrument. (Denscombe 1998) To achieve a high degree of reliability when doing qualitative interviews the interviewer should be observant on everything that the interviewed actor says and expresses to be certain that the interview would get the same result performed later on. (Trost 2005)

# 4 Literature study

*This chapter will first present general facts about wood pellets and the latter part will present findings of the studied region; British Columbia, but also the regions that have been identified as export markets; Europe and South Korea.*

## 4.1 Production of wood pellets

Wood pellets are usually produced from wood industrial by-products such as saw dust, shavings or ground wood chips. These byproducts are compressed under high pressure and high temperature into pellets. (Peksa-Blanchard, et al. 2007) The quality of wood pellets can vary to a quite large extent depending on what type of feedstock that is used in the production. (Peng, et al. 2010)

Pellets can also be produced from roundwood but the reason why waste residues are used is simply because it often is cheaper. When roundwood is used as the primary source the steps in the manufacturing process are: debarking, chipping, drying, and hammer milling. Waste residues do not require such comprehensive process since they usually are bark free, drier and already reduced in size. (Spelter and Toth 2009)

The lignin in the wood material works as a natural binder for the pellets. In some cases additives are added to further improve the strength or improve chemical characteristics. (Spelter and Toth 2009) Figure 6 below show a flow chart for a typical wood pelletizing process. (Karwandy 2007)

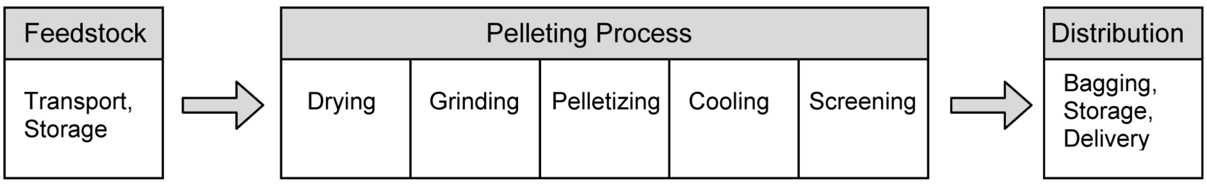


*Figure 6. The flowchart shows a typical pelletizing process. (Karwandy 2007)*

An important property of the raw materials in the production process is its moisture content. If it is too low the pellet surface can get burned, while too high moisture content can reduce the durability of the pellets and lead to breakages and dust creation. (Spelter and Toth 2009) A desirable moisture content of the raw material before being pelletized is 8-10%, but material with as high as 17% can still be pelletized. The moisture requirement is the reason why the sawmill residues have to be dried as the first step in the pelleting process. Some exceptions of the raw materials, such as panel shavings, do not need to be dried before the grinding process. The most common type of drier used in North America is drum driers. They consume a rather large amount of energy and are either fueled by natural gas or waste wood. (IEA Bioenergy 2011)

The purpose with the second step in the process, grinding, is to get a homogenous material before the pelletization. If particles are too big it will decrease the wood pellet quality and grinding are for that reason crucial to get a high quality end product. Raw material is usually filtered before grinding to remove stones and waste. Optimal size of the particles after grinding is smaller than the pellet diameter (6 mm). (Peksa-Blanchard, et al. 2007) The particle size often end up less than 2 mm. (Tumuluru, et al. 2010)

In the pelletizing process two different types of machines can be used. The essential difference between the systems is the design of the metal plate with holes (die) that the material is pressed through. The die can either be horizontally mounted or the material can be pressed through a ring die with rotary presses. The purpose of the die is to provide the right resistance to make heat and pressure optimal for the lignin and resins in the wood to soften and work as binder in the pellets. (Peksa-Blanchard, et al. 2007) Some pelletizing systems also use hot steam for conditioning of the sawdust before extrusion.

The pellets are cooled down after the pelletization process. The reason for this is that the temperature of the pellets after the pelletization is usually between 90 to 95 °C. The cooling process makes the lignin in the pellets to solidify which increase the durability and strength of the pellets. An additional amount of energy input is not needed when the pellets are cooled down.

After the cooling process the pellets are moved over a vibrating screen to remove fine materials that are undesirable in the final product. After this screening, the pellets are ready to be stored before distribution takes place. The way it is distributed depend on the end use of the pellets and it can either be distributed in bulk form or in bags. (Peksa-Blanchard, et al. 2007)

## 4.2 Wood pellet standards

The physical parameters that wood pellet standards regulate are diameter, length, bulk density and particle density. Chemical properties that are evaluated are moisture content, ash content, heating value and concentration of different elements such as nitrogen, sulfur, chloride and other additives.

Several countries have developed wood pellet quality standards to make the trade easier. The quality of wood pellets is decided upon its physical, chemical and mechanical properties. The national standards for pellets have significant differences in their quality parameters and guidelines which can be a barrier to further development of the international wood pellet trade. The European countries with official standards for wood pellets are Sweden, Germany and Austria. Some other countries, such as France and Italy have published recommendations for wood pellet manufacturing. (García-Maraver, Popov and Zamorano 2011)

The European Committee for standardization (CEN) has been assigned by the European Commission to develop standards for solid biofuels, which include wood pellets. The standards has been developed by the Technical Committee (TC) 335 Solid Biofuels. A common wood pellet standard in Europe is likely to decrease barriers for increased trade between the European countries and is also likely to facilitate increased international trade. (García-Maraver, Popov and Zamorano 2011)

The CEN has so far published 30 new standards for solid biofuels and they include descriptions of classification, terminology, test methods and sample-taking. The standards are expected to become international ISO-standards in 2012-2013 through the Vienna agreement. (Swedish Standard Institute 2011) This agreement is an agreement of cooperation between the International Organization of Standardization (ISO) and CEN and is aiming to avoid duplication of work between the organizations. (International Organization for Standardization 2011)

The wood pellets standard published by CEN has been given the name; *EN 14961-2 Wood pellets for non-industrial use* and the corresponding ISO-standard which currently is under development will be called *ISO 17225-2 Graded wood pellets.* The CEN standard will cover the properties presented in Table 2 below.

*Table 2. This table presents the properties that are covered in the CEN wood pellet standard and the right column shows the number of classes that the standard divides them into. Additives are expressed in weight percentage of pressing mass while net calorific value is expressed by MJ/kg or kWh/kg (Alakangas 2010)*

| Properties | Number of classes | Total range |
|---|---|---|
| **Diameter and length** | 5 | D 6-25mm L3,15-50mm |
| **Moisture content** | 2 | ≤10/15% |
| **Ash content** | 10 | <0,5- >10% |
| **Mechanical durability** | 4 | > 97,5 - <95% |
| **Amount of fines** | 5 | < 1- > 5% |
| **Additives** | 1 | w% of pressing mass |
| **Bulk Density** | 5 | >550 - >700 kg/m$^3$ |
| **Net calorific value as received** | 1 | MJ/kg or kWh/kg |
| **Sulphur** | 6 | ≤0,02 – >0,20 % |
| **Nitrogen** | 6 | ≤0,3 - >3,0 % |
| **Chlorine** | 5 | ≤0,02 - >0,10% |

The Pellet Fuel Institute, which is a North American trade organization, developed national standards for US in 1995. The standards were adopted by the industry and they were followed up by updated standards in 2008 which divided wood pellets into four different types of qualities (super premium, premium, standard, utility). (Spelter and Toth 2009) Canada has not developed a national standard for wood pellets. The export of wood pellets from Canada to Europe typically fulfills the CEN standards. (Tumuluru, et al. 2010)

### 4.3 Characteristics and end use of wood pellets

Wood pellets have a cylindrical form with broken ends and a length ranging between 5 and 40 millimeters. (Junginger, et al. 2010) The diameter of wood pellets is typically ranges between 6 and 12 mm. The 8mm pellet common among European producers while 6 mm have become standard in North America. (Tumuluru, et al. 2010)

A study by Wu et. al. (2011), compared the bulk density for different solid biofuels and among the wood pellet samples the 8 mm showed to have highest bulk density, 6 mm second highest while the 12 mm pellets had the lowest bulk density. (Wu, Schott and Lodewijks 2011) The length of wood pellets also affects the bulk density. If the length increases from 6mm to 12 mm the bulk density decrease with 1% and if the length increases to 25 mm the bulk density decreases with 7,2% compared to 6 mm pellets. (Melin, Optimizing Pellets for Ocean Transportation 2006)

The growth in wood pellet consumption has been made possible by several factors. One of them is the varied end use that wood pellets provide. Wood pellets are usually used in different types of combustion which ranges from small scale residential heating to large scale co-firing in coal power plants. The North American market has traditionally been using pellets for residential heating in single family houses while the European market is characterized by a wider end-use. When used as co-firing fuel in large scale coal power plants the amount of wood pellets usually reaches 5-10% of fuel weight. (Peng, et al. 2010)

The advantages of wood pellets compared to wood residues that not have been densified are several. Wood pellets have higher energy density, lower moisture content and is uniformly sized which make the handling and usage more efficient. (Spelter and Toth 2009) The energy density of wood pellets is usually about 17 MJ $kg^{-1}$. The space requirement for 10 MWh wood pellets compared to other fuels are shown in Figure 7 below. (Heinimö and Junginger 2009) (Alakangas 2005) Wood pellets are usually distributed in small bags (15-20kg), large bags (500-1500kg) or in bulk form. (IEA Bioenergy 2011)

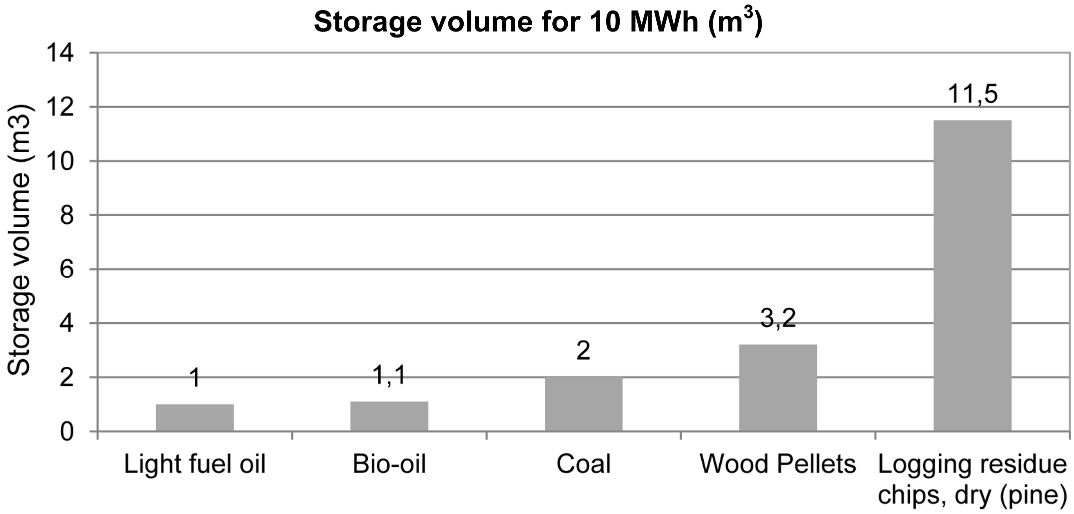


*Figure 7. This graph shows the storage volume for 10 MWh wood pellets compared to the storage volume for light fuel oil, bio oil and logging residue with the same energy content. (Alakangas 2005)*

Using biomass based fuels in heat and power plants can have both positive and negative effects. Some of the positive are that it is considered more climate friendly compared to fossil fuels, which is an important property for large scale power plants that are regulated by emission legislations. It has also been proven that wood pellets can compete with fuel oil considering price per MWh. (Peksa-Blanchard, et al. 2007) Some challenges when using wood pellets and other biomass based fuels are that it can increase the operation and maintenance cost in combustion plants due to slagging or other deposit formations. (Alakangas 2005)

Wood pellets are classified as hazardous material when shipped in bulk form. The explanation to this is that the large volumes can lead to off-gassing and the levels of CO, $CO_2$ and methane can get high. Storage of wood pellets can also lead to temperature build up caused by bacteria and fungi which previously have caused explosions. (Bradley, et al. 2009) Other issues are that ungentle handling of pellets can generate dust and fines which also can lead to dust explosions.

## 4.4 Recent trends in the global wood pellet trade

The first long distance shipment of wood pellets occurred in 1998 from Canada to Sweden. (Sikkema et al. 2009b) The supply of fiber had become more constrained on the European market which meant higher raw material cost for producing wood pellets. This motivated the European firms to look for other sources of wood pellets, such as North America. (Spelter and Toth 2009)

An effect of the fast development of the global wood pellet market has been that the statistics of production, consumption and trade has been lagging behind. Steps have been taken to increase the transparency in the pellet market and since 2009 the European statistic institute, Eurostat, publishes data over the European pellet trade. Eurostat defining wood pellets as;

*"Sawdust and wood waste agglomerated in pellets"* and the product code is 44.01.3020 (IEA Bioenergy 2011) Prior, wood pellets were not registered as a separate product in foreign trade which been the reason for the insufficient statistics. Another reason for the poor statistics is that producers and consumers have been reluctant to share information about their production. (Junginger, et al. 2008)

Another step to increase the transparency in the wood pellet sector was the establishment of IEA Bioenergy Task 40 which work is focusing on trade with bioenergy products. The vision for the Task 40 group is to help develop the international bioenergy commodity trade in a sustainable way. It publishes country reports over the bioenergy development in member countries. (Junginger, et al. 2008) Currently the T40 has 13 member countries, 10 European, Japan, USA and Canada. (IEA Bioenergy Task 40 2012)

Figure 8 below shows the growth in the world wood pellet market from 2004-2010. The growth has been almost 1,5 million tons in average per year during the displayed period. The world production was 13,1 million tonnes in 2009 and rose to 14,3 million tonnes in 2010. This indicate a large increase in demand but according to IEA Bioenergy (2011) the world production capacity rose from 23,2 million tonnes to 28,3 million tonnes during the same years. Which corresponds to a decrease in the world overall utilization rate of production capacity from 56 percent to 50,5 percent.

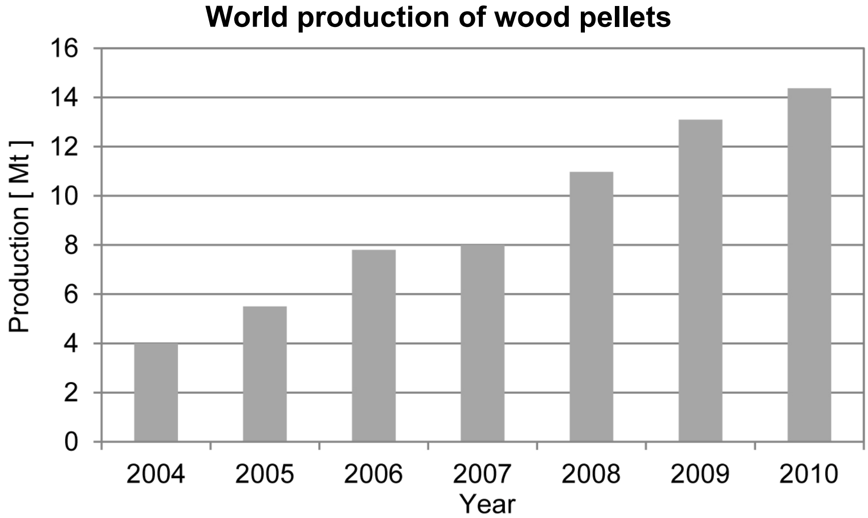


*Figure 8. Total world production of wood pellet 2004-2010. The graph is a compilation from several sources. (IEA Bioenergy 2011) (Heinimö and Junginger 2009) (Pirraglia, Gonzalez and Saloni 2010)*

## 4.5 Forecasts for demand and production

Several projections for future wood pellet demand have been made by consulting firms and pellet organizations. Figure 9 present how some of these projections. A large part of the future growth is expected in Europe. Northern Europe, (Sweden, Denmark, Netherlands, Belgium and UK) currently represents some of the largest consumers and is predicted to have the most rapid growth in wood pellet consumption in the short term.

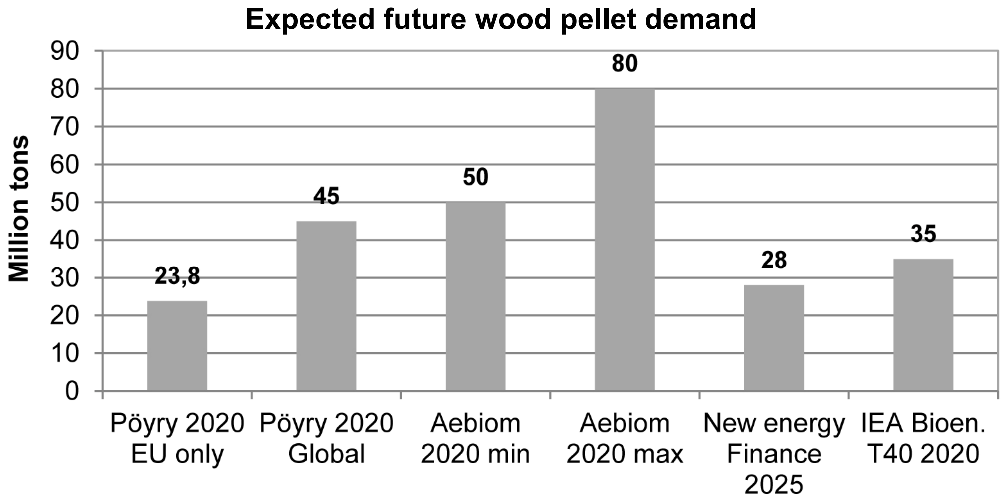


*Figure 9.The chart shows estimations of future demand of wood pellet (IEA Bioenergy 2011)*

Technology development will play an important role in the future wood pellet production. Equipment for torrefied pellets (black pellets) is currently being developed on several places around the globe. (BC Committee on Bio-Economy 2011) Torrefied pellets are basically pellets that have been thermally treated at 200-300 °C without air or oxygen. This process increases the energy density and the hydrophobicity of the pellets is also improved. The end products usually have a bulk density of 750-850kg/$m^3$and the energy density ranges from 20,4 to 22,7 GJ/tonne. Compared to traditional pellets, these properties make the volumetric energy density of torrefied pellets 1,4 to 2,4 times higher which improves the suitability for long distance transport. (Peng, et al. 2010) It is assumed that torrefied pellets will have 40% lower transportation costs compared to regular pellets. (Sikkema, et al., 2010) Torrefied pellets are also likely to have a lower risk for dust explosions. Dust from white pellets needs 17 mJoule to ignite while coal dust needs 110 mJoule to ignite. (Melin 2012)

The theoretical advantages with torrefied pellets compared to non-torrefied pellets (white pellets) can also be explained by lower capital investments for coal power plants that want to start co-fire with biomass. The disadvantages with black pellets are that the technology is quite new and have not been tested on commercial scale. (BC Committee on Bio-Economy 2011)

## 4.6 International bulk distribution of wood pellets

Companies that trade with bulk commodities can ship their goods in different ways. Large companies that are shipping coal and ore usually have their own ships or charter ships on long term contracts. In other sectors, such as the agricultural business, the ships are often hired on charter markets via brokers for single voyages. It is the volatility in some markets that makes it more suitable to use short term contracts. (Bradley, et al. 2009)

Different types of contracts can be used between the buyer and seller in international shipping. The different types of contracts are called "Incoterms", which stands for International commercial terms. There currently exists 11 types of incoterms and they differ in the division of cost and risks between the buyer and seller. The purpose with the terms is to make it easier for importers and exporters to overcome difficulties between countries with different legislations. The incoterms was also divided into two groups, some applicable for all types of transport and some only applicable for sea and inland waterway transport. (Luk 2011) Figure 10 below shows the types of contracts that are defined as suitable for those types of transports.

*FAS – Free Alongside Ship* – When this term is used the seller is obliged to deliver the goods alongside the ship at the port where the loading of the ship is going to take place. The seller is also required to notify the buyer of the shipment and arrange export license and pay potential export taxes or fees. The buyer bears all risk for the freight which requires him to arrange insurance. (Luk 2011)

*FOB – Free On Board* - When the FOB term is used, the seller places the goods on board a ship at the port which is named in the contract. The risk for damage or loss of the goods is transferred from seller to buyer when the goods are passed over the rail of the ship. The buyer is the one liable to arrange and pay for insurance. The obligations that the seller has to fulfill are: deliver the goods to the named vessel in the contract, obtain export license and paid costs, duties and taxes that are related to export. (Luk 2011)

*CFR – Cost and Freight Rate* – In this case the seller has to pay all cost and freight associated with the shipping to the named destination. The buyer gets possession of the risk of loss or damage when the goods are passed over the rail of the ship in the destination port. The seller is obligated to obtain export license and the buyer is obligated to obtain import license. The buyer has to arrange and pay insurance for the freight. The buyer also has to pay unloading costs, when it not is included in the freight charges. (Luk 2011)

*CIF – Cost, Insurance and freight* – this Incoterm is very similar to CFR except that in this case the seller has to arrange insurance against risk and loss or damage of the goods

*Figure 10. The different types of incoterms used in sea and inland waterway transportation. (Luk 2011)*

Ships that transport bulk commodities are often divided into four different types of size categories. Table 3 below shows the names and cargo weight for typical vessels used in bulk shipping. All of the ship types below can pass through the Panama Canal except the capesized vessels. The largest ships are used for shipping crude oil, iron ore and coal while the smaller bulk ships usually are used for shipping grain, sugar and chemicals. (Branch 2007) Overseas shipments of wood pellets are almost exclusively carried out by handymax-sized vessels. (IEA Bioenergy 2011)

*Table 3. The list below show some of the typical sizes of bulk ships ranked by cargo weight (Branch 2007)*

| **Ship type** | **Dry weight cargo** |
|---|---|
| Handysize | 20000-35000 dwt |
| Handymax | 35000-50000 dwt |
| Panamax | 50000-80000 dwt |
| Capesize | 80000-150000 dwt |

Just as on other markets the price for shipping wood pellets overseas is decided by the demand and supply on the market. The Baltic Dry Index (BDI) measures the cost of global shipping of raw materials by sea freight. This cost index is compiled on a daily basis by The Baltic Exchange in London and the index is based on the cost for shipping on 22 different routes around the globe. The Baltic Exchange is connected with shipping companies worldwide which allows them to calculate an average price for shipping. (Råvarumarknaden 2011)

BDI is also used by analysts when looking at the future economic development around the globe. The reason is that the index reveals the demand for shipping raw materials which in the end will be used in all different types of products. For that reason it is a good indicator for the future consumption and GDP development in general. (Råvarumarknaden 2011) The BDI between year 2000 and February 2012 is shown in Figure 11 below.

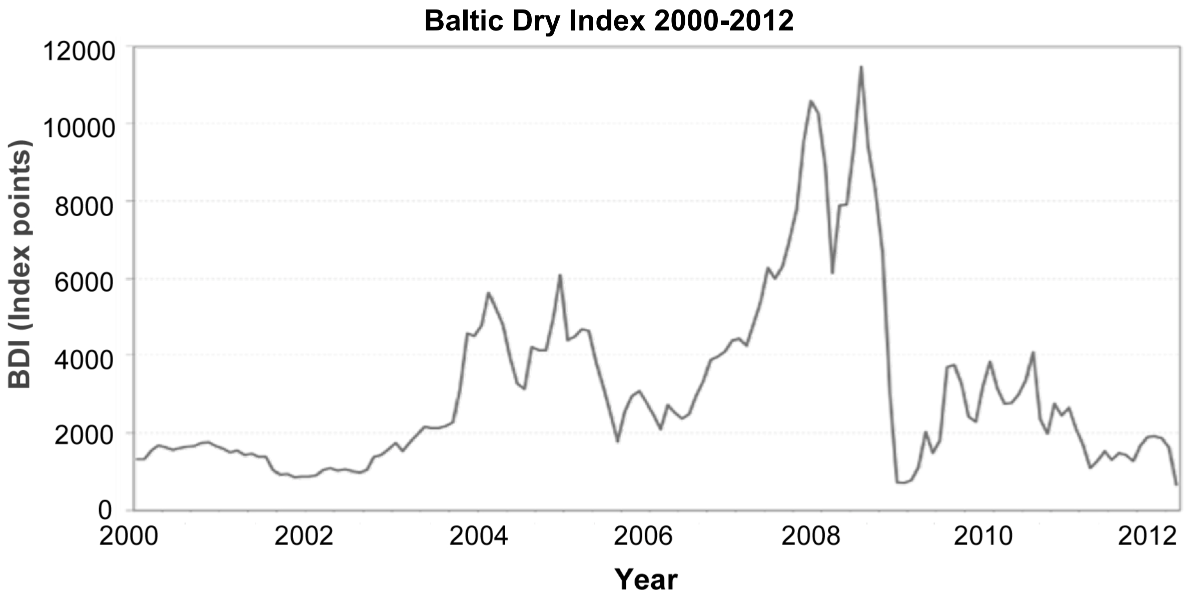


*Figure 11. Baltic Dry Index 2000-2012. The index reached an all-time high in 2007 and 2008 but fell drastically during the last financial crisis. (Bloomberg 2012)*

Shipping is a very competitive business and the prices can change dramatically just over a few months. One reason for this is that it takes years to build ships which make it difficult to increase the amount of shipping when the demand rises. (Bradley, et al. 2009) As an example, the BDI reached its peak in 2008 at 11 793 index points but dropped by 94% until December 2008 at a level at 663 index points. The daily rate to hire a panamax sized vessel was US$ 47 100 per day in April 2008 and US$ 6 357 per day in December 2008. (David and Stewart 2010)

The last financial crisis is likely to delay major investments in port facilities for biomass trade. This gives the regions with already developed port facilities, such as Canada and the US south, a competitive advantage compared to regions that have not yet developed port capacity for handling wood pellets. (Bradley, et al. 2009) Logistics have been identified to be the largest potential barrier to international wood pellets trade while other biofuels such as bioethanol and biodiesel will potentially be affected by the implementation sustainability certification systems. (Junginger, et al. 2011)

Another important factor for shipping prices is whether the port is on a common shipping route or if it has less shipping traffic. As an example, the cost of shipping wood pellets is almost the same from Vancouver to Europe as it is from Halifax, on the east coast of Canada, due to the frequent traffic in Vancouver. (Bradley, et al. 2009) This statement is not confirmed by shipping prices that been presented more recently, which is shown in Figure 12 below. (Melin 2012)

The volatile prices in the shipping market can be exemplified by the price of shipping between Vancouver and Rotterdam in Netherlands. The price per tonne was $35 in 2004 and peaked in

2007, see Figure 11, at a price of almost $100 per tonne. (Bradley, et al. 2009) The large price fluctuations are also confirmed by Sikkema et. al. (2010). The price for shipping wood pellets from North America to Europe is estimated to have been about $25/tonne in 2001 and about $95 in 2007. (Sikkema et al. 2010)

Olsson showed in a study in 2009 the price of shipping wood pellets from different locations around the globe to Europe (Sweden). The price, when shipped with a small panamax sized vessel (50 316 dwt), was estimated to be 36 $/tonne from west coast Canada, 27 $/tonne from Brazil, 33 $/tonne from US south, 29 $/tonne from South Africa and 24 $/tonne from Malyasia. (Olsson 2009) All prices have been converted from SEK to US$ with an exchange rate of 6,75 SEK/$.

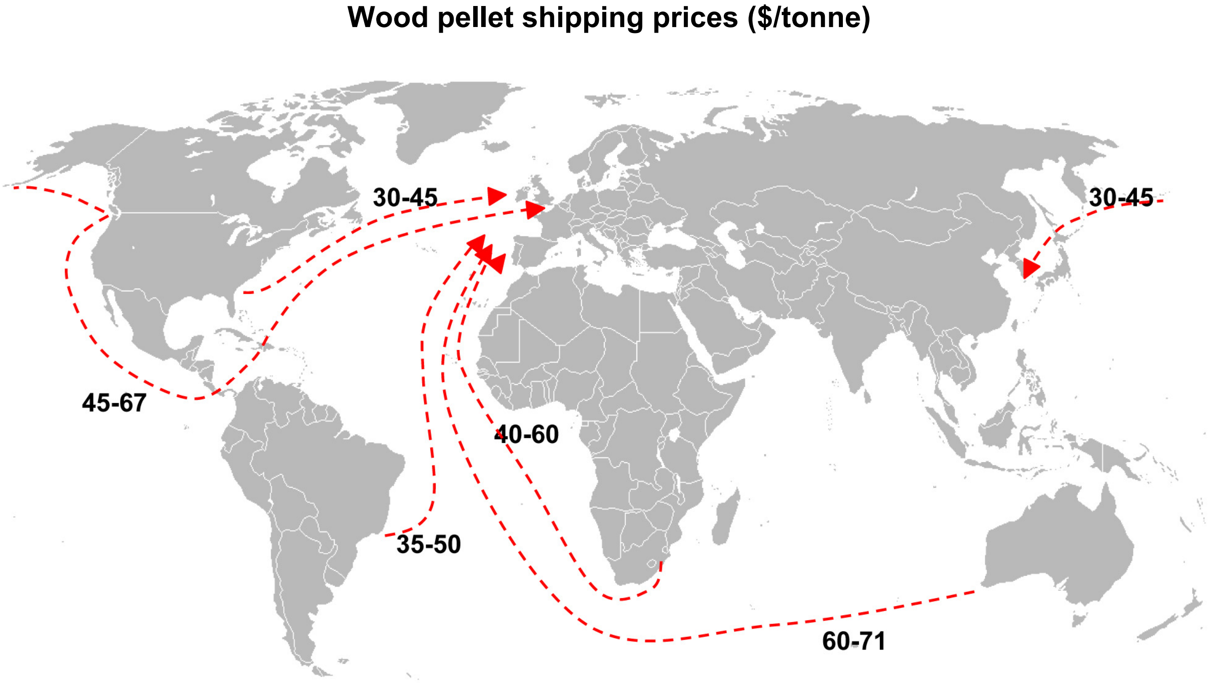


*Figure 12. Wood pellet bulk shipping prices. The shipping rates can be quite volatile and these rates have been calculated with the following key assumptions: speed 14kn, long term daily charter rate: 15000, time for loading and unloading: 5 days, load for dry bulker: 60000m$^3$/42000 tons, Fuel cost HFO/MDO 497/825 USD/ton. (Melin 2012)*

## 4.7 British Columbian wood pellet industry

### *4.7.1 British Columbia energy and climate policy*

The BC Government launched its climate action plan in 2008 were they presented their actions to decrease the impact on the global warming. The legislative targets are defined in the greenhouse gas reduction act and have the following goals:

- Reduce the GHG-emissions with 33% by 2020 compared to 2007 levels.
- Reduce the GHG-emissions with 50% by 2050 compared to 2050 levels.
- The public sector will be carbon neutral by 2010. The goal is to try to keep the public sectors carbon footprint as low as possible. (BC Government 2008)

The BC government also point out that the province has abundant opportunities to develop the biomass based energy sector, where wood pellets can play an important role. At least 10 community energy plants that will convert local biomass to energy will be developed by the provincial government by 2020. (BC Government 2008)

### *4.7.2 Forest sector characteristics*

The total area of British Columbia is 95 million hectares. About 60 million hectares of this is forested area and the land available for harvesting amount to 23 million hectares. The annual harvested area is about 200 000 hectares. (Snetsinger 2010) The harvest levels in British Columbia are regulated by the provincial government that decides an annual allowable cut (AAC).

Just as in many other provinces in Canada the provincial government owns most of the forested land. This share in British Columbia amounts to 95%.The remaining part is owned by the federal government (1%) and private owners (4%). Harvesting on land owned by the provincial government is regulated by forest tenure legislation. This system is the tool to transfer property rights of forest resources on crown land to the private sector for commercialization. There are several types of crown forest tenures and it exist both volume-based tenures and area-based tenures. The volume based tenures gives the tenure holder the right to harvest a certain amount of timber within a timber supply area while the area based tenures gives the tenure holder an exclusive right to crown timber in a designated area. Volume-based tenures are the most common type in British Columbia and they accounted to about 60% of the provincial AAC in 2003. The tenure holders pay a stumpage fee to the provincial government on the harvested volume. In the cases where the tenure is area based, its tenure holder has to pay an annual rent that is charged per hectare. (Watts and Tolland 2005)

British Columbia is known for its very diverse types of forest ecosystems that has been created due to the large variety in climate and topography. The coastal areas are covered with temperate rain forest while the interior is characterized by dryer ecosystems with a different set of tree species. (Watts and Tolland 2005) The forest sector is one of the key drivers in the British Columbian economy. The value of wood products export in 2009 were 3,5 billion CAD and export value of pulp and paper reached the same value. In total the forest products contributed to 28% of the total export from the province. (Snetsinger 2010)

The total harvested volume in British Columbia was in the beginning of the 2000's about 85 million cubic meters. This number is expected to fall due to the large Mountain Pine Beetle infestation that has affected the province since the late 1990's. (Snetsinger 2010) The mountain pine beetle has killed vast amounts of Lodge Pole Pine in the interior of the province. Figure 13 shows the eruption of the infested areas from 1999 to 2009. (Biodivcanada 2011) The beetle killed over 700 million $m^3$ of pine in British Columbia from 1998 to 2010. This volume corresponds to about 50% of the pine forests that are suitable for commercial harvesting in the province. The outbreak peaked in British Columbia in 2005 in terms of annual killed volume. However, the beetle has found its way cross the Rocky Mountains and has started to attack Jack Pine forests in Alberta. (Canadian Forest Service 2012) One of the reasons to why the mountain pine beetle has been able to kill such a vast amount of forest is the recently warmer winters. Because of the lack of cold snaps during winter time the populations of mountain pine beetle has been able survive and to continue to kill forests the following years.(BC Government 2008)

The AAC in British Columbia is expected to fall below 60 million cubic meters during the first half of this century. By 2080 the annual harvest is estimated to increase to a future stable level of 67 million $m^3$. It is only the interior of British Columbia that will be affected by the upcoming decline. The coastal areas, which not have been affected by the mountain pine beetle, is likely to have a stable annual harvest of 18,2 million $m^3$. (Snetsinger 2010)

**Infested area for Mountain Pine Beetle**

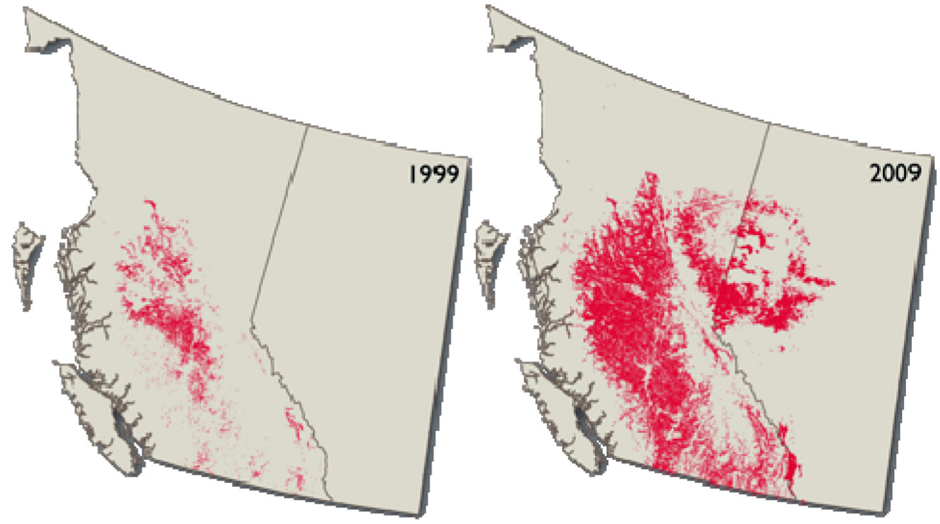


*Figure 13. This map show the areas infested by mountain pine beetle in 1999 and 2009. As seen the coastal areas have not been infested by the beetle. (Biodivcanada 2011)*

### *4.7.3 Wood pellet industry*

Traditionally the pellet producers in Canada have served the bagged wood pellet market in Canada and US, but have increasingly started to rely on overseas export after the advent of the Kyoto agreement. The Canadian pellet industry, especially in British Columbia, has built up a production capacity that today is almost fully based on the increased demand from the EU. (Spelter and Toth 2009) The province of British Columbia has been indicated to have the greatest opportunity for an increased export of the Canadian provinces. This can partly be explained by its close access to ports which enables overseas transport. The central provinces are more dependent on the US demand to be able to export. (Junginger, et al. 2008)

British Columbia, on the west coast, and New Brunswick, Quebec and Nova Scotia on the east coast are the provinces that hold most of the production capacity. (Tarcon 2011) The annual capacity for all pellet mills in Canada was 3,22 million tonnes in 2011. (Bradley and Bradburn 2011) The eastern production units are focused on the markets in US, Netherlands and the domestic market. They are characterized by a rather small size and only a few of the mills ships overseas. Ports on the east coast used for overseas shipments are Halifax and Belledune. (Murray 2011) The average mill in New Brunswick has an annual production capacity of about 40 000 tonnes. (Bradley and Bradburn 2011)

In 2010, the weight of exported wood pellets from Canada was 1,35 million tonnes to Europe, 90000 tonnes to North America and about 60 000 tonnes to Japan. These numbers are estimations from the Canadian Wood Pellet Association. Detailed trade data is difficult to find since Statistics Canada does not track wood pellets as a separate product and producers are sometimes unwilling to share data. (G. Murray 2011) The large export makes Canada one of the major suppliers to the European market and the Canadian producers holds roughly 15% of the European market. (BC Committee on Bio-Economy 2011) The major importers of Canadian wood pellets are Belgium, Netherlands, Denmark, UK and Italy. (Murray 2011)

There are currently 14 wood pellet mills in British Columbia with a total annual capacity of 1,98 million tons. This corresponds to 62% of the total production capacity in Canada. The largest producer in British Columbia owns 6 pellet mills in the province which altogether reaches a production capacity of 1,1 million tons. (Bradley and Bradburn 2011) The sector has seen a rather rapid development. The annual capacity in 1996 was 50 000 tons and it became almost 40 times larger by 2011. (Tumuluru, et al. 2010) The increase in capacity has not yet declined. The capacity growth in British Columbia between 2010 and 2011 were almost 800 K tonnes.

Figure 14 below maps out the production units within British Columbia and the size of the circles demonstrates the production capacity for each mill. The average mill has a production capacity of 140 000 tonnes and the capacity ranges from 30 000 to 350 000 tons annually. (Bradley and Bradburn 2011) As seen in Figure 14, most of the pellet mills are located in the interior. The pellet mills are further described in Appendix 2 with name of the companies, location and production capacity.

The pellet mills in British Columbia are focused on the export market. About 95% of the wood pellets produced in British Columbia are shipped to Europe. (Tumuluru, et al. 2010) One reason to this is that Canada has no tradition of domestic use of wood pellets. The domestic use has during recent years reached about 100 000 tons. With such small domestic consumption the reliance on export will continue to be high both in the short and medium term. (IEA Bioenergy 2011) Between 1980-2009 three district heating plants that used biomass where built in the entire country. However, in recent years the development has taken off and 16 biomass district heating plants started up between 2009 and 2011 in Canada. Further 26 plants were at different stages in the planning process and 16 more were under construction in 2011. (Bradley and Bradburn 2011)

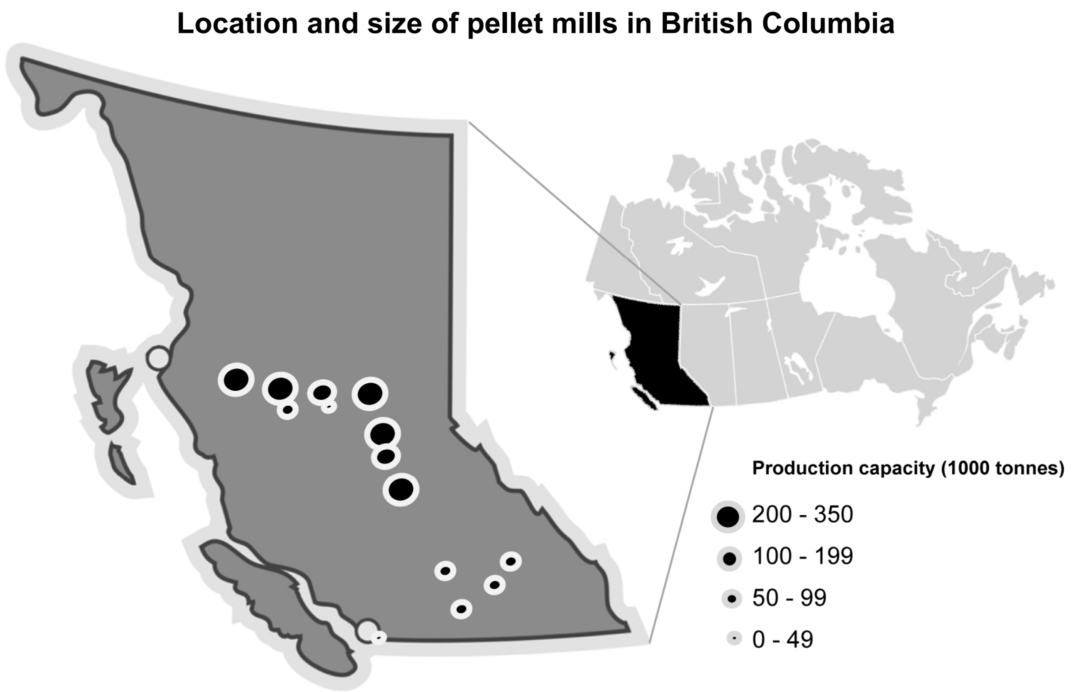


*Figure 14. This figure shows the location of the wood pellet mills in British Columbia and the size of the circles illustrates their annual capacity. (Bradley and Bradburn 2011)*

### *4.7.4 Raw material supply*

The wood pellet production in British Columbia is based on forest industry residues. (Peng, et al. 2010) This has led to that many pellet mills are collocated with saw mills to reduce transportation costs. It also means that the supply of wood residues is dependent on the overall demand on sawnwood. The higher production of sawnwood, the higher is the supply of wood residues, which can be converted to wood pellets. Figure 15 below shows the trend of Canadian sawnwood production between year 1995 and 2010. As seen, the last financial crisis including the housing downturn in US had a large effect on the Canadian sawmills.

The reason why the pellet mills in British Columbia are located in the interior are due to the high concentration of sawmills in the region. The available residues from sawmills in feasible transportation distance from the pellet mill is a factor that often limits the size of the mills. The pellet mills in British Columbia have a rather large size compared to pellet mills in general because of the large supply of sawmill residue. (Spelter and Toth 2009)

The supply of sawmill residues has varied to a quite large extent during the last ten years due to the financial crisis and decreased demand of lumber in US. The production of lumber in British Columbia peaked in 2004 when the production reached 39,2 million $m^3$. The production in entire Canada was 83,5 million $m^3$ the same year which mean that the production in British Columbia corresponded to 47% of national production. The lumber production in British Columbia fell with 30% by 2010 from 2004 years level to 27,5 million to $m^3$. The supply of sawmill residues (saw dust, bark etc.) in the province was 6,98 million ODT in 2010.


*Figure 15. Sawnwood production in Canada from 1995 to 2010. (FAOSTAT 2012)*

The mountain pine beetle infestation has made the timber that is harvested in the interior British Columbia less suitable for high value end products, such as lumber and plywood. (Spelter and Toth 2009) Declines in lumber and plywood production mean less mill residues and less raw material available for the pellet mills.

Because of this relation it is likely that future growth of the pellet industry has to rely on other fiber resources. Two of the future sources in British Columbia could be either round wood or forest residues. However, it has been shown that the cost of accessing the mountain pine beetle round wood to be used only for production of bioproducts is too high. The reason to this is that no high value saw logs can be cut and the harvesting cost is generally too high to only produce bioproducts. The provincial government has tried to facilitate improved access for companies to be able to extract the mountain pine beetle wood but further steps has to be taken to make it economically viable. (BC Committee on Bio-Economy 2011)

Forest residues, which are left in the forests after harvesting, make up another potential source for fiber supply. The current logging practices in British Columbia leave about 5-7 million tons of slash and tops in the forests annually. About 1,5 million tons of this is estimated to be a possible source to the bioenergy sector. A large part of this volume is located below 60 km from a processing facility. As a result, it is likely that new technologies and new product applications will play an important role in the future to be able to access these unexploited volumes at a viable cost. (BC Committee on Bio-Economy 2011)

Figure 16 below shows the demand and supply balance for fine wood residues in North America (US and Canada). The demand curve is an aggregation of the demand from four major consumers of fine wood residues (pellets, particleboard, medium density fiberboard and pulp). The large surplus of the supply is not a perfect reflection of reality since many mills use the residues themselves in heat and co-generation processes. Nevertheless, it shows that the supply of residues has dropped with over 40% in the region which is a reason to why pellet producers have started to evaluate other fiber resources. The demand for wood pellets is characterized by a rather stable demand because of its use in the heat and power sector. The residue-producing industries, on the other hand, are characterized by a cyclical demand that follows the economic situation. (Spelter and Toth 2009)


*Figure 16. Demand of fine woody residue from four major consumers in North America (US and Canada). The demand is measured in million metric tonnes. (Spelter and Toth 2009)The graph only show data until 2009 but the downward trend probably turned around in 2010 when the Canadian lumber production rose with 20% from 2009 years level. (IEA Bioenergy 2011)*

### *4.7.5 Logistics*

The BC Committee on Bioeconomy has addressed the logistics to be one of the limiting factors for further growth of the wood pellet sector in British Columbia, especially the northern part of the province. The factors that have been found to be most crucial are limitations in rail service and port capacity. These two factors are estimated to have a large impact on the growth of the wood pellet sector in British Columbia until 2015. (BC Committee on Bio-Economy 2011) Also Junginger et.al. 2008 pointed out that logistics is the most obvious current barrier for wood pellet export. Appendix 2 shows the railroads in British Columbia. It displays that the ports in British Columbia with rail road access are Vancouver and Prince Rupert.

The current export of wood pellets from British Columbia goes to the European market. The shipping distance from Vancouver in British Columbia to Rotterdam in Netherlands is 16357 km. The distance from Vancouver to Kwangyang in South Korea is 8628 km. This relation is presented in Figure 17 below. The distance to the European market means that producers on the east coast in North America have a logistic advantage compared to British Columbia. (BC Committee on Bio-Economy 2011). As comparison, the distance between Halifax, on the Canadian east coast, and Rotterdam is 5141 km. (Portworld 2012)

**Distances from British Columbia to potential markets**


*Figure 17. This map shows the distances from the port in Vancouver to the port of Kwangyang in South Korea and Rotterdam in the Netherlands. The figure is based on calculations from the following source: (Portworld 2012).*

### *4.7.6 Costs of wood pellet production and distribution*

There are many factors which affect the costs of producing wood pellets. Several studies confirm that the wood fibres from forest residues are generally cheaper than from standing stems in British Columbia. Forest residues can be delivered to a mill at the cost of $80-90/ODT when the transport distance is less than 75 km. With a maximum transportation distance of 150 km the price increase to $120-130/ODT. The cost of standing stems with the same transportation distance is $100-120/ODT and $140-160/ODT. (Sauder 2012)

The large differences in price for different feedstocks are also confirmed by Verkerk (2008). His study examined the cost and supply of different feedstocks suitable for bioenergy production. The cheapest feedstock, saw mill residues, started at a price of $17/ODT delivered at the pellet plant, whereas roadside residues from harvesting had a price of $43/ODT and roundwood from mountain pine beetle killed trees started at $99/ODT. (Verkerk 2008)

Peng et. al. (2010) examined the price of producing wood pellets in British Columbia with different types of raw materials as feedstock and at different plant sizes. The different sources of raw materials that were examined were mill wood residues, wood bark piles, wood harvest residues and wood chips from mountain pine beetle infested wood chips. The costs per tonne for the different feedstocks was estimated to range from $0-2 for wood bark piles, $13 for mill wood residues, $25-46 for wood harvest residues and $65 for mountain pine beetle infested wood chips. All prices are estimated at mill gate and are based on 2008 years levels. Peng et al (2010) estimates that, despite the current price differences, wood harvest residues and mountain pine beetle infested wood will increasingly support the rising demand for raw materials for wood pellet production in British Columbia. The potentials to produce pellets in British Columbia from wood bark are large but the combustion properties of brown pellets (bark pellets) are less favorable compared to white pellets. (Junginger, et al. 2008)

With the most common type of feedstock that is used in wood pellet production in British Columbia today, mill wood residues, the total production cost reaches a production cost of 64,7 $/tonne, assuming a 10% return on investment (ROI) and a plant size of 180 000 tonnes annually. Figure 18 below show the cost of production related to the cost of distribution of British Columbian wood pellets to the European market with these assumptions. The calculations assume that the production take place in Prince George, in the interior, which also is one of the centers for wood related industry. (Peng, et al. 2010) The total cost of delivering British Columbian wood pellets to a customer in Europe is estimated to be about $160 (120 € with 0,75 $/€ exchange rate). The cost without adding the transfer, handling and delivery to the end customer from the port in Rotterdam reaches $147 or 110 Euro. The sea freight in this calculation reaches $48/tonne.

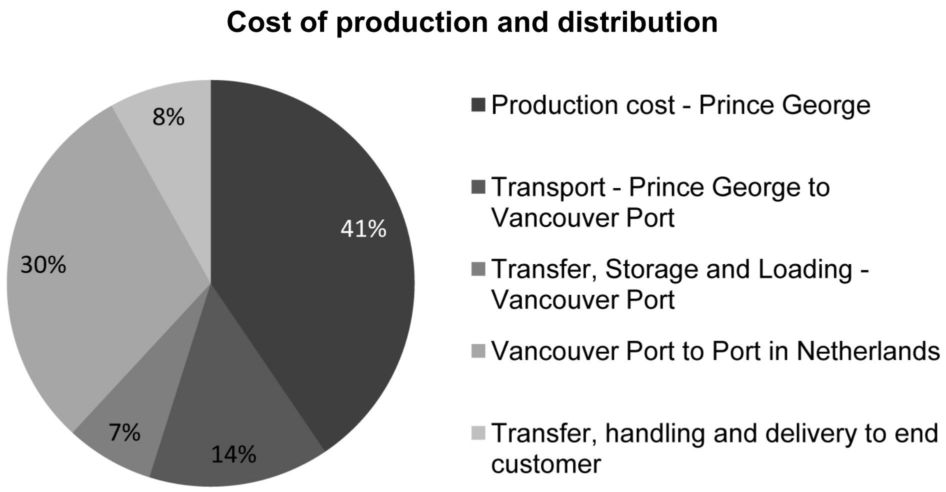


*Figure 18. This chart presents the costs of production in Prince George in British Columbia and distributed to the European market in the Netherlands. The cost is estimated by assuming that the raw materials, mill residues, have a price of 13 $/BDt. The cost of raw materials is included in the production cost and is estimated to have a ROI of 10%. The total cost for production and distribution in this example is $160/tonne. (Peng, et al. 2010)*

If the price of mill wood residues increases to 20 $/tonne the production cost reaches 74 $/tonne. In comparison, wood harvest residues would have a production cost of 80,7-108,6 $/tonne assuming that the feedstock price ranges from 25-46 $/tonne.

The largest wood pellet export ports in North America are located in Vancouver in British Columbia, Mobile in Alabama and Panama City in Florida. The FOB price in July 2009 for wood pellets from these ports was $78/tonne from Vancouver and $85/tonne from the US ports. The prices rose to $112/tonne by November 2010 in both areas which can be explained by the increased competition of feedstock. Figure 19 below presents the development of the price of wood pellets from the major North American harbors' from July 2009-January 2011. (Sikkema, Steiner, et al., The European wood pellet markets: current status and prospects for 2020 2010)

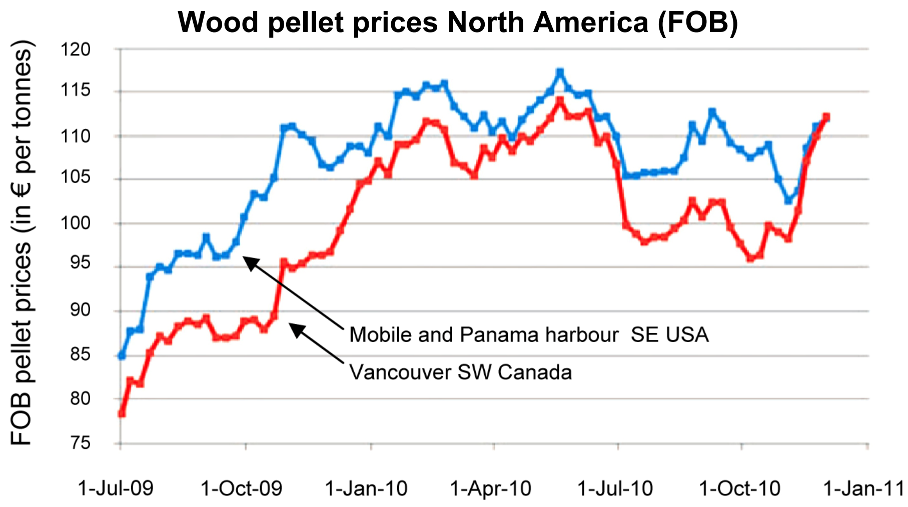


*Figure 19. FOB pellet prices in the Vancouver harbor and Mobile and Panama harbor in South East US. (Sikkema 2010)*

## 4.8 European pellet market

### *4.8.1 Market characteristics*

As mentioned in the introduction, the EU has decided to increase the share of renewable energy and decrease the GHG-emissions. Wood pellets can serve both these objectives when replacing fossil fuels. Before 2009, the trade data for wood pellets was not published as a separate product within the European Union. This changed in 2009 and when wood pellets got an own product code (44.01.3020) and Eurostat started to publish data. (Sikkema, et al. 2010) Figure 20, 21 and 22 below show the consumption, production, import in EU as well as the exporting countries to the EU. (AEBIOM 2011) The consumption for UK reaches 176 000 tonnes in the statistical data but was according to the same source 760 000 tonnes in 2009. Figure 21 below also reveals that the consumption for UK might be underestimated.

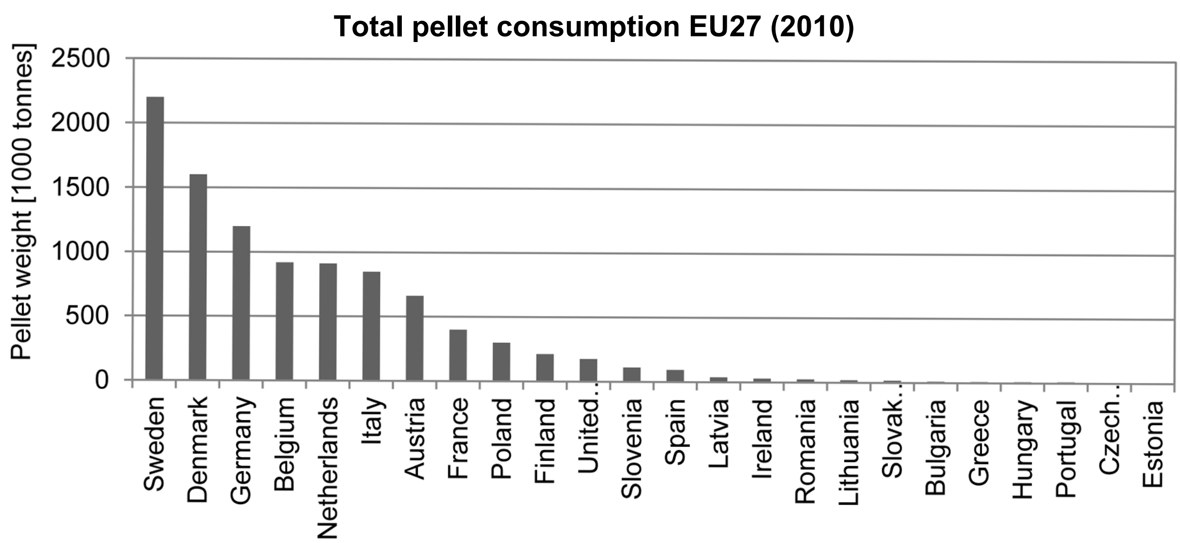


*Figure 20. Consumption of wood pellet in the EU in 2010. (AEBIOM 2011) Note that the numbers for UK differ from Figure 21 and might be underestimated.*

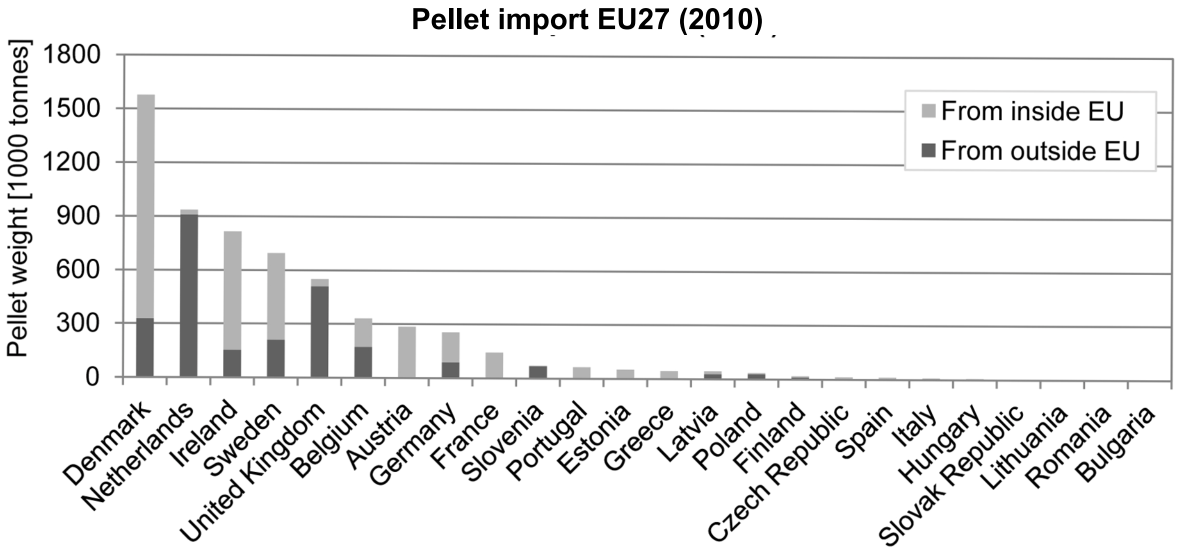


*Figure 21. Import of wood pellet to the EU in 2010. The total import for each country are divided on import from inside versus outside EU. (AEBIOM 2011)*

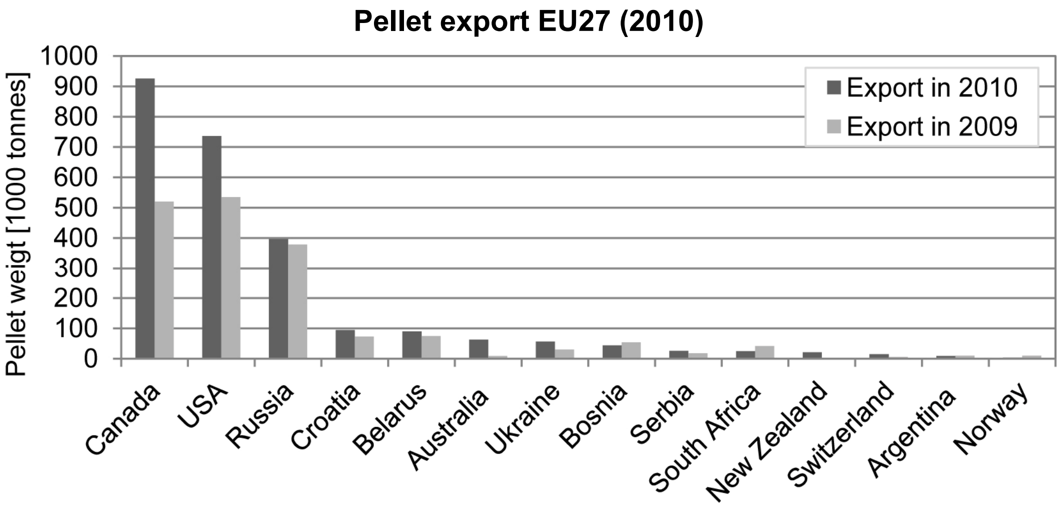


*Figure 22. Pellet exported to the EU countries in 2009 and 2010 divided on exporting country. Canada, USA and Russia unquestionably the largest exporters. (AEBIOM 2011)*

As seen in Figure 20 and 21 above the consumption and trade patterns for wood pellets differ a lot between the countries within EU. Some countries are almost self-sufficient while some countries are dependent on import. The total import in countries within EU reached 3,8 million tons in 2010 and 47% of this derived from countries outside of EU. The import is dominated by three forest rich countries; Canada, US and Russia. The wood pellet trade between US and Europe started in 2008 and has seen a large growth during recent years. (Sikkema, Steiner, et al., The European wood pellet markets: current status and prospects for 2020 2010)

The European Union has a joint goal to increase the share of bioenergy until 2020 to 20%. The countries within the union have very different history in using biomass fuels and the existing technology suitable for pellet consumption differs between the countries. As an example the percentage of the gross electricity generation produced by CHP plants ranges from 46% in

Denmark to below 5% in France, Greece and Cyprus. CHP plants account for almost 63% of the heat and power produced from solid biomass within the EU27. (AEBIOM 2011)

Figure 23 below show how the countries within EU differ in end use of wood pellets. The countries that can be classified as large-scale industrial pellet markets are the Netherlands, Belgium, the UK and Poland. The pellets in those countries are to large extent used as co-firing in coal power plants. (Sikkema, Steiner, et al., The European wood pellet markets: current status and prospects for 2020 2010) The co-firing in those countries started about 10 years ago and the consumption has grown quickly.

In the Scandinavian countries (Sweden, Denmark and Norway) there also exist bulk consumers in the form of CHP or district heating plants. It also exist a bulk market for households in the Scandinavian countries.

The European countries are dependent on biomass import. Junginger et.al. 2008 showed that the import of biomass in the Netherlands, Sweden, UK, Belgium and Finland ranged between 12% and 43%.

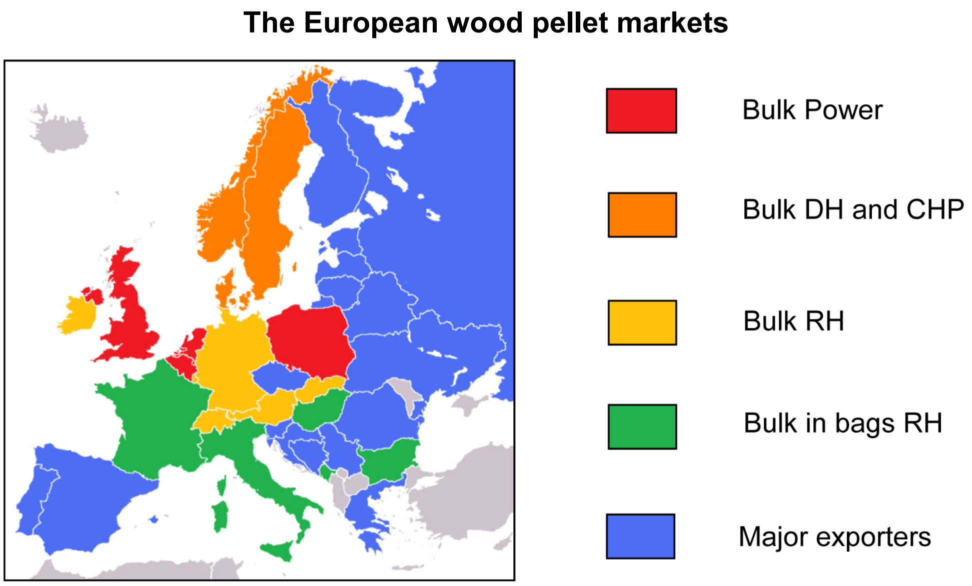


*Figure 23. The map is an overview of the European wood pellet markets and the main market type for each country. The map is based on data from 2009.The abbreviations have the following meanings: DH-District heating, CHP- Combined power and heating plant, RH- Residential Heating. (Sikkema, Steiner, et al., The European wood pellet markets: current status and prospects for 2020 2010)*

*Prices*

Figure 24 below show the development for wood pellet prices for two big pellet markets within EU, the Netherlands (ARA: Amsterdam-Rotterdam-Antwerp) and Denmark. The shown price statistics cover the development from January 2008 to December 2010. (Pelletatlas 2012) It has been pointed out that the CIF spot prices on the European market not necessary reflects the market price since contracts are more frequently negotiated on longer terms, up to three years.

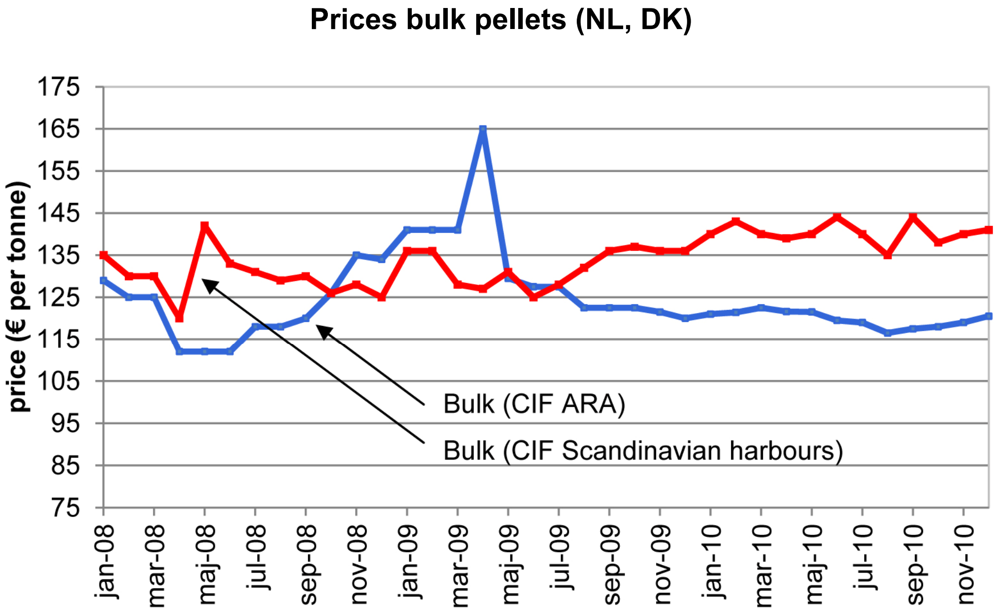


*Figure 24. Graph for CIF prices of wood pellets in the Netherlands and Denmark. (Pelletatlas 2012)*

The international shipping prices to the European market have been presented in section 4.6. Those prices can be compared to the short distance shipping within Europe. In 2009 the price of shipping wood pellets was about €20 per tonne from Riga to Denmark. The price from St Petersburg to the same destination was about €25per tonne. The FOB prices from the same ports were €105-115 in 2009. (Sikkema, Steiner, et al., The European wood pellet markets: current status and prospects for 2020 2010)

## 4.9 South Korean wood pellets market

### *4.9.1 Market characteristics*

The current production of wood pellet in South Korea is very small. There is currently only one large-scale wood pellet plant in the country which produces about 18000 tons that is aimed for the bagged pellet market. In total, there is about 22 pellet plants in the country but with low capacity and in most cases attached to woodworking operations. (IEA Bioenergy 2011)

The International Energy Agency presented in 2011 that the import of wood pellets to South Korea reached 20000 tonnes in 2010. IEA also presented estimated import prices from different countries. The import prices from countries in the Asian region (Vietnam, Malaysia, China, Indonesia) ranged from 91 to 116 €/tonne while the import price from Canada was estimated to be 184 €/tonne. (IEA Bioenergy 2011)

The South Korean pellet market has been identified by the Canadian Wood Pellet Association as one of the future markets for Canadian wood pellets, especially wood pellets from British Columbia. (Tarcon 2011) A major reason to this is that South Korea has adopted a renewable fuel portfolio standard (RPS) that will affect the large power producers within the country.

### *4.9.2 Renewable Portfolio Standard*

The standard for renewable will start to affect the power producers in 2012 and the reason to its creation is basically because the South Korean government is dissatisfied with the past achievements of its GHG reductions and renewable energy share. The creation of the renewable energy portfolio are aiming make the country achieve its national targets in the Kyoto Protocol.

The RPS was first proposed in 2003 and it was adopted in 2008. It obligates the power producers in South Korea to supply a certain amount of renewable energy to the market, starting 2012 with 2%. The percentage of the producers' share of renewable energy will progressively increase until 2020. The increase will be 0,5% per year until 2016 and after that it will increase by 1% annually until 2022.

If a company produces 1000 GWh it means that the renewable energy share has to be 20 GWh in 2012. It is only companies with production over 500 MW which is obliged to adapt to the RPS. It will affect 6 companies and their aggregate production contributes to 95% of the total electricity production in South Korea. (Ministry of Knowledge and Economy 2012)

The RPS will affect 13 electricity supplying companies in Korea and the eligible energy sources that can be produced to cover the renewable percentage target are: photovoltaic (solar), wind, hydro, tidal, biogas, landfill gas, biomass, fuel cell, integrated gasification combined cycle (IGCC), waste and refuse derived fuel (RDF). The South Korean Government has introduced a market mechanism that gives each renewable energy source different weight. The weight depends on the economics of investing in the specific energy type, The environmental impact, future potentials, industrial effect and suitability for the targets that the government wants to achieve. The multipliers are shown in Table 4 below.

*Table 4. The table below presents the multipliers that are affecting the Renewable Portfolio Standard in South Korea (Ministry of Knowledge and Economy 2012)*

| Energy type | Multiplier |
|---|---|
| **Solar Energy**<br>(multiplier depends on used land type, capacity and installation type) | 0,7-1,5 |
| **IGCC** | 0,25 |
| **Waste, LFG** | 0,5 |
| **Hydro, Wind (on-shore), Bio-gas, Bio-mass, Tidal I (construction under having its tide embankment)** | 1,0 |
| **Off-shore Wind** (connecting point length under 5km), **wood biomass full firing** | 1,5 |
| **Off-shore Wind** (connecting point length over 5km), **Tidal II** (newly construction its tide embankment), **fuel-cell** | 2,0 |

To clarify the multipliers an arithmetic example is following; If a company producers 1000 GWh it will have to produce 20 GWh renewable energy during 2012. The company can decide if it wants to produce 10 GWh off-shore wind energy (10*2=20), 40 GWh (40*0,5=20), from waste or 20 GWh from biomass(20*1=20). When woody biomass is used it can be given different multipliers depending on if it is used in a full firing or co-firing facility. Full firing with woody biomass has a multiplier of 1,5 while co-firing is only given 1.

The South Korean government has proposed how large each renewable energy type will contribute to the total renewable electricity production in 2022. The largest part will be covered by Offshore wind (38,8%), tidal energy (20%) and fuel cell (12,1%). Biomass is estimated to be the 7th largest source and contribute to 2,1% of the total renewable power production.

The coal consumption for the large electric producers in South Korea is currently about 80 million tons and the expected rate of co-firing until 2022 is 3 to 10%. If 3% of the current coal consumption is substituted to wood pellets the demand would reach 3,2 million tons and if co-firing reaches 10% it would correspond to a demand for 10,7 million tons of wood pellets. (Kyung Anh 2012)

The large power producers have several projects that soon will start to consume biomass in their power production. Three of those companies has announced that four of the projects will need about 1 030 000 tons of biomass annually, such as pellets or wood chips. The current use of wood chips in CHP facilities are 600 000 tons/year. It is not only wood chips and wood pellets that are being evaluated as a future source of biomass for South Korea. Other sources could be palm kernel shells (PKS) or empty fruit bunch pellet (EFB), both produced in Indonesia and Malaysia. Another source could be bio coal or torrefied pellets. The power producers have the objective to use the cheapest legal source for the bioenergy production. Currently are PKS and EFB not allowed to be counted as biofuel but this legislation can be revised in July 2012. (Kyung Anh 2012)

# 5 Interview study

*The findings from the interviews will be presented in this chapter, divided on the following sections: raw material, domestic transportation, terminal handling and overseas transportation. The different sections represent the parts presented in Figure 25 below.*

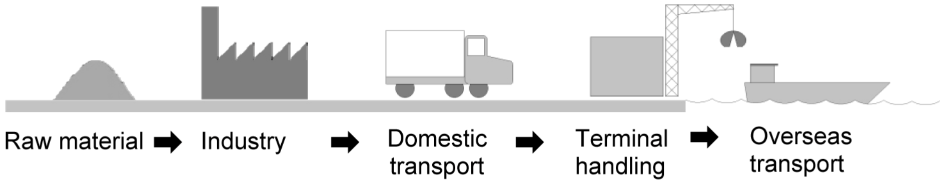


*Figure 25. The areas covered in the interviews which will be further described below.*

## 5.1 Raw material

The wood pellet mills in British Columbia use different sources of raw material. Some of the mills produce high quality wood pellets with very low ash content, 0,2 to 0,3%. These pellets are made of saw dust and panel shavings. Other companies have up to 60-70% of harvest residues in their pellets which make the chemical features different, with higher ash content.

The potential to increase the extraction of fiber for wood pellet use in British Columbia is huge but it still exist challenges to extract the fiber sources in a cost efficient way. In a typical harvesting in British Columbia as much as 30 to 50% of the fibers are left in the forest in the form of residues and non-merchantable stems.

The wood pellets producers in British Columbia have historically been relying on residues from sawmills but have since the housing downturn in US been progressively more dependent on forest residues. It is not only the cost that is a crucial future question for raw material for wood pellets, also the quality of the material and that it can be delivered regularly is other important factors. High quality material for wood pellet production is characterized by dirt free wood fiber material with low moisture content.

Mountain pine beetle wood is not valued as high as green timber because the lower suitability for sawn wood production. This makes saw milling activity less profitable which decreases the likelihood of increased supply of high quality sawmill residues for wood pellet production.

The interviewed actors have shown different opinions to what extent beetle killed stands will be cut only for pellet production. It has been pointed out that it would not make any economic sense to do that and the provincial government has already tried to lower the stumpage fees to support an increased harvest. One respondent pointed out that ”*there is no way you can be profitable by making wood pellets from mountain pine beetle killed trees, and it is very unlikely that the BC-government will subsidize this activity since the wood pellets are used in Europe”*.

Simultaneously, it has been pointed out that the skepticism towards beetle killed trees in pellet production is exaggerated and some companies are already using round wood for pellet production. An increased demand for wood pellets and raised prices make it even more viable to use round wood. Ten years ago, the pellet producers only used sawdust as raw material input in the pellet production whereas one respondent estimated the current proportion to be

70% mill residues and 30% roundwood. It was also pointed out that in other regions, such as the US south, the use of round wood in pellet production is the major source of fiber.

One of the few positive effects with mountain pine beetle wood is that it has higher energy content than wood from healthy trees. The reason to this is that the trees have been stressed and have produced more resins. Another positive effect is that the moisture content in beetle wood is lower which can shorten the drying process in pellet production due to lower moisture content.

The pellet industry is expected to be even more dependent on non-sawmill residues during the upcoming 10 years because the mountain pine beetle infestation will limit future harvest levels. The levels are likely to decrease the most in the central interior where the beetle infestation has done most damage. Meanwhile, the harvesting levels can increase in other parts which can create opportunities for pellet production in other areas.

Figure 26 below shows a harvesting site in interior British Columbia which gives an idea about the type of fiber sources that is left and burnt in the forest. This type of material has been addressed as one of the future potential sources for an increased pellet production.

*Figure 26. This photo shows a harvesting site in interior British Columbia. The right part of the photo shows timber that is going to be utilized while the pile in the left part of the picture is going to be burnt on site. (Photo taken by the author 2011-08-11)*

The pulp mills are, as well as pellet mills, dependent on residues from saw mills. This makes wood pellets mills affected by the competition by pulp mills. The pulp mills have generally a higher paying capacity than wood pellets producers.

### 5.2 Industry

The wood pellet mills in British Columbia have in an international context a very large average production capacity. A major reason for this is that they are focused on the export market while pellet production on many other places is dimensioned for local consumption. The size of pellet mills is generally limited by the amount of raw material in acceptable transportation distance. It has been possible to develop large pellet mills in central British Columbia due to the high concentration of wood processing industries in the area.

South Korean representatives have, according to the interviewed actors, been interested in the wood pellet industry in British Columbia for several years. However, no transactions have been completed so far which could be explained by the fact that the RPS targets were introduced in 2012 and has not yet affected the biomass import. The lack of terminals with suitable equipment for bulk wood pellet handling is another explanation. For this reason it is expected that the export can see a growth if torrefied wood pellets become commercial which theoretically have easier handling and better transport efficiency. There are currently no standards developed for torrefied pellets which could delay the initialization of large scale production. The willingness among pellet producers to shift to torrefied pellets has been estimated to be good but the producers need to be guaranteed long term contracts,

The general opinion among the respondents is that the wood pellet industry will see a moderate growth in British Columbia in the near future. Several of the respondents pointed out that the east coast of Canada is likely to have larger growth in the near future.

### 5.3 Domestic transportation

The exporting wood pellet producers in British Columbia ship their pellets by rail to the port of Vancouver. The major part of the volume transported by rail in British Columbia is shipped in bulk carriers and only 1% is shipped in bags.

The rail cars used are covered hoppers that take approximately 100 tonnes per car. There is currently only one company, CN, that is shipping wood pellets by rail in British Columbia and many of the interviewed actors see this as a limitation for the manufacturers. The only other option for the pellet producers is to truck the pellets to the port and as previously shown in Figure 12 the pellet mills are located in the interior which make the trucking distance to port very long. Another limiting factor is that there is a lack of truck drivers in the region and companies in the truck driving business have difficulties to hire workers. Truck driving jobs are basically not appealing to the younger generation.

Another issue with train transportation in British Columbia is that the rail roads around Vancouver have a very high utilization rate which creates traffic congestion and makes it difficult for train companies to stick to time schedules. It costs about 40 CAD per day to park a rail car when waiting for rail access which can affect the profitability.

The price of shipping by rail depends on how frequently they are shipping pellets and how effective they are with loading and unloading. The contract with the rail company is usually one year in length. The price increase is expected to be 2-6% in the short term, estimated by one of the respondents with insight in rail transportation.

### 5.4 Terminal handling

There is currently only one bulk terminal in Vancouver that is used in the wood pellet export. The terminal, Fibreco Export Inc, is located in the Burrard Inlet in Vancouver. One other bulk terminal in Burrard Inlet has previously been shipping wood pellets but have no current handling. Another bulk terminal in south Vancouver is planning to build capacity for wood pellets. A wood pellet terminal is also under planning stage in Prince Rupert but has faced some local opposition which has extended the planning process.

The bulk pellet shipments from Vancouver usually have a weight of 40000 tonnes and the loading speed is about 900 tonnes per hour which result in a total loading time of a ship of about four days. When filling a bulk carrier with wood pellets the weather can sometimes play an important role. It is important that it is not raining too heavily. In those cases the cargo has to be covered and loading can only continue when it stops raining or the buyer has to be willing to take risk of getting a damaged cargo.

The terminal handling has also been mentioned as one of the current bottle necks in British Columbia by the interviewed actors. In the typical case the wood pellets will be stored in the silos for 3 to 5 days but if problems occur it can change the schedule. This was revealed in the fall of 2011 when it took about 3 weeks to load one ship because of problems with the loading equipment.

Self-heating, off-gassing and dust explosions are factors that have to be taken into account when handling wood pellets. The properties for wood pellets have been researched while the consequences of handling large amounts of torrefied pellets are still unknown. As a result, more research has to take place before torrefied pellets can be started to be produced and shipped in large volumes.

## 5.5 Overseas transportation

The most common way to ship wood pellets from Vancouver is FOB. The size of the ship used is only handymax (35000- 50000dwt). One reason to why these types of ships are used is because they are usually equipped with $CO_2$-fire extinguishers which are a requirement for shipping wood pellets. This equipment is not as common on panama sized vessels but many new ships are including this equipment.

Table 5 below compares shipment calculations for wood pellets from Vancouver to Rotterdam in Netherlands versus Vancouver to Kwangyang in South Korea. The calculation method and the data have been derived from the interviewed actors. One of the assumptions in the calculations is that the discharge is carried out at two ports in the importing country. The calculations estimate the current price to ship wood pellets with a handymax vessel to Rotterdam is $33 and $24 to Kwangyang. Converted into euro with an exchange rate of 0,75 the shipping prices end up to be €25,0 and €18,3. One of the respondents said that a current likely price for shipping wood pellets from British Columbia to Europe is $35 per tonne +/- 10%.

The major differences that affect the price of shipping to Rotterdam compared to Kwangyang are the days of travelling and the daily rent (Baltic index rate). One reason to why the daily rate is cheaper from Vancouver to Europe is the fact that there are more empty ships travelling that route.

Table 5 below presents a calculation for the current costs of shipping wood pellets from British Columbia to Europe and South Korea. The numbers for the calculation have been given by the interviewed actors with knowledge in overseas transportation. The cost for shipping wood pellets is calculated for time chartering of the ship. This means that the charterer has to pay a fixed charter rate and all voyage expenses which include bunker fuels, port charges, canal dues and handling of the cargo. The operating costs for the ship will be paid by the ship owner and examples of these costs can be maintenance, repair costs, crew salary. Figure 27 gives further explanation to some terms used in shipping calculations.

*Table 5. Costs for shipping wood pellet from Vancouver to Netherlands and South Korea*

| **Typical vessel characteristics** | **Rotterdam** | **Kwangyang** | **Unit** |
|---|---|---|---|
| Total hatch space capacity | 53 802 | 53 802 | $m^3$ |
| Stowage factor | 1 | 1 | $m^3$/tonne |
| Dead weight tonnage | 46 000 | 46 000 | tonne |
| Net deadweight | 42 000 | 42 000 | tonne |
| Bunker fuel consumption | 32 | 32 | tonne/24 hours at sea |
| Diesel consumption | 2 | 2 | tonne/24 hours at sea |
| | | | |
| **Costs** | | | |
| Bunker cost | 775 | 775 | USD/tonne |
| Diesel cost | 1 100 | 1 100 | USD/tonne |
| Baltic Index rate for ocean vessel | 7 000 | 12 000 | USD/24 hours |
| | | | |
| **Time consumption** | | | |
| Loading speed | 10 000 | 10 000 | tonne/24 hours |
| Discharge speed | 10 000 | 10 000 | tonne/24 hours |
| Transit time Vancouver to Netherlands | 30 | 16 | days |
| Transit time to discharge port | 3 | 3 | days |
| | | | |
| **Calculations for cost** | | | |
| Payload cargo (wood pellets) | 36 600 | 36 600 | tonne |
| Days in loading port | 4 | 4 | days |
| Days in discharge port | 4 | 4 | days |
| | | | |
| Baltic index rate during loading | 25 620 | 43 920 | USD |
| Baltic index rate during discharge | 25 620 | 43 920 | USD |
| Husbanding cost loading port | 60 000 | 60 000 | USD |
| Husbanding cost discharge port # 1 | 70 000 | 70 000 | USD |
| Husbanding cost discharge port # 2 | 70 000 | 70 000 | USD |
| Baltic index rate during transit | 210 000 | 192 000 | USD |
| Bunker during transit | 744 000 | 396 800 | USD |
| Diesel in port | 16 104 | 16 104 | USD |
| | | | |
| Total voyage cost | 1 221 344 | 892 744 | USD |
| | | | |
| **Freight rate** | **33** | **24** | USD per tonne |

*Dead weight tonnage (DWT):* This measures the difference of how many tons of water the ship displaces submerged to its load line versus unloaded. It is usually expressed in metric tons and simplified it can be said that it shows how many tonnes of cargo the ship can transport , including crew, passengers, fuel, water ballast, fresh water and goods. (Bradley, et al. 2009) (Stopford 2009)

*Net deadweight:* Usually the non-cargo items account for 5% of the total deadweight in medium sized ships. This means that a 40000 dwt bulk carrier only will be able to carry about 38000 dwt cargo. (Stopford 2009)

*Stowage factor:* this term indicates how many cubic meter of space one metric tonne of a specific cargo occupies in the ship. It can also be measured in cubic feet per long ton. As an example wood chips usually have a stowage factor of 2,5 $m^3$/mt, coal 1,4 $m^3$/mt, light crude oil 1,07 m3/mt. (Stopford 2009) The loading stowage factor (LSF) can differ from the discharge stowage factor (DSF) due to compacting of the cargo during transportation.

Hatch space capacity: the total volume that is available for the cargo.

*Figure 27. Definitions for some of the important factors when calculating sea freight for wood pellets.*

# 6 Discussion and analysis

*The results from literature and interviews will be discussed and analyzed according to the areas that are summarized in Figure 28. The upper part of the figure represents the different factors that are affecting the international competitiveness of wood pellets exported from British Columbia. The advantage that will be examined is the cost advantage since that type of advantage is usually most crucial in commodity markets.*

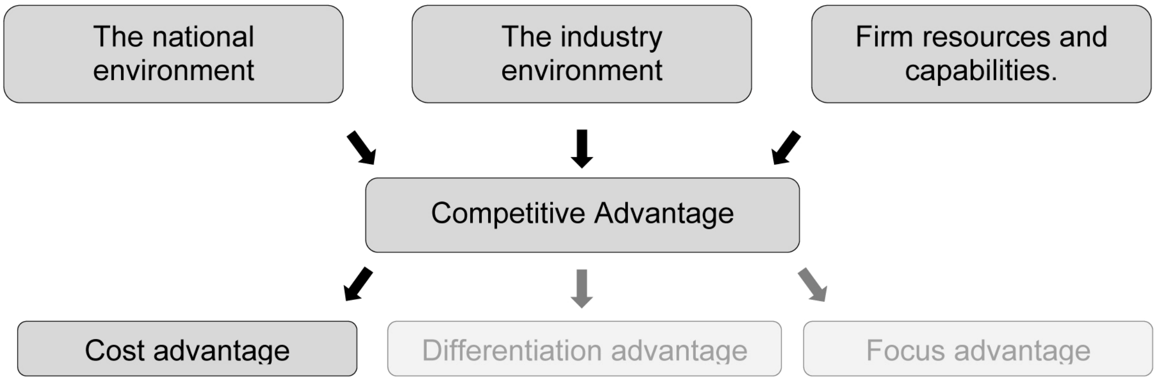


*Figure 28. The figure summarizes the parts that will be analyzed in this chapter. The analysis will focus on factors affecting the competitive advantage and how it is achieved through cost advantage.*

## 6.1 Production conditions & competitive advantage

Both the literature studies and interviews confirm that the potential to extract more wood fiber for wood pellet production in British Columbia is large. Both also confirm that the price differences between different sources are large and the future extraction levels of wood harvest residues and standing stems will depend on improvement of methods for extraction of fiber and the paying capacity by the customers. It is more likely that harvest residues will be a larger raw material contributor compared to round wood due to the cost differentiation.

Sawmill residues have historically been the major source for wood pellet production in British Columbia and the literature studies and interviews confirm that this is a cheap raw material source for wood pellet mills. One of the sources of the competitive advantage for British Columbia is the large supply of mill residues due to the cluster of large wood processing industries. The source of clustering industries for a countries competitive advantage was described in chapter 2 and is likely to contribute to the competitive advantage also in the future.

The domestic market for wood pellet consumption in British Columbia is expected to grow but the withdrawal by Canada from the Kyoto protocol raises questions about the further development and utilization of bioenergy in the country. However, the literature has shown that an increased amount of biomass district heating plants is likely to increase the domestic consumption.

The growth of the wood pellet industry in British Columbia has been large during the recent years. The literature showed that the production capacity grew with 4000% from 1996 to 2011 (50 K tonnes to almost 2000 K tonnes). A large part of this capacity has been added during recent years with 800K tonne increased production capacity in 2010-2011. The general opinions transmitted by the interviewed actors were that the rapid growth will slow down and we will see a more moderate growth in the near future. The explanation to this is that it will be more difficult to find cheap raw material.

The transport costs for the wood pellet industry in British Columbia is a crucial factor for its competitiveness. The calculations based on interview data show that the current prices are historically low which also the Baltic Dry Index rate reveals. The current prices reach €25 per tonne to Rotterdam which results in a delivered price in Europe at 120-143€. Assuming a price (FOB) in Vancouver fluctuating from 95 to 118 € (see Figure 18). The bulk prices in European ports have during the last years fluctuated between €115-145 (see Figure 23). This makes wood pellets from British Columbia price competitive in Europe and can explain why Europe is the major market for British Columbian wood pellets. However, this also reveals that the wood pellet industry is very sensitive to price increases in shipping prices. Different sources have confirmed that the price was almost $100 (€75) per tonne to ship to Rotterdam in 2007. This reveals that long term contracts are essential for wood pellets producers in British Columbia to remain long term competitive in overseas markets.

According to IEA (2011), the price of wood pellets in South Korea is fluctuating from 91-116€ per tonne. This is almost in the same range as the recent FOB pellet prices in Vancouver. This reveals that when transportation cost are added on pellets from Vancouver the delivered cost in South Korea ends up at 113,3-136,3 €/tonne. This can explain why South Korean consumers not have started to buy wood pellets from British Columbia yet. The prices in Vancouver, Europe and South Korea are summarized in Table 6 below. Several of the interviewed actors have pointed out that torrefied pellets might be the way for British Columbian wood pellets to penetrate the South Korean market. This can partly be explained by the improved suitability for long distance shipments and less requirement of storage facilities.

Both the literature studies and some of the interviewed actors have confirmed that rail services and port facilities can be barriers for an increased export. Only one rail company and one terminal are currently handling wood pellets in British Columbia at the moment. One of the respondents confirmed that increased terminal capacity in Vancouver and that it is planned to build terminal capacity in Prince Rupert as well. More competition among wood pellet terminal handling in the province is likely to reduce the price which according to literature findings currently is about $11,2 /tonne, which is included in the FOB prices.

The development in the wood pellet sector is fast and will be interesting to follow during the upcoming years. Considering future studies, it would be interesting to compare the paying capacity among South Korean and European wood pellet consumers. Such study would even further assess the future competitiveness of wood pellets from British Columbia. A report from IEA indicated that the imported prices from countries in region close to South Korea are much cheaper than wood pellets from Canada(about €100 vs €185). However, with the current shipping price to South Korea (€18,3/tonne) and an FOB price of €100-110 in Vancouver the difference compared to the Asian countries become less than that.

*Table 6. The table summarizes recent prices of wood pellets in different markets and the shipping cost from Vancouver*

| | Price €/tonne |
|---|---|
| **British Columbia** | |
| Recent price in British Columbia (FOB) | 95-118 |
| | |
| **Netherlands** | |
| Recent price in Netherlands (CIF) | 115-145 |
| Current shipping rate from Vancouver | 25 |
| Price of British Columbian pellets at current shipping rate | 120-143 |
| | |
| **South Korea** | |
| Recent price in South Korea | 91-116 |
| Current shipping rate from Vancouver | 18,3 |
| Price of British Columbian pellets at current shipping rate | 113,3-136,3 |

## 6.2 Identified challenges

Many of the challenges that often occur in emerging markets that have been presented in chapter 2 have been identified in the wood pellet sector in British Columbia. The most obvious ones are listed in Table 7 below.

*Table 7. Summary of identified challenges that often occur in emerging markets that have been identified in the wood pellet sector in British Columbia*

| Identified challenge in litterature | Found in this study |
|---|---|
| *shortages in raw materials* | Proved by the fact that companies moving towards an increased extraction of more expensive raw materials compared to mill residues which historically have been the primary source |
| *the absence of infrastructure* | British Columbia have functional infrastructure for wood pellet export but it could be improved with increased competition in rail transportation and terminal handling. |
| *high costs* | Proved by the slow process in selling wood pellets to South Korea and the price relation presented in Table 6. |
| *absence of product standardization* | proved the fact that no technical standards have been adopted for torrefied wood pellets |

## 6.3 Method

One challenge during the literature study has been to find reliable data. The wood pellet market is an emerging market and it has been obvious that high quality statistical data for wood pellet trade is difficult to find. I have aimed to use sources which are considered to be reliable. However, in some cases even the data from the most reliable sources seem to be a bit doubtful. An example of this is the consumption of wood pellets in the United Kingdom which have been difficult to find.

The initial aim for this study was to be able to validate data both from literature studies and interviews, but this triangulation could not be fulfilled on all discussed areas i.e the costs for the different steps in the distribution chain within British Columbia were only gathered through literature. When I asked some of the interviewed actors with knowledge of these costs they answered that it was confidential information that their company did not want to share. Despite this, I could find answers to most of my questions in both literature and interviews and in most cases the answers were similar.

When I chosed the actors to interview I used the snowball-sampling method. By doing this I could get in touch with experts in different sectors in an efficient way. While asking for recommendations for more people to interview I have tried to get recommendations from a wide range of areas in which the actors work. As a result I got in touch with people from the research sector, transportation sector, and consulting and a trade organization. I think this sampling method suited this project well because the wood pellet sector is still quite small and I could get in touch with some of the experts in an efficient way. Another aspect that can be discussed is if an increased number of respondents could have improved the results of the project. It is likely that more aspects could have been added to the findings with more respondents. However, the project was limited in time to be performed during one university semester. If this time period would have been longer the number of respondents could have been enlarged and might have added more aspects to the results.

An alternative, to my chosen method, could have been to use a quantitative method and doing a survey to find the answers. However, while designing the study I was recommended from several directions that such method would not be likely to be successful. The response rate was expected to be low due to reluctance to share data. In the end I think both the literature study and interview study contribute with valuable information and I hope that this project can contribute to an increased understanding of the trade with wood pellets.

# 7 Conclusions

The wood pellet sector in British Columbia has grown with 4000% from 1996 to 2011 (50 K tonnes to almost 2000 K tonnes). A large part of this capacity has been added during recent years with 800 000 tonne increased production capacity in 2010-2011. The general opinions transmitted by the interviewed actors were that the rapid growth will slow down and we will see a more moderate growth in the near future.

The conditions for wood pellet production in British Columbia have changed to a quite large extent during recent years. Mill residues have been the major source for wood pellet production in the province but this raw material is limited in supply and producers have to start to use other fiber sources for increased production. Other raw material sources such as harvest residues and mountain pine beetle killed wood may contribute to a future capacity increase but they have been shown to be more expensive than mill residues. Especially mountain pine beetle killed wood is relatively expensive and does not seem to be suitable for wood pellet production due to the price difference.

The competitiveness of wood pellets from British Columbia is to quite large extent dependent on the price of shipping the goods to potential markets. The price in Vancouver port has recently been fluctuating from €95 to €118 (FOB). The shipping market has been rather volatile during recent years and the price of shipping rate from Vancouver to Rotterdam has fluctuated between €19 to €75/tonne between 2001 and 2007. The current price for shipping has been estimated to be €25,0/tonne to the Netherlands which result in a delivered price from 120 to 143€/tonne in Europe. The bulk prices in European ports have during the last years fluctuated between €115-145. This makes wood pellets from British Columbia price competitive in Europe and can explain why Europe is the major market for British Columbian wood pellets.

The current shipping price of wood pellets from Vancouver to South Korea has been estimated to be €18,3/tonne. This would result in a delivered price in South Korea of 113,3-136,3 €/tonne. The price for wood pellets on the South Korean market has recently fluctuated from €91 to €116/tonne. This reveals that British Columbian wood pellets currently have difficulties to be cost competitive on this market. A future success for British Columbian wood pellets on the South Korean market is dependent on how much wood pellets or similar biomass based products that can be delivered from Asian countries which currently have a lower price level. This would be an interesting future study and would give the British Columbian producers valuble information if the South Korean market can become a future large consumer of canadian wood pellets.

Several areas have been identified where the competitiveness can be further improved. There is currently only one terminal that is handling wood pellets for bulk export and only one rail company that transport the pellets from the production facilities to the port. An increased competition on this market is likely to affect the price of distribution. Another interesting area for the future development is if torrefied pellets can be produced in a cost efficient and safe way. Torrefied pellets have theoretically better properties for long distance shipment due to higher energy density and does not have the same demand for storage facilities as regular wood pellets.

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Respondents for the interview study
-the respondents in the interview study is described below by gender, which sector they work in and their specific area of knowledge

1. Male, Consulting, bioenergy technology
2. Male, Consulting, forest resources
3. Female, Transportation, domestic transportation in BC
4. Male, Transportation, overseas transportation from BC
5. Male, Trade organization, wood pellets
6. Male, Research sector, supply chain
7. Male, Research sector, logistics
8. Male, Research sector, pellets production

# Appendices

## Appendix 1. Interviews

The initial discussion areas for the interviews are listed below. The questions are divided in five different sections: raw material, processing, domestic transportation, storage, overseas transportation

**Raw material**
Which fiber types are used in production of wood pellets in BC? (how much from sawdust, chips/roundwood, salvage wood, bark, other residue)
How do the prices for the different raw material sources differ?

**Industry/Processing**
Which type of qualities that are produced? (energy content, bulk density, moisture content, ash content)
What is the cost of producing different qualities at the average size of mills?
Other characteristics of wood pellets from BC?

**Domestic transportation**
Describe distribution chain within British Columbia
Limitations in this train transportation?
Costs related to train transportation?
Other characteristics of domestic wood pellet transport in BC?

**Storage/terminal handling**
Limitations of storage/terminal handling at the ports?
Cost of storage/terminal handling?
Other characteristics of terminal handling of in BC?

**Overseas transportation**
Limitations of ports?
Limitations of ships to Rotterdam? (size, time consumption, limitations at importing port)
Limitations of ships to Korea?
Costs related to overseas transportation?
Other characteristics of overseas transportation of wood pellets from BC?

## Appendix 2. Railroads in British Columbia


**Railroads in British Columbia.** This map show the rail roads in British Columbia. The thicker red lines represent main lines while the thinner lines display the collector and feeder lines. The darker areas in the map show where the population density is greater than or equal to 0,4 persons per square kilometers. (Natural Resources Canada 2011)

## Appendix 3. Wood pellets producers in British Columbia

The table below shows the wood pellet producers in British Columbia in 2011. The pellet mills are ranked after highest production capacity. The largest pellet producer in the province, Pinnacle pellet, holds 58 percent of the production capacity. (Bradley and Bradburn 2011)

| | Pellet mill | Location | Production capacity (tonnes) |
|---|---|---|---|
| **1** | Pacific Bioenergy Corp. | Prince George | 350 000 |
| **2** | Pinnacle Pellet | Burns Lake | 320 320 |
| **3** | Pinnacle Pellet | Houston | 240 240 |
| **4** | Pinnacle Pellet | Strathnaver | 220 000 |
| **5** | Pinnacle Pellet | Williams Lake | 200 200 |
| **6** | Premium Pellet Ltd | Quesnel | 140 000 |
| **7** | Pinnacle Pellet | Vanderhoof | 100 000 |
| **8** | Princeton Co-Generation | Princeton | 90 000 |
| **9** | Tahtsta Pellets Ltd | Burns Lake | 80 000 |
| **10** | Pinnacle Pellet | Armstrong | 61 880 |
| **11** | Woodville Pellet - Highland Plant | Merrit | 60 000 |
| **12** | Okanagan Pellet Company | West Kelowna | 50 000 |
| **13** | Gold standard Pellet Fuel | Surrey | 45 000 |
| **14** | Vanderhoof Speciality Wood Prod. | Vanderhoof | 30 000 |

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