LAPPEENRANTA UNIVERSITY OF TECHNOLOGY
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Degree Programme in Environmental Technology

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CARBON FOOTPRINT AS PART OF A COMPANY'S EXTERNAL ENVIRONMENTAL COMMUNICATION

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ABSTRACT

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Carbon footprint as part of a company's external environmental communication

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The aim of this thesis was to find out how the carbon footprint calculations can be utilized in the company's external environmental communication, what is the demand for carbon footprint from the market, and how the other actors in the forest industry have approached the issue. The aim was to recognize the best practises to communicate carbon footprints and to find possibilities to extend the UPM-Kymmene Wood Oy's mill specific carbon footprints. This research included a literature review, an inquiry to the UPM-Kymmene Wood Oy's sales offices, and Internet survey concerning the external environmental communication in the forest industry and three small case studies based on mill specific parameters.

The inquiry to the sales offices showed that the carbon footprint is not yet a common demand from the customers in the wood product sector. In addition, the Internet survey showed that generally in the forest industry, not much has been done concerning carbon footprint communication so far. The biggest challenge in carbon footprint communication is the variation in the knowledge level of the receivers. In addition btob and btoc communication situations demand a different approach to the issue. Carbon profile brochures developed in the company can be seen as suitable for btob communication situations. Case studies have shown that the contribution of final product transport to the overall carbon footprint was significant. It was recommended to include post mill transport in the carbon footprint information supplied to the btob customers.

When discussing environmental communication on a general level it can be stated that a good external environmental communication is based on facts, is open and proactive and takes into account the needs of the receiver. However, the openness and the quality of external environmental communication are essentially strategic decisions. The significance of internal communication as well as the knowhow in the communication and marketing networks play a major role in achieving success in external environmental communication. Carbon footprints are only one part of good balanced external environmental communication. One specific environmental feature like carbon footprint should not be over emphasized to the detriment of other important environmental aspects.

TIIVISTELMÄ

Lappeenrannan teknillinen yliopisto
Teknillinen tiedekunta
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Mari Ovaskainen

Hiilijalanjälki osana yrityksen ulkoista ympäristöviestintää

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Tämän diplomityön tarkoituksena oli selvittää kuinka hiilijalanjälkiä voitaisiin hyödyntää yrityksen ulkoisessa ympäristöviestinnässä, minkälainen kysyntä markkinoilla on hiilijalanjäljille ja kuinka muut toimijat metsäteollisuudessa ovat asiaa lähestyneet. Työn tavoitteena oli löytää parhaat käytännöt hiilijalanjälkiviestintään sekä selvittää mahdollisuuksia laajentaa UPM-Kymmene Wood Oy:n tehdaskohtaisia hiilijalanjälkiä. Tutkimus koostui kirjallisuusselvityksestä, kyselystä myyntikonttoreille, Internet-tutkimuksesta sekä kolmesta tehdaskohtaisesta tapaustutkimuksesta liittyen tehtyihin hiilijalanjälkilaskentoihin.

Myyntikonttoreille tehdyn kyselytutkimuksen tuloksista voitiin päätellä, ettei hiilijalanjälki ole vielä kovinkaan yleinen vaatimus asiakkaiden taholta puutuotetoimialalla. Lisäksi Internet-tutkimuksen perusteella voidaan olettaa, ettei muuallakaan metsäteollisuudessa olla edetty hiilijalanjälkiviestinnässä kovinkaan pitkälle. Suurin haaste hiilijalanjäljistä viestittäessä on erilaiset kuulijoiden tietotasot. Lisäksi btob ja btoc viestintätilanteet vaativat erilaiset lähestymisensä asiaan. Yrityksessä kehitetyt carbon profile -esitteet voidaan nähdä soveltuviksi btob viestintätilanteisiin. Tehtyjen tapaustutkimusten perusteella valmiiden tuotteiden kuljetukset nähtiin merkittäviksi tehdaskohtaisiin hiilijalanjälkiin suhteutettuna, ja tämän tiedon lisäämistä suositeltiin btob asiakkaalle toimitettavaan hiilijalanjälkitietoon.

Yleisesti ympäristöviestintää tarkasteltaessa voidaan todeta, että hyvä ulkoinen ympäristöviestintä perustuu tosiasioihin, on avointa ja proaktiivista sekä ottaa kuulijan tarpeet huomioon. Hiilijalanjäljet ovat vain yksi osa tasapainoista hyvää ulkoista ympäristöviestintää. Yhtä yksittäistä tekijää, kuten hiilijalanjälkeä, ei tulisi ylikorostaa muiden ympäristösuorituskykyyn liittyvien näkökohtien kustannuksella. Pohjimmiltaan viestinnän avoimuus ja laatu ovat aina strategisia päätöksiä. Sisäisen viestinnän merkitys sekä viestintä- ja myyntiverkostojen osaamisen rooli, ovat huomattavat onnistuneen ulkoisen ympäristöviestinnän takaamiseksi.

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Still, this was only one leg of the race and now I'm ready to head towards new adventures.

Helsinki, November 2010

Mari Ovaskainen

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ABBREVIATIONS

BRE	Building Research Establishment (British company)
BSI	British Standards Institution
Btob	Business to business
Btoc	Business to consumer
CEPI	Confederation of European Paper Industries
CF	Carbon footprint
COP	the Conference of the Parties
CO_2	Carbon dioxide
CO_2-eqv	Carbon dioxide equivalent
E-PRTR	European Pollutant Releases and Transfer Register
EU	European Union
FSC	Forest Stewardship Council
GHG	Greenhouse gas
GWP	Global Warming Potential
IPCC	International Panel of Climate Change
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LPG	Liquefied Petroleum Gas
NGO	Non-governmental organization
NMVOC	Non-Methane Volatile Organic Compounds
PAS	Publicly Available Specification
PEFC	Programme for the Endorsement of Forest Certification schemes
UNFCCC	United Nations Framework Convention on Climate Change
VTT	the Technical Research Centre of Finland

1 INTRODUCTION

Climate change discussion is a hot topic today. The media is full of news and consumers' environmental awareness is rising. This will affect consumption habits and could, for example, lead to an increase in the popularity of timber construction. From the climate change point of view, wood products are excellent because the wood binds carbon dioxide from the atmosphere through photosynthesis. In addition, the principals of sustainable forestry will guarantee constant renewal of the forest biomass.

The plywood products can also be seen as carbon pools and another positive point of view is that the energy sources used in the production are mainly bio based. Energy efficiency and high utilization rate for process residuals, for example in energy production, are competitive advantages which not only bring cost savings, but also build a positive image.

Carbon footprint calculations are based on standardized life cycle assessment (LCA) principles. Simply described, and in most of the cases, the carbon footprint measurement method illustrates the forming of greenhouse gas emissions from the supply chain of the product or service, or in some cases individual, national or organizational. It is a modelled numerical value, converting the emissions to carbon dioxide equivalents. Based on the information gathered from the supply chain, it is possible to examine the efficiency of actions, and in some cases compare the result to other corresponding systems in the markets. Carbon footprints can be used as a follow-up tool for greenhouse gas emissions in the supply chain. It shows the critical hot spots, from the climate change perspective, in the supply chain where the biggest benefits could be gained via improvements. It can help in developing even more environmentally friendly products in even more demanding markets.

In order to benefit from the carbon footprint calculations the company should be able to use the results innovatively, find the right ways and channels to communicate the results, and focus the message to respond the information demand from the

stakeholders. Tightening legislation and new energy efficiency demands will create opportunities as well as threats in the future. Environmental thinking and enforcement in all company operations is, after all, a strategic decision. Solid environmental performance, knowledge of one's own products, and production, and a willingness to improve the performance connected with a desire towards leadership in sustainable communication and marketing, will most likely bring positive benefit for businesses in the future.

1.1 The objectives, research questions and delimitations

The main objective of the study is to determine how to respond to the market and customer demand of plywood's environmental performance from the climate change viewpoint. The aim is to increase the Company's knowledge of their product's environmental performance, as well as to create the tools to increase the knowledge externally via more versatile communication in the future. The research question to be answered is how to bring out the good qualities of plywood in climate change issues?

Another objective is to find the most innovative ways to make the most from the carbon footprint calculations in external environmental communication and marketing. The aim is to find the best practices in the field, review those critically, and adapt methods which suite the best for the Company. The questions to be answered are how ”hot” is the carbon footprint topic in practise from a sales perspective and how the carbon footprint calculations can be used in external communication and marketing?

The third objective is to clarify the stage and possible effects of global climate policy to wood products, and to find the viewpoints which could be beneficial to plywood products in the future. The aim is to review the possible effects of international climate agreements, standardization issues, and development of carbon footprint calculation methods, as well as to discuss critically what kind of effects could increasing overall environmental consciousness have to the plywood business. The question is what kind of possibilities there are to extend the scope of the carbon footprint calculations and is it possible to compare existing calculations to other carbon footprints?

Concerning the methodology in this research this is a qualitative study, even though it also includes quantitative aspects. A qualitative study is typically base on comprehensive acquisition of information. The data can be acquired e.g. by observing or via interviews. Also questionnaires can be use as an aid in data acquisition. With these methods the visions and opinions of the participants are mapped. The target group is selected purposefully and the interpretation of the material is done case by case. (Hirsjärvi, Remes & Sajavaara 2002, 155.) In this study an inquiry to the sales offices, observation of the forest industry companies Internet sites, small case studies connected to carbon footprint calculations and a literature review were selected to be the research methods.

The biggest limitations of the study are connected to the aim of the study. The aim is to gain an overall view of how the carbon footprint issues are communicated, how they should be communicated, and what kind of benefits could be gained via communication. Environmental communication and marketing strategies, and their development are excluded even though they are closely connected to the subject.

Another important limitation of the study is related to the mill specific carbon footprint and case studies connected to the overall carbon footprint of the product. Due to the system boundary settings and the limitations of mill specific carbon footprints, a full comparison to other carbon footprint studies is not possible. Case studies will clarify the impact of emissions outside the mill gate in some special cases, and only the order of magnitude of those emissions can be reliably compared to mill specific carbon footprint.

1.2 Structure of the thesis

The thesis consists of seven main chapters. The first chapter introduces shortly the context and the structure of the study. The chapter also contains objectives of the thesis, the research questions, as well as the limitations of the study.

The second chapter discusses the climate change and the wood products. The approach to the topic is the political context of climate change issues, and the potential connected to harvested wood products from the climate change mitigation viewpoint.

The third chapter discusses environmental communication from the external communication viewpoint. The chapter presents the principals of environmental communication and environmental marketing. In addition, special features in business to business communication are discussed shortly and, the role of environmental labels and declarations in external communication is also explained.

In the fourth chapter the concept of carbon footprint is presented. The chapter includes the basic definition of the carbon footprint, and a quick overview of the typically used measurement methodologies, standards and frameworks connected to the issue. After this, the carbon footprint calculation method which is used in UPM-Kymmene, is presented and compared to other commonly used methods. In the end of the chapter, carbon footprint's weaknesses and its role in stakeholder communications is also discussed.

The fifth chapter presents the empirical part of the study. It includes the company presentation and the introduction of the plywood manufacturing process. Also the concept of UPM-Kymmene Wood Oy's plywood mill specific carbon footprint is presented. In the following sub-chapters, the results of a market inquiry done in the sales offices are presented. Also the results of the Internet research of how other companies in the forest industry have used the carbon footprints in their external communications in the Internet, are presented. The final sub-chapter presents a case study related to the possibilities to extend the mill specific carbon profiles.

Chapter six presents the results of the study, and in the last chapter of the thesis, the conclusions based on the results of the study are discussed. Recommendations, evaluation of the study and further research needs are also presented.

2 CLIMATE CHANGE AND WOOD PRODUCTS

In addition to the environmental aspects of climate change, it also has a growing political dimension. In the following chapters, the political context around the subject and the positive effects that the wood products could have from the climate change perspective, are introduced.

2.1 Political context

Climate change has become an issue that will affect all living species on Earth. It has stimulated discussion how we can both prevent it, and on the other hand adapt to the unavoidable changes (Belz & Peattie 2009, 9-10). An important early discussion generater was the Intergovernmental Panel of Climate Change (IPCC) and its first report announced in 1990 where it showed the human impact to climate change (IPCC 2007, 95). The first step towards global climate change control was taken at Rio de Janeiro 1992 where the United Nations Framework Convention on Climate Change (UNFCCC) determined the common rules for the battle against the global climate change. (Gustavsson et al. 2006, 1098.) The Kyoto Protocol followed in 1997 and supplemented the climate convention. The protocol determined binding greenhouse gas (GHG) emission reduction targets for the developed countries for a commitment period of 2008-2012. So far 184 countries have ratified the protocol. (UNFCCC 2010.)

In a conference held in Bali in 2007, it was agreed that the new protocol to mitigate the GHG emissions will be launched by the end of 2009 (UNFCCC 2007). The 15th conference of the parties (COP15) meeting in Copenhagen in 2009 was a disappointment for many reasons, but mostly due to the fact that a legally binding contract was not endorsed. As a positive achievement of Copenhagen many important political decisions were made even though they were not signed. The participating countries agreed that global GHG emissions need to be cut down and the increase of global temperature should be held under 2 degrees Celsius. Countries that are party to

the Kyoto protocol agreed to further strengthen the emission reducing actions before 2020, and to support the emission reduction efforts in developing countries with international funding. (UNFCCC 2009.) The next climate change conference will be held in Mexico City 2010. The biggest challenge in Mexico is to formulate the new protocol into a legally binding contract, and to get the parties of the convention to adopt the resolution.

The next IPCC report will be ready in 2014 (Valtioneuvosto 2009, 7). From the forest and wood product industry's perspective it is important to note that this far, the IPCC reports have paid notable attention to carbon conservation and sequestration management, and less to the substitution effects related to the use of wood products (Gustavsson et al. 2006, 1098). Even though the 2006 IPCC guidelines for national greenhouse gas inventories describe three different methods for calculating harvested wood products impact. The carbon stock effect of harvested wood products was ignored in the first commitment period of the Kyoto protocol, but will be taken into account most likely in national greenhouse gas inventories in the next commitment period of the UNFCCC from 2013. (Tonosaki 2009, 390-391.)

In addition to the global aspect, the climate change issue has been important in regional as well as national levels. Climate change mitigation has been part of European Union policies for a long time. The first European Climate Change Programme (ECCP) was launched in 2000 to help to identify and develop the most environmentally and cost effective policies and measures to reduce GHG emissions. The second ECCP was established in 2005. The goal of the ECCP is to ensure that EU reaches its targets to correspond to the targets of the Kyoto Protocol. Both ECCPs, as well as actions at the national level have helped to cut down the overall GHG emissions in the EU region. It is clear that in the future and after 2012, EU policies and measures will aim for even deeper emission cuts to tackle climate change. (European Commission 2006, 5-9.)

At the national level, another political aspect connected to wood products, are the public procurements and in some cases even the legal control of construction work. This aspect is relevant in the building sector, where commercial green building schemes are

becoming more common, and sometimes even compulsory for public procurements. Examples of green building systems are the US Green Building Councils LEED standard, and the environmental assessment method for buildings by British Building Research Establishments, also known as BREEAM. In these kinds of rating systems for buildings, wooden building products can contribute to achieving credits for the final certification of the building.

Another example of policy actions at the national level is from France, where a new law was accepted in 2009 for minimum use of wood materials in the construction of new buildings. The wood amount demanded is depending on the purpose of building and overall floor area. The new law also requires that the wood is sourced from a sustainably managed forest. (Viljakainen 2009.)

2.2 Climate change mitigation and carbon storages

Considering climate change mitigation, the role of the forest industry should not be underestimated. Forests and wood materials are a part of the global carbon cycle. The forest binds atmospheric carbon dioxide through photosynthesis, and stores it as carbon in forming biomass. Stored carbon stays bound in the wood material until it is either burned or decomposed. In other words there is carbon in the living biomass, in the soil, and the forest floor due to decaying biomass, and also transferred out of the forest residing in different types of wood based products. (Sathre & O'Connor 2010, 1.)

Wood based products can be seen from two different perspectives considering global climate change. One viewpoint is that wood works as a biogenic carbon store and when growing become a carbon sink. On the other hand wood can be used as a substitute for more energy intensive raw materials and fossil fuels. (Pingoud 2006, 11; Gustavsson et al. 2006,1112.)

The biogenic carbon content in wood raw material is approximately 50% from dry wood. For Nordic tree species more specific values are for spruce 51,9% and for birch 50,5% (Pingoud & Perälä 2000, 28). One way to determinate the amount of bound

carbon dioxide in the wood is to convert the bound biogenic carbon content in the wood into bound CO_2 by multiplying the storage of C with the molar mass ratio of CO_2 and C (44/12). This is presented in Equation 1. This method to calculate the biogenic carbon bound into the wood can be used, for example, in a case when the aim is to express the amount of carbon in the product as it enters commercial use. Notably this equation does not take into account the service life of the material. The Equation only gives the net accumulation of CO_2 in raw material without taking in to account the theoretical reduction of carbon over time.

$$m_{drywood} * \frac{kgC}{dry\ wood} * \frac{mCO_2}{mC} = kgCO_2 \qquad (1)$$

Substantial emission reductions can be gained while using wood as a substitute for fossil fuel or energy intensive material. Substitution issues are complex, and to be able to determine the wood substitution effect, the emission from fossil based systems should be allocated into the same functional unit. When considering material substitution, it is most likely that wooden building materials will create the biggest quantifiable potential to material substitution. From the energy substitution perspective, the most viable way is to use exploitable by-product flows from the wood processing industry, and the end-product in its end of life stage in energy the recovery purposes. (Pingoud 2006, 13-14.) Gustavsson et al. (2006) pointed out, in their research based on historical facts, how difficult it is to predict the amount of wood used and its changes, but noted also the role of wood in GHG mitigation. The importance of wood substitution will probably increase, if suitable policy instruments are implemented. (Gustavson et al. 2006, 1100.)

An important aspect of wood product carbon balances is that those should never be extracted from the forest carbon cycle. Only sustainably managed forests will ensure that the amount of carbon in the forest carbon cycle is not reduced via harvesting. In sustainable forestry, the harvested wood biomass will be replaced with new wood biomass through plantation and the average forest growth can be seen to be equal to the volume of the wood harvested. (Pingoud 2006, 11.)

In addition to forest carbon pools and wood products, another aspect is that the wood waste in landfills can work as a carbon sink (Pingoud 2006, 11). Several studies (e.g. Pingoud 2006, 11; Sathre & O'Connor 2010,3; Micales & Skog 1997, 151-154) have pointed out that a notable fraction of landfilled wood will decay in a way which does not result in GHG emissions, and instead turn into a nonreactive solid mass providing an accumulative carbon sink. Micales & Skog (1997) concluded in their survey that only 0-3% of the carbon from wood are ever released as landfill gas (e.g. methane) in typical anaerobic landfill conditions. The study summarized results from previous studies and concluded that due to the woods lignin, which is highly resistant to anaerobic degradation and embedded in easily degradable cellulose and hemicellulose, the wood stays resistant to decay in the landfills. (Micales & Skog 1997, 149.) In addition, methane formed can be partially covered and used as a biofuel and substituted for fossil fuels (Saltre & O'Connor 2010, 3). Even with these viewpoints, carbon sinks in the landfills are contradictory because the same amount of landfilled wood waste could have been used as biofuel, substituting fossil fuels in energy recovery. In the European Union consistent waste management procedure are lacking even though political guidance via directives has equalized the procedures. For the time being, landfilling of demolished wood products is prohibited in many parts of the European Union, and the overall amount of landfilled wood waste is decreasing. (Dodoo et al. 2009, 276-277.)

Consensus of how the effect of carbon pools should be determined has not been reached at the international level. The Kyoto protocol does not take the carbon sink effect of a managed forest fully into account, even though the countries report the complete sink effect to the convention on climate change. (Pingoud 2006, 13.) Another weakness from the forest industry’s viewpoint is that the protocol takes the carbon sink effect into account in the forests, but excludes the carbon stored in harvested wood products. Despite this the IPCC has recognized the possibility of harvested wood materials in the battle against climate change in its fourth assessment report. (Laturi et al. 2008, 308.) Also the EU has noted the possibilities of wooden products (European Commission 2009, 17).

Hennigar et al. (2008) summarized in their study “optimization of management strategies for carbon storage in to forest and wood products” that to be able to maximize the carbon storage effect, the carbon pools such as landfills and wooden products should be taken into account in the calculations. This should be done to accomplish the forests’ actual contributions to atmospheric carbon sequestration, and to the positive effect of climate change mitigation. (Henningar et al. 2008, 786.)

3 ENVIRONMENTAL COMMUNICATION

Due to public concern and interest, environmental values, actions, and performance have received increasing attention. In the future, the meaning of environmental communication will become even more important due to the rising political, legal, and consumer demands.

Environmental friendliness of the products and operations is not enough, if it has not been communicated to the consumers and the other stakeholder groups properly. The way that the companies communicate outside, highly depends on the eco-performance of the company. If the company has a strong environmental performance, it could gain great competitive advantage with open communication to the market (Peattie 1995, 216).

However, even the best message could be miss-interpreted. Concerning the communication, it is important to understand the process of how the message is transmitted from the sender to the receiver and what are the aspects which affect the communication process. Earliest communication models suggested that the communication process is a linear one-way process where the sender sends out a message to the receiver via a communication channel and the receiver assigns the meaning to the received message (Narula 2006, 13-14; West & Turner 2008, 12-15). A more developed communication model, an interactional communication model, includes feedback in to the model. This transformed the basic one-way communication in to a circular model where the communication goes in two directions, from the sender to the receiver and from the receiver to the sender. (West & Turner 2008, 15-17.) In addition to these, the latest developed model of communication, transactional model, underlines the cooperative nature of the communication process. Figure 1 presents the transactional model of communication which assumes that the sender and receiver do not only send messages and feedback, but instead build a shared meaning through simultaneous and mutual sending and receiving. (West & Turner 2008, 17-18.)

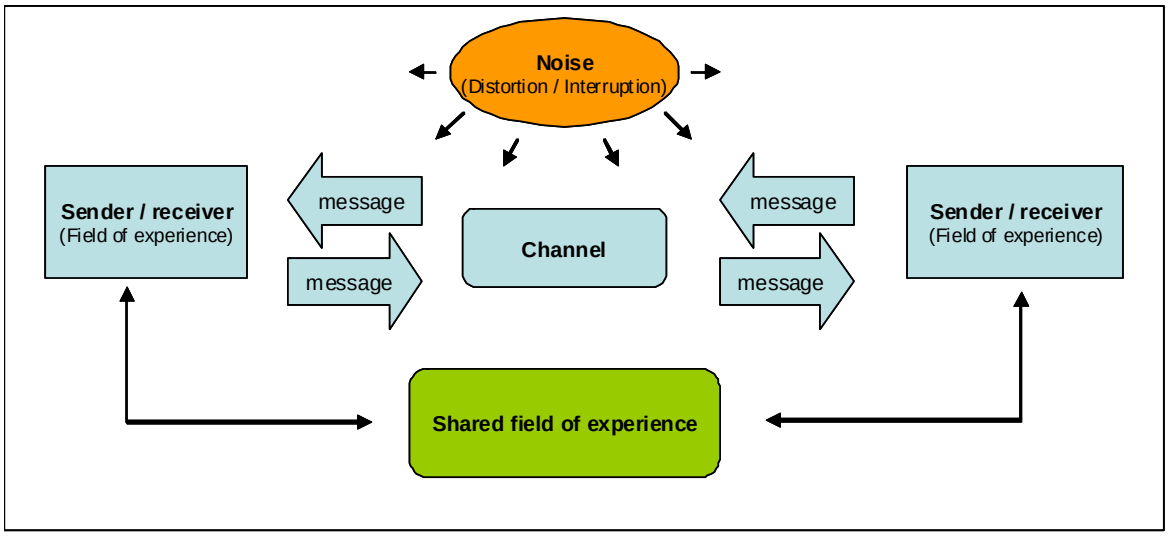

Figure 1 Transactional communication model (Adapted from West & Turner 2008, 18)

It is important to remember that communication is always a dynamic process which takes place in some specific surrounding environment. This exposes the communication process to constant external distractions and makes it vulnerable. In a communication model context these distractions are commonly referred to as noise. The key note from the transactional communication model compared to other models (linear, interactional) is that the model highlights the meaning of the sender / receivers' field of experience as well as build a shared field of experience via communication. This approach emphasizes an aspect where both, sender and receiver, have responsibility for the effect and effectiveness of the communication. Even though the backgrounds of the communicators could differ in the beginning, the expansion in the shared field of experience through communication will support the success of communication in the future. (West & Turner 2008, 12-20.)

Marketing communication and informing are the two basic ways for a company to communicate externally. Basic marketing communication methods can be divided in to advertising, sales promotion, and sales support material. Informing can be either direct customer communication, or taking care of media relations. (Linnanen et al. 1997, 129-131.) In this study, external environmental communication is used as a synonym for informing.

In the following chapters the principals of environmental communication and environmental marketing communication are presented from the external communication point of view. Current trends in business to business environmental marketing communication are also described. Internal communication methods are excluded from this study.

3.1 External environmental communication

Concerning a company's environmental communication and reputation, it can be stated that the environmental reputation is build slowly and based on the facts. The global environment, a large amount of stakeholder groups, and quickly changing trends will bring their own challenges to the adaptability of the environmental communication. (Linnanen et al. 1997, 129-131.) In order to get long term benefits, environmental issues should be integrated into all organizational levels and activities (Polonsky et al. 2001, 22). Due to this, the goals of external environmental communications should not be separate, but should be derived from the company's common environmental objectives and markets (Linnanen et al. 1997, 133).

The International Organization for Standardization (ISO) established in 2006 the ISO 14063 environmental communication guideline standard ("Environmental management. Environmental communication. Guidelines and examples"). The aim of this standard is to help organizations to go through the process of developing their environmental communication and answer the increasing expectations of the interested parties. (ISO 14063 2006, 6-11.) Actions described in the standard are based on the principals of continuous improvement, the so called Plan-Do-Check-Act -cycle. Figure 2 presents the context of the environmental communication, its interrelationships and flow in the organization according to the ISO 14063 standard.

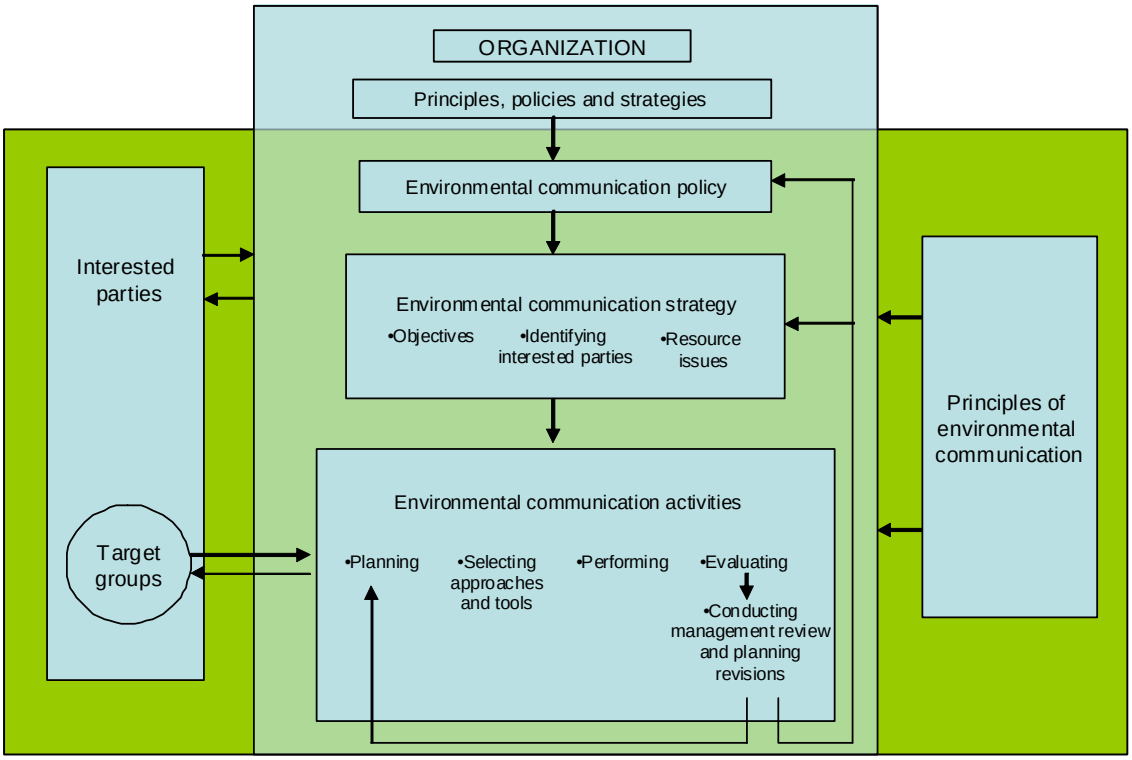

Figure 2 Context of environmental communication, interrelationships and flows (Adapted from ISO 14064 2006, 9)

As a concept, environmental communication is much wider than routine annual environmental reporting practices. The ISO 14063 standard defines environmental communication as a dynamic process where an organization provides, obtains and shares information connected to environmental issues, aspects and performance to its interest groups. The motivators behind the communication can vary but the main purpose is to share environmental information to build trust, credibility, and partnerships while it raises environmental awareness and works as a tool in decision making (ISO 14063 2006, 7).

Traditional external communication is often referred to as marketing communication or conventional promotional communication. In comparison to external environmental communication the biggest difference is that external environmental communication does not aim directly at the larger market shares of the product. Also, the focus of the communication can be wider than just the product, as it is commonly in marketing communication. The customers are most likely interested also in other important

environmental issues of the company, than just the products environmental performance. (Halme 2004, 7-10; Belz & Peattie 2009, 180.)

Communicating the sustainability performance of a company or solutions that the company provides, demands a holistic approach. In order to get the customer's confidence, company's messages, actions and management have to be consistent and transparent. (Belz & Peattie 2009, 198,191.) The basic principles in environmental communication are considered to be transparency, appropriateness, credibility, responsiveness and clarity (ISO 14063 2006, 15).

The biggest challenge in external environmental communication is to find the right ways to communicate with different interest groups so that the basic demands for good environmental communication practices are fulfilled. The background knowledge in environmental issues can vary enormously between different audiences, and this should be taken into account in external communication strategy planning. The level of communicated information should be inline with the needs of the receiver. In addition, the channel for communication should be chosen carefully, in order to achieve a good environmental reputation.

In addition to mandatory environmental reporting, a mix external environmental communicating can include, for example, press releases, articles, brochures and datasheets, environmental labels, declarations and claims, and common environmental information. They can be presented, for instance, on the company Internet sites or in printed form (Halme 2004, 5).

One of the most typical methods that companies use in their external environmental communication is environmental reports. The environmental performance report of a company can be a part of normal annual report or then they are published independently on yearly basis. In addition to traditional printed reports, the companies could have updated online version of the reports on their Internet sites.

Another important way to communicate environmental performance of a product is with third party verified certificates and labels, placed on product packaging. Information verified by the third party is an important tool in gaining customer's trust and increasing the credibility (Belz & Peattie 2009, 189). Different environmental labels and declarations are discussed in more detail in chapter 3.4.

Other typically used environmental communication tools are self declared brochures, datasheets, and environmental claims. All of these could have both printed, as well as an online version in the Internet. Also, the media should be mentioned as an efficient communication channel to support the development of a company's positive environmental image via, for example, articles, newsletters, and press releases.

In the book Sustainability Marketing, Belz and Peattie (2009) present a new way to approach environmental communication, which includes both social and environmental aspects. Sustainability communication is based on an open dialogue between the company and the consumer or other interest groups. Transparency and responsibility are the key issues and the sustainable way to create long lasting partnerships. Despite this it should be kept in mind that open dialogue does not mean that a company should inform interest groups in a real time. (Belz & Peattie 2009, 180, 185; Kuvaja & Malmelin 2008, 91.)

When comparing the sustainable communication model by Belz and Peattie (2009) to the communication models presented in chapter 3.0, considerable similarities between the Belz and Peattie's model and the transactional communication model can be found. This kind of interactive communication has lots of possibilities. For example, it works as an efficient way to establish relationships between the company and potential customers, when compared to traditional linear or even to interactional external environmental communication. It offers a possibility for the consumers to learn and to understand sustainability solutions that the company provides, and on the other hand it provides better understanding for the company considering customer needs connected to environmental information. (Belz & Peattie 2009, 180, 185.) While planning the communication with interest groups there are several possible forms of dialogue.

Examples these are e.g. roundtable meetings, interest group panels, strategic and tactical partnerships. The company should consider how it well it masters different dialogue forms and what are the suitable forms to communicate with different interest groups. (Kuvaja & Malmelin 2008, 91.)

One alternative to adapt the principles of the sustainable communication is to utilise the possibilities connected the use of the Internet as a communication channel. Typically companies have used Internet sites as a one-way information channel to their customers. For example, the product information could be shared via the Internet sites as an addition to the printed brochures. The new trend is to use the Internet also to inform and educate the customers about the sustainability issues related to the brand. This kind of information can be added to the company's main websites, or even a separate website could be launched to serve the purpose. (Belz & Peattie 2009, 185.)

Another new phenomenon is to collect customer feedback via websites and to use the information gathered to highlight the correct areas of commitment in communication. This kind of active role in communication helps the company to stay up to date in various topics in environmental discussion, and at the same time it helps to engage the customers. In the future, the role of new social media solutions such as social networks, podcasts, review sites et cetera will change the methods of a company's environmental communication and become even more hectic than today. These applications have great power to enhance, or on the other hand to destroy the brand and its reputation. However, this risk is controllable. Proactive and open external environmental communication helps to deal with any criticism against the company's sustainability performance and reputation. (Belz & Peattie 2009, 185.)

Even though the company's environmental image is based on its environmental performance, it does not necessarily mean that the environmental competitiveness of the company is good and result in positive financial profits automatically. In this connection, environmental competitiveness means how the interest groups see the company's level of environmental protection and management. (Lovio & Kuisma 2004, 42-43.) In order to achieve financial profits, external environmental communication

efforts need to be carefully planned, managed, and controlled (Belz & Peattie 2009, 180).

Lovio & Kuisma (2004) have determined two combining factors between a company's real environmental protection performance and environmental competitiveness. The first explanation is that insufficient external communication in environmental issues, lead to a lack of knowledge about the company's environmental performance to the interest groups. The other explanation is that environmental issues are highly time-related and weighted differently by different interest groups. (Lovio & Kuisma 2004, 43.) The importance of a specific environmental issue in public environmental discussion can change rapidly, and in addition new topics are raised to the discussion all the time. If the company takes an active role in its external communication, and reacts to the new environmental issues fast, it could gain a positive environmental image. It is important to show to the interest groups that the company has already taken new issues into consideration, even though it has not had time to take the proper actions. (Lovio & Kuisma 2004, 44-45.) Openness and telling the future plans and, in the ideal situation, bringing up new aspects to the public environmental discussion, and giving the answers before the questions are asked are good opportunities for a company to stand out from competitors (Halme 2004, 9-10). Still it should be remembered that the consistency between company's messages and actions have a great role in building the credibility (Belz & Peattie 2009, 189). After telling the future plans, also the actions taken and the results of the actions should be communicated properly.

After all, the intensity and the openness in environmental communication is a strategic decision. How good the company wants to be in environmental issues and what is the weight of the communication in the chosen strategy are the key issues. If the company has good environmental performance, an active role in external communications could be beneficial. This way the company can make sure that the stakeholder groups are aware of the work that the company is doing in environmental issues, and gives its contribution to public discussion aiming to ensure that important environmental issues, from the company's point of view, will stay in the focus of the media and the topic of public discussion. (Lovio & Kuisma 2004, 45-46.)

3.2 Environmental marketing communication

Environmental marketing or sometimes referred to as the green marketing concept was developed in the late 1980's as in response to the rising number of environmentally conscious green consumers. Traditional industries with significant direct impact on the natural environment, as well as new industries have noted the possibilities connected to environmental issues and more environmentally conscious customers. (Belz & Peattie 2009, 28, 30; Rex & Baumann 2007, 568.) Different from earlier marketing practices, green marketing highlighted a variety of environmental issues, and turned those in to competitive factors in the market. At the same time, the focus of the environmental issues started to expand from focusing only directly on the production processes environmental effects, to covering also the other stages of the product life cycle. (Belz & Peattie 2009, 29-30.)

Linnanen et al. (1997) divide the environmental market in to three categories 1) environmental market 2) environmentally sensitive market and 3) environmentally inflexible market. Environmental elasticity of the market determines how much the environmental consciousness of the consumers will effect the consumption patterns. (Linnanen et al. 1997, 133.) Roos & Nyrud (2008) concluded in their study of potential consumers of eco-labelled wood products in do-it-yourself retail stores, that the green consumers of wood products are less price sensitive than indifferent consumers. They also noted that when the buying decision approaches, the consumer value for environmental credits of a product can become less important. Despite these findings Roos & Nyrud concluded that environmental arguments and eco-labels have an important impact on many consumers' preferences for wood products. (Roos & Nyrud 2008, 405-406.)

It has been noted in several consumer attitude surveys that in real life the buying behaviour does not always correspond to the answers given in the surveys (Linnanen et al. 1997, 133; Rex & Baumann 2007, 569; Belz & Peattie 2009, 29). Despite this Linnanen et al. (1997) highlighted that today's attitudes will effect tomorrows markets and consumer behaviour. (Linnanen et al. 1997, 133.) Today's public environmental

discussion should be seen as a possibility from business' standpoint and companies should follow it carefully. The most competitive companies have noticed that potential, and have been exploiting it in their strategic decisions, such as product development and marketing strategies. (Linnanen et al. 1997, 135; Polonsky et al. 2001, 28.) Even though sustainable issues are not the main business requirement for most of the customers, this can rapidly change. In order to be able to answer their fast changing requirements suppliers have to be ready. (Sarshar et al. 2009, 411.)

Concerning actions to achieve a competitive advantage in the market, the green marketing process does not differ substantially from a conventional marketing process. It demands the same basic concepts as conventional marketing; marketing strategy and promotion mix. The green marketing mix consists of the same group of variables as the conventional marketing mix: *product, price, place* and *promotion*. These four variables are important tactical tools that the company uses to influence the demand of their products. (Rex & Baumann 2007, 571-572; Baumann & Tillman 2004, 356.) In this thesis the focus is in promotion.

The main goal of the green marketing communication, or green promotion, is to provide better information about the green properties of the products offered to the customer. When talking about consumers, one way to implement this, is to use third party verified ecolabels in marketing efforts. Other examples of product related ways to bring out the green message are for instance "home-made" labels and verbal claims. By providing information about the green properties of the product to the consumers, they can include the information in their buying decisions, and in the long term this will push the companies to provide products which are more environmentally friendly. (Rex & Baumann 2007, 568; Baumann & Tillman 2004, 357-358.)

In the article "Beyond ecolabels: what green marketing can learn from conventional marketing" Rex and Baumann (2007) summarize the problems connected with ecolabels and green marketing. The basic problem is that the environmental labels developed into policy instruments rather than marketing ones. Despite this, in practice the ecolabels have become the prevailing instrument to position the green products in the market. On

the other hand, it is important to note that the labels are part of the technical information attached to a product, not a direct promotional tool. This means that simple labeling alone is not enough to increase the market share of the product. Pricing decisions, distribution channels and assortments, advertisement, publicity, and sales promotion are the main tools, and labeling is only one step on the road of gaining market advantages. (Rex & Baumann 2007, 573.)

When discussing marketing communication tools, it is important to notice that the media is only a channel to convey the marketing communication messages while advertising, sales promotion, public relations, direct marketing and personal selling can be seen as the actual marketing communication tools. (Fill 2005, 20.) The key issue is efficient and versatile use of different media applications simultaneously e.g. the Internet, brochures and newspapers etc. Also, the simultaneous use of different communication tools is desirable, because different communication tools have different effects and objectives. For example, while advertising is a good tool for creating awareness, personal selling works better at promoting the purchase behavior. Also notable is that still the most efficient marketing communication form is by word-of-mouth. (Fill 2005, 25.) This should be kept in mind especially in planning promotional efforts targeted to business customers, because in business to business market relations there is more room for personal communication compared to business to consumer communication (Baumann & Tillman 2004, 357). In order to harness that potential in an environmental marketing communication mix, a low profile in external communication is not the correct answer.

When discussing environmental marketing messages, the role of credibility in external communication cannot be over emphasised. The use of environmental marketing claims and arguments in marketing has to fulfil the requirements of valid advertising regulations. In the EU region the main legal instrument is Directive 84/450/EEC on misleading advertising, and in addition the member states may have specified more detailed rules to ensure more extensive protection with regards to misleading advertising. (Palerm 2000, 25.)

In addition, several organizations such as the European Commission, the International Chamber of Commerce and the Nordic Consumer Ombudsmen have developed guides concerning what are good and suitable environmental arguments and how to use those. For example, in the Nordic Consumer Ombudsmen's guideline, the basic principles are that marketing claims must be clear, accurate and balanced, the overall impression given by claims must be correct and based on facts, and the company using the claims must be able to substantiate the claims accuracy. In addition to these principles, the guideline states that marketing claims must not:

- conflict with good marketing practises.
- be wrong, misleading or untruthful.
- conflict with the rules of comparative advertising. (Kuluttajavirasto 2005.)

The aim of these principles is to make sure that the environmental claims, as well as self-declared labels and symbols, are applied in accordance with the marketing law requirements in the Nordic countries (Kuluttajavirasto 2005). Common rules prevent the companies from using exaggerated environmental claims, and thus help the consumers to evaluate the truthfulness of the claims.

The term "greenwashing" is often used to describe situations where false or misleading environmental claims are used (Belz & Peattie 2009, 189-190, Polonsky et al. 2001, 26). On the other hand when there is a good guidance how to use environmental claims in marketing, the companies should not hesitate to use them if they are justified. Openness in communication and giving the needed evidence to back up the environmental claims made are important aspects in environmental marketing communication.

The use of environmental marketing does not demand that the product should be fully organic or throughout green. Environmental friendliness is only one viewpoint in the marketing concept. (Linnanen et al. 1997, 133.) Therefore, green promotion alone is ineffective and a better way would be to add it to traditional marketing efforts (Polonsky et al. 2001, 26). The focus of promotional efforts should be targeted to issues

of how the environmental aspect compliments other needed functionality to provide better value-added benefits (Sharma et al. 2008, 8).

In the future, the role of green promotion in companies' promotion is not likely to diminish. Greenwashing claims and credibility issues will not probably disappear either because of the rising number of actors in the environmental marketing field. In addition, the more common it is to use environmental promotion in marketing, the more important it is to differentiate. Besides the effective delivery of improvements in already communicated environmental issues, e.g. carbon footprints, the companies need to show evidence of what they have done to improve their overall environmental performance.

Also notable is that not all environmental market communication is product related. Another approach to the issue is so called green branding. A company can include in the external environmental communication also more company related issues, like news about the implementation of environmental management systems or ongoing co-operation activities with environmental associations. (Baumann & Tillman 2004, 357-358) A comprehensive approach to environmental issues as a part of company's corporate responsibility will help to raise and retain the sustainable image of a company.

Even though this thesis focuses on external communication, companies should not forget their internal communication either, because in the case of word of mouth communication, employees and the other internal interest groups have great power. In order to increase the credibility of the messages that the company is sending, the company's internal interest groups need to believe in them themselves. If the internal interest groups can stand together behind the environmental messages, they will also spread the messages with proudly.

3.3 Business to business environmental communication

It is obvious that in business to business communication, the form of environmental information needs to be different than in business to consumer communication.

Furthermore, the demands from the environmental information are different. Average consumers benefit the most from simple environmental information, such as labels, which they can use as support for their buying decisions, while business customers have different objectives for the use of the information.

A good example of environmental information demands in business to business communication is a large end product manufacturer which has high demands for its own environmental performance. Companies' environmental policy targets, along with adapted life cycle thinking, will bring demands also for pre-manufacturers in the supply chain. Demands for pre-manufacturers could include, for example, wood origin certificates, environmental management systems, or corresponding general management systems, and perhaps in the future, information about the climate change effects of the products (product carbon footprint).

Concerning marketing in business to business situations, the marketing promotion mix is also emphasized differently compared to business to the consumer marketing promotion mix. According to the research of Erlandsson & Tillman (2009), the case studies indicate that informal, personal communication is commonly used to complement the documented information (Erlandsson & Tillman 2009, 804). The role of personal selling is emphasized in business to business marketing communication, while for example the role of advertising is more like a starter to a sales discussion (Egan 2007, 370; Fill 2005, 32). This means that the salesperson's knowledge in environmental issues is critical. And as stated earlier, the importance of internal communication cannot be overemphasized. Only a trained salesperson, who believes the message he is passing on to a customer, can help the company to get maximum benefit via environmental marketing.

Along with environmental marketing, companies have included the environmental policies and targets into their everyday procurement, in order to fulfil their own corporate responsibility targets, and to maintain a sustainable corporate image. This claim gets support, for example, from a survey made in North America 2005 by the EcoMarketer. In the survey, 63% of Canadian companies have an environmental or

corresponding sustainability policy, and over a half of those (34%) also have a green procurement policy (McDougall 2005, 3). It can be assumed that the meaning of the green procurement policies in business to business trade will rise, the same as in the public sector as discussed earlier in Chapter 2.1. It is obvious that in the future the demands for environmental information will increase, also in business to business markets, as an indirect consequence of the strengthening of the public's environmental awareness.

3.4 Environmental labels and declarations

Environmental labels and declarations are typical tools used in communicating the products environmental performance. In the following chapter the background of environmental labels and declaration are presented. In addition, the most commonly used and requested environmental labels in the forest industry sector are presented.

Environmental labels have two different functions. The main purpose is to increase the consumers' environmental awareness and at the same time redirect the consumption (Linnanen et al. 1997, 52; Rex & Baumann 2007, 574). The other important aim is to guide industries to develop more environmentally friendly products. Typically the labels are setup for different product groups. The key element is that the products inside the certain group are comparable to each other and they have the same function. (Linnanen et al. 1997, 52.)

Environmental labels can be divided into mandatory and voluntary labels. A good example of a mandatory environmental label is the EU energy label for household appliances. (Rex & Baumann 2007, 570; Erlandsson et al. 2009, 803.) Voluntary environmental labels are classified with ISO standards in the ISO 14020 series. The ISO 14020 series includes all together four standards, and the first one (ISO 14020) gives the general principles for environmental labels and declarations. (SFS 2008.) Standard 14024 covers the type I environmental labels which aims to show the products from a certain product group which are less harmful to the environment than others. Type I labels are third party verified, and involve multiple environmental indicators. In general

discussion, the term ecolabel is used commonly while speaking of type I environmental labels. The positive aspects of type I labels are that, in the ideal situation, they provide reliable environmental information in a concise form, and on the other hand enable consumers to make a quick purchasing decision while also taking the environmental aspects into account. (Erlandsson et al. 2009, 803; Fullana et al. 2008, 11.) EU-flower and Nordic swan label are examples of this type of environmental labels (Nissinen et al. 2008, 15).

Type II environmental labels are self-declared environmental claims, and presented in the ISO14021 standard (Erlandsson et al. 2009, 803-804; Rex & Baumann 2007, 570). The standard determines requirements for the self-declared claims and gives guidance on how to use them (ISO14021 2001, 5-6). A manufacturer, importer, distributor, retailer, or anyone else likely to get benefit from these kind of claims, can pose these environmental statements. The claims are not third party verified and the biggest problems are connected to the credibility issues. (Nissinen et al. 2008, 15; Fullana et al. 2008, 11; ISO14021 2001, 5.) Environmental claims connected to the product can be in a statement, symbol or graphic form, and they can be placed, for example, on product literature, technical bulleting, packaging, advertising, and publicity material or in the Internet (Fullana et al. 2008, 11; ISO14021 2001, 5).

The standard ISO 14025 presents the type III environmental product declarations (EPD). EPDs are third party controlled, and based on the LCA information. In addition to LCA information, the EPDs present other relevant information connected to the product group. More specialised information requirements for EPDs are presented in the product category rules, approved in an open multi-stakeholder consultation process. (Fullana et al. 2008, 12-13.) EPDs are primarily intended for business to business communication, and for sharing the environmental information of the product in the supply chain, but this does not limit other stakeholder groups from the scope if needed. (Erlandsson et al. 2009, 803-804.) The biggest difference in EPD to other environmental labels, is that they do not compare environmental claims to other products which have the same function. Examples of product declarations accordant with ISO 14025 are the Finnish RT Building Information's Environmental declarations and Paper Profile. (Nissinen et al. 2008, 15; Fullana et al. 2008, 12-13.)

In addition to mandatory-voluntary aspect, the labelling programs vary depending on whether they involve single or multiple environmental issues, and the level of information they provide. Also it is notable that the labelling schemes can be national, as well as international or regional. (Belz & Peattie 2009, 183.) When discussing the disadvantages of ecolabels, Linnanen et al. (1997) noted that in some cases the ecolabels pass only a very limited amount of information and they can be very unclear from the consumer's point of view, due to the high variety of different labels and labelling criteria (Linnanen et al. 1997, 52). This could be one reason why the market share of ecolabelled products has stayed relatively low in some product groups. On the other hand this can not be generalized, because an opposite example of this is the printing paper of which the share of ecolabelled production is over 70 %. (Rex & Baumann 2007, 570.) Then again, in a product group where the ecolabels are commonly used, the lack of specific label can be a force majeure for trading (Linnanen et al. 1997, 52-53).

The limitations connected to type I ecolabels have had an effect on the type II labels which are becoming more popular among companies' external communication. It is typical that the companies want a simplified expression of the complex life cycle information, and to promote the products from the life cycle perspective to customers in an easily understandable form. For business to business communication, the use of type III environmental declarations is increasing. (Fullana et al. 2008, 14-15.)

Todays markets are full of different environmental labels, and the trend should be to limit the amount of labels instead of increasing them. Restricting the amount of labels would be beneficial for business as well as for consumers. From the business point of view, the labeling processes are expensive and they require extra time for reporting, following work, and certificates. (Nissinen et al. 2008, 9-10)

3.4.1 Environmental labels and declarations in the forest industry

Environmental labels in the forest industry can be divided in to a three sub-categories. The most commonly used are labels from forest certification schemes indicating the wood origin. In this context the labels from the Forest Stewardship Council (FSC) and

the Programme for the Endorsement of Forest Certification schemes (PEFC) are presented shortly. The second sub-category is comprised of commonly used type I ecolabels such as the EU ecolabel and Nordic Swan label. In addition to these two, the LCA approach based, carbon and water footprint labels development are also discussed shortly. The third category is comprised of EPDs. In this context the EPDs are presented from the building products viewpoint.

FSC

The Forest Stewardship council established in 1993, is an international non-governmental initiative promoting sustainable forestry. FSC's widely accepted international standards provide a framework for national FSC standards for sustainable forest management. The system focuses only on the origin of wood raw material by requiring sound forest management. (FSC 2009; Nordic Ecolabelling 2009, 4-5.)

PEFC

Like FSC, PEFC's focus is to certify the sustainable forest management and the traceability of raw materials, and its basic working models are the same. The program was established in 1999 by individual European forest owner organizations. As in the FSC, certification is voluntary, but necessary for using the label. (Nordic Ecolabelling 2009, 5-6.) In order to get the right to use FSC or PEFC labels, the company must have a verified chain of custody system, which can be verified by the classification societies.

EU ecolabel

The European Union ecolabel was established in 1992, and it is also known as "the Flower" due to the shape of the mark. It is administered by the European Ecolabelling Board (EUEB) and according to the ISO 14020 classification it belongs to the "Type I environmental labelling". It is a voluntary market tool which aims to promote the environmental excellence of products and services in Europe. (Baldo et al. 2009, 1-3.) The labelling criteria is based on the LCA approach, and it takes the environmental impact during a products entire life cycle into account. Existing product category criteria are, for example, wooden coverings (including in-house floors without support structural function containing over 90% wood raw material) and wooden furniture,

while the criteria for houses is under development. Actual wooden building boards, such as plywood, do not have their own product category criteria. The topic has been under discussion in EUEB, but a new product category criteria for building board have not been taken into development in this program period. In practise this means that the development work for a new product category criteria will not start in the next three years period. (Nyqvist-Kuusola 2010.)

It has been considered that GHG emissions as CO_2 equivalents should be included among the EU Ecolabel criteria, but consensus over the issue has not yet been reached (Baldo et al. 2009, 1). At the moment the EU ecolabelling scheme is under re-evaluation in the EU comission where, for example, one objective is to make the product group criteria acceptance procedures easier (Metsäteollisuus ry 2010, 11).

Nordic Swan label

The Nordic Swan label is a type I ecolabel used in the Nordic countries and founded in 1989. The basic principles behind the labelling scheme are similar to the EU ecolabel scheme and neither the strictness of the requirements differs notably. Compared to the EU ecolabel the Nordic Swan label is more widely used, and it includes a greater amount of accepted product croup criteria. (Ympäristömerkki 2010.) The Nordic swan labelling scheme includes criteria for houses and kitchen furniture, as well as building boards. For building boards, including e.g. plywood, the labelling criteria is being updated. (Nyqvist-Kuusola 2010).

Carbon and water footprints

At this point there are no widely accepted product carbon or water footprint ISO type I labels. The reason for this is that there has not been a commonly accepted standard on which the labelling schemes should be based. In the future this will most likely change, due to the on going standardization work in carbon and water footprint schemes.

One of the most important on going activities in the industry will be the development work on the ISO 14046 standard for water footprint which will specify the requirements and guidelines to assess and report the water footprint based on the LCA. The working

group started its standard development work in November 2009, and the aim is to finish the new standard in 2011. ISO is not the only framework developer in the field, and many other actors, for example, CEPI have started to develop a guideline for water footprint calculation. (Wessman 2010, 7.)

The first widely acknowledged guidance for carbon footprint calculation was Publicly Available Specification (PAS) 2050, published in October 2008 by the British Standards Institution (BSI). Based on this standard British company Carbon Trust, originally set up by the British government, established in 2009 The Carbon Trust Footprinting Certification Company to provide independent and impartial certification services for product carbon footprints based on the PAS 2050 standard. (Carbon Trust 2010.) Another recognized under development standard for product carbon footprints is ISO 14067, which is to be completed in March 2011 (Pajula 2010, 9). At this point, it is typical for carbon footprint labels that they are ISO type II self declarations. This kind of carbon labels have been introduced by, for example, Raisio Group for its food products, e.g. oatmeal, (Raisio Group 2010) and Sumitomo Forestry Crest Co., Ltd. for its plywood made from Japanese timber (Sumitomo Forestry Crest Co., Ltd. 2010).

The biggest benefit of climate labels, such as carbon footprint, would be its clear message which focuses purely on the climate effects of the product or service. The opposite side of this is that the other important environmental aspects of the product or service can be left out of the scope. (Nissinen et al. 2008, 9-10.) These same aspects can also be connected to water footprints. Also, credibility remains as a problem as long as there is no commonly known and accepted procedure for carbon and water footprint labels.

Environmental product declarations

The field of EPD systems is fragmented and typically based on national product category rules. An example of these are the Finnish RT Building Information's Environmental declaration and environmental profiles by British Building Research Establishment (BRE). Generally EPDs are meant to fulfil the environmental information needs in business to business situations, and to help the purchasers and users to make

environmental friendly buying decisions. Another important application for EPDs, are green building rating schemes such as British BREEAM. Notable is that despite the function of the EPDs, they are not fully comparable because of the possible differences in the methods used e.g. different system boundaries. (ISO14025 2006, 14-16). On the other hand, if the baseline, limitations and the calculation procedures are exactly the same then the EPDs are comparable to each other.

ISO 14025 type III environmental declarations are commonly referred to as environmental product declarations (EPDs). When considering building products, the ISO 21930 standard for environmental declarations of building products should also be mentioned. It is very similar to the ISO 14025 but it gives more detailed general guidance. Both these standards base their EPDs on independently verified LCA studies and inventory analysis and give general requirements for declarations and declaration content. (ISO 14025, 30-34; Schenck & Costello 2009,44.)

In the EU region CEN/TC 350 is developing a range of horizontal European standards for sustainability of construction works. The resulting standard will include a framework for sustainability assessment of buildings, but also guidance for the calculation methods, the assessment of environmental performance of buildings, as well as an international EPD system. The EPD system will include guidance for the use of EPDs, product category rules, and communication formats. In the future, the use of EPDs in external communication will most likely become more popular due to the new standards, and the promotion of sustainable construction. EPDs for building materials are a fundamental requirement in the development of environmental profiles of sustainable houses. (Vares & Häkkinen 2009, 129-131)

4 CARBON FOOTPRINT

This chapter presents the basic definition of the carbon footprint, typical measurement methodologies, standards and frameworks connected to the issue. After this, the carbon footprint methodology applied in UPM-Kymmene Wood Oy is presented and shortly compared to other commonly used methodologies. Carbon footprint's weaknesses and the role in stakeholder communications are also discussed at the end of this chapter.

4.1 Definition

Carbon footprint, sometimes also referred to as carbon profile, does not yet have an established definition. Basically, the term is developed to describe the cumulative amount of greenhouse gas (GHG) emissions produced during a product's life cycle. The scope of the study, as well as the system boundaries and cut-off criteria can vary. The carbon footprint can represent the cumulative emissions from the cradle to the gate perspective or include all life cycle stages from the cradle to the grave standpoint. It can be calculated for products, services, companies, persons as well as activities. (Nors et al. 2009, 42.) The basic approach for the emissions is to divide them into direct - on-site emissions, and indirect - off-site or downstream emissions, which both should be taken into account in the carbon footprint calculations (Wiedmenn & Minx 2007, 5). Sometimes also a third group, avoided emissions are included to the carbon footprint calculation (Miner & Perez-Garcia 2007, 80). Simply described, the carbon footprint can be seen as a subpart of a full LCA. (JRC European commission 2009, 1).

The lack of a strict definition is mainly caused by fact that footprinting is promoted by nongovernmental organizations (NGOs), companies, and different private initiatives. The various definitions can include overall carbon emissions (fossil + biogenic), or only fossil carbon emissions, but also overall carbon supplemented with non-carbon GHG emissions, such as methane (CH_4), nitrous oxide (N_2O) and different halogens by using

carbon dioxide equivalent indicators like the global warming potential (GWP) indicator used in the LCA. (Nors et al. 2009, 42; Weidema et al. 2009, 3.)

Different greenhouse gases have different radiative forcing influence on the global climate system due to their different radiative properties and lifetimes in the atmosphere. Characterization factors are needed to model the overall climate impact of GHG emissions. The most commonly used emission characterization factors for CO_2 equivalents are defined by the Intergovernmental Panel on Climate Change (IPCC) calculated for a 100-year time horizon (Nors et al. 2009, 42-42.) If the carbon footprint calculation does not take the non-carbon emissions into account, the calculation results are presented in kg of CO_2 per chosen functional unit, while when using the characterization factors for non-carbon emissions, the calculation results are presented as the sum of kg of CO_2 equivalents per chosen functional unit.

Carbon footprint is a tool which helps to determine the critical life cycle stages causing GHG emissions in a supply chain and pointing out the life cycle stages where the potential to decrease the emissions are. After recognizing the most significant GHG emission sources in different life cycle stages, it is possible to focus on reducing those. Carbon footprint can also point out the weaknesses in the supply chain from an eco-efficiency point of view.

4.2 Measurement methodologies, standards and other frameworks

One way to classify carbon footprint measurement methodologies is to divide those in to general guidelines, specific guidelines, and specific calculation tools. ISO standards (e.g. ISO 14040 for life cycle assessment) stand for the basic normative standard and general guideline. PAS 2050 is a class example of a typical specific guideline or a framework. A calculator assessing the consumer behaviour's impact in climate change constitutes as a specific calculator. (Baldo et al. 2009, 592-593.) Common for all these methodologies is that they are based in one way or another on LCA. The basic requirements for the LCA are 1) Goal and scope definition, 2) Inventory analysis, 3)

Impact assessment and 4) Interpretation (Minx et al. 2007, 12; ISO 14040 2006, 8) and these basic steps can also be found in different carbon footprint methodologies.

The purpose of standardization is to create and synchronize the rules to ease co-operation between different actors such as authorities, industries and consumers. Also, the frameworks have the same aim. The use of these tools is mainly voluntary but in some cases the authorities can refer to standards practically making them compulsory. An example of a typical mandatory standard is the CE marking used in the EU region confirming that the product fulfils the essential safety requirements.

In practise, the standardization is carried out at the international, regional (e.g. EU region) and national level by independent organizations in cooperation with specialists from different countries and industrial organizations. The largest non-governmental standard developer and publisher in the world is the International Organization for Standardization (ISO). It has developed widely approved and referred basic standards in many fields, including standards on environmental management, climate change and sustainable development.

The ISO standards are commonly seen as a good practise, robust, transparent and most importantly, they are widely accepted. 14000 standard series is focused on the environmental management systems. From the carbon footprint's perspective, the most important standards in the series are ISO 14040 standards which cover the life cycle assessment issues. ISO 14040 gives the LCA principles and framework and ISO 14044 closer requirements and guidelines for LCA.

From existing ISO standards, ISO 14064-14065 standards are focused directly on the climate change issues, and should be mentioned in this context, even though they are developed for corporate level GHG accounting. These two standards define the methods to quantify the greenhouse gas emissions and to communicate the environmental impact. ISO 14064 Greenhouse gases standard is divided into three parts. Part one consists of the specification and guidance for organizational level quantification and reporting of GHG emissions and removal. Part two consists of the specification and guidance at the project level for quantification, monitoring and reporting of GHG

emission reduction or removal enhancements, and part three gives guidance for the validation and verification of greenhouse gas assertions. The ISO 14065 standard consists of requirements for greenhouse gas validation and verification bodies for use in accreditation or other forms of recognition. (ISO 2009.)

ISO has also started a standard developing work for product's carbon footprints. And this is maybe the most important ongoing standardization work concerning product's carbon footprinst. When finished, the new standard will have two parts. Part one covers the quantification (ISO 14067-1) and part two the communication (ISO 14067-2). New carbon footprint standards will fulfil the existing standard family of green house gas management and related activities and the targeted publication date is March 2011. The new standard will be based on ISO 14040 and 14044 standards. (Nors et al. 2009, 46; Miner 2009, 23.)

As mentioned in chapter 3.4, maybe the most widely acknowledged guidance for product carbon footprint calculation this far has been the PAS 2050 "Specification for the assessment of the life cycle greenhouse gas emissions of goods and service" published in October 2008 by BSI and co-sponsored by Carbon Trust and the UK Department for Environment, Food and Rural Affairs. (Miner 2009, 22; The British Standard Institution 2008b, 2-3.)

In this content the GHG Protocol, published by World Resource Council Institute (WRI) and World Business Council for Sustainable Development (WBCSD), should also be mentioned, due to its consistency and comparability with the ISO 14064 standard (corporate level GHG accounting). In addition to the GHG Protocol, also WRI and WBCSD have started to develop a standard for product level carbon footprint accounting, "Product and Supply Chain Initiative", and aim to complete the standard in 2010. (Miner 2009, 22-23.)

From the forest industry's view point, the first consensus framework for carbon footprinting was developed by The Confederation of European Paper Industries (CEPI). CEPI's "Framework for the development of carbon footprints for paper and board

products" was established in 2007. The special features of the CEPI framework are that it underlines the meaning of carbon sequestration and storage in the forest products value chain. The system boundary setting from the cradle to gate is also emphasized, even though the framework gives also guidance on how to implement the cradle to the grave system boundary setting in the carbon footprint procedure. (Miner 2009, 22.) The framework is presented in chapter 4.3.1.

Appendix 1 includes a short list and description of the standards and frameworks discussed in this chapter.

4.2.1 CEPI Framework

CEPI is a non-profit organization representing the European pulp and paper industry. It has member organisations in 17 countries and all together it represents 800 pulp, paper and board producing companies all over Europe.

The aim of the CEPI framework is to help the companies to develop carbon footprints which are easy to use, understand and communicate as well as credible and transparent. Another important aim of the framework is to help the stakeholders to understand the relations between the forest products' value chains and the global carbon cycle. (CEPI 2007, 15.) The framework is adapted commonly in the forest industry, and in addition to UPM-Kymmene, for example, Finnforest (Finnforest 2009) and Stora Enso Group (Stora Enso 2008, 15) have used this framework to determine the carbon footprints of their products.

The general rules in CEPI guidance are similar to typical LCA approaches, and it refers to the ISO 14044 standard several times. The problem is that there is no broadly accepted and standardized approach for the calculation method of product level carbon footprints, and the CEPI framework only offers one viewpoint to this problem. Selected objectives will identify how the guidance is used and which aspects are taken into account. (CEPI 2007, 11.)

The baseline in the CEPI framework is that it identifies ten critical elements for forest products, and guides how to calculate and how to present the results of the carbon footprint. The framework allows both, from the cradle to the gate as well as from the cradle to the grave carbon footprints, even though it emphasizes the value of cradle-to-gate footprint. This is because the carbon footprints which do not include the whole life cycle can be seen as more accurate than cradle-to-grave footprints that involve more uncertainty. At the same time, the cradle-to-gate footprint can be seen as more useful in transferring carbon information in business to business communication. (CEPI 2007, 4, 13; Miner 2009, 22.)

Another important issue in the framework, is how it handles the biomass carbon and biomass-derived CO_2. Biogenic CO_2 emissions derived from burning the biomass for energy at the production site, purchased heat and electricity, or biogenic transportation fuels, are excluded because they are not considered to contribute to global warming. On the other hand the framework also recognizes the importance of biomass fuels in the forest products' value chains, and encourage companies to communicate it as additional information in the carbon footprint. (CEPI 2007, 17; CEPI 2009, 4.)

The ten key elements of carbon footprints are introduced in following paragraphs. Table 1 presents the relations of the different elements in the final carbon footprint. The CEPI framework takes into an account what positive effects the forest industry could have on the climate change. This means that the framework includes items which could also have a decreasing net effect to the final carbon footprint.

Table 1 The ten elements of a carbon footprint and their net effects to the final footprint. (Adapted from CEPI 2007)

Ten elements of a CF	Increase the final CF	Decrease the final CF
1. Carbon sequestration in forests		-
2. Carbon stored in forest products		-
3. Greenhouse gas emissions from forest product manufacturing facilities	+	
4. Greenhouse gas emissions associated with producing fibre	+	
5. Greenhouse gas emissions associated with producing other raw materials/fuels	+	
6. Greenhouse gas emissions associated with purchased electricity, steam and heat and hot and cold water	+	
7. Transport-related greenhouse gas emissions	+	
8. Emissions associated with product use	+	
9. Emissions associated with product end-of-life	+	
10. Avoided emissions and offsets		-

The first toe of the ten key elements is carbon sequestration in forests. The framework states that with sustainable forest management practices, the renewal of the harvested biomass can be assured in the forest. The minimum requirement that the CEPI framework demands, is for the company to illustrate their forest management and wood procurement practises. (CEPI 2007, 25-26.)

The second toe represents the amount of biogenic carbon stored in the product the moment it is put into commerce. The carbon bound in the wood will remain in the product through the whole life cycle until the product is demolished. The CEPI framework presents this as a positive effect on the climate change issue. According to CEPI the return of biomass carbon is delayed compared to the normal carbon cycle, and this way it is possible to remove carbon dioxide from the atmosphere faster than it is returned back to atmosphere. (CEPI 2007, 27-28.)

The third toe includes greenhouse gas emissions from forest product manufacturing facilities. This means direct emissions from burning fossil fuels in the manufacturing processes. The cut-off criteria used defines if non-CO_2 greenhouse gas emission are included and presented contributing the total CO_2 equivalent emission or not. The main non-CO_2 GHG emissions from burning are methane and nitrous oxide which can contribute one to five percent to the total CO_2 equivalents in fossil fuel combustion. If the facility produces more than one product, the emissions should be allocated among the various outputs, even though typically in LCA studies emissions are not allocated to by-products that are produced in small quantities. Also, miscellaneous emission sources should be considered in some cases, even though those are normally excluded from the greenhouse gas reporting standards. Other possible emission sources, in some special cases, could be e.g. sludge and wood waste landfills and combustion of fossil fuel based waste. (CEPI 2007, 29-30.)

The fourth toe deals with the question of greenhouse gas emissions associated with producing fibre. This includes the emission from the primary production of wood raw material. In the case of plywood, this toe stands for the forest management and harvesting. (CEPI 2007, 31-32.)

The fifth toe is the greenhouse gas emissions associated with producing other raw materials and fuels. This includes emissions from producing fossil fuels, and other non wood based raw material used in production. This toe comprises direct emissions from the raw material manufacturer, as well as indirect emissions associated with purchased energy to produce these raw materials. The role of cut-off criteria is essential in this toe. Which inputs are relevant and should be included in the carbon footprint, and which inputs have only minor influence and can be left out from the study. Sometimes generic information from lifecycle databases is the only way to obtain the needed information, because these emissions are outside the control of the manufacturer of the product described in the carbon footprint. (CEPI 2007, 33.)

The sixth toe comprises greenhouse gas emissions associated with purchased electricity, steam and heat, and hot and cold water. Emissions in this toe are highly dependant on

the location of the production site because the fuel mix to produce the purchased electricity varies a lot. There are also big differences in emission factors for grid electricity, depending if it is an average factor or specified by the energy supplier, or does it include transmission losses or possible emissions associated with producing the fossil fuels. If the company itself sells electricity, steam, heat, or hot or cold water, emissions can be allocated to them and subtracted from the net carbon footprint. (CEPI 2007, 35-36.) It should be noticed that if the facility itself produces energy on site, it is calculated in the toe three instead of this toe.

The seventh, and the last toe which increases the carbon footprint is transport-related greenhouse gas emissions. System boundaries for the footprint will determine which transport related emissions are included in the footprint. If the system boundaries are set to from cradle-to-gate, this toe includes the emissions from transportation of the harvested wood and other raw materials to the mill site. If the system boundaries are set to from cradle-to-grave, this toe also includes the final product transportation from the mill, and the after use transportation to the disposal site. The toe seven can also include transportation of manufacturing residuals, waste from manufacturing process and transportation of intermediate products. According to CEPI, the internal transportation in the mill site and the waste transport-related emissions are relatively low compared to the emissions from the other sources and in most cases it can be left out of the study. (CEPI 2007, 37-38; CEPI 2009, 4-6.)

In some cases the company could decide to expand the system boundaries from the cradle-to-gate review to the cradle-to-grave study, and in this situation the eighth toe can be included into carbon footprint. Toe eight includes only those emissions which are caused by the product during use, according to the chosen functional unit. Nevertheless these emissions are very rare for forest products when compared to, for example, electronic products. (CEPI 2007, 39.)

The ninth toe represents the emissions associated with the product's end-of-life stage. This toe can lead to distorted comparisons between different product's carbon footprints due to high uncertainties. Uncertainties are caused by several reasons, for example,

product manufactures low control over the issue, the end of life conditions are location specific etc. For these reasons, the CEPI guidance recommends to exclude this stage from the carbon footprint. If this toe is included, one option is to model different end of life options and sketch the possible effects. (CEPI 2007, 41-42.)

The tenth and last toe in the CEPI framework is the amount of avoided emissions and offsets. The most important viewpoint in this toe is transparency, and that the assumptions and methods are well explained. The number of avoided emissions is almost endless and claims should be used carefully. From the wood product standpoint, one interesting point is that the wood-based building materials can replace other more energy intensive building materials and in this way contribute in a positive way to the climate change issue. (CEPI 2007, 43-44.)

4.2.2 CEPI framework's relation to other general carbon footprint guidances

The CEPI framework is developed for the forest industries needs and it highlights the issues which are relevant for this special industry sector, such as carbon sequestration and storage to the forest products. In Figure 3, is presented how the framework corresponds to the life-cycle steps in the basic LCA approach.

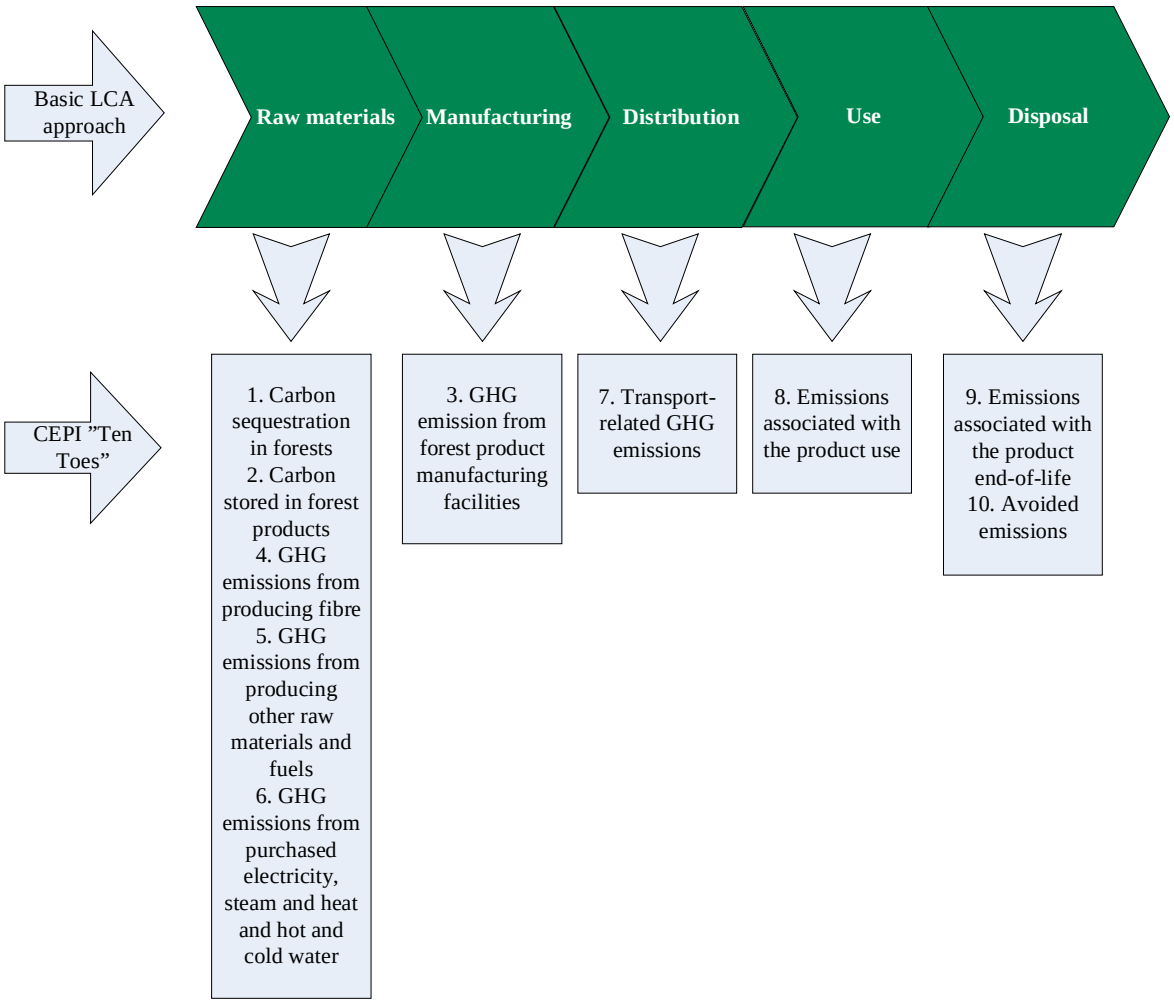

Figure 3 CEPI framework's relation to the life cycle stages in the basic LCA approach.

When comparing the CEPI framework to PAS 2050, it is found that PAS 2050 is a more universal guideline for carbon footprinting and more closely related to the basic LCA approach (Miner 2009, 22-23). In both guidances there is a similar demand for transparency. Both guidelines also allow the alternative use of cradle-to-gate and cradle-to-grave system boundaries (CEPI 2007, 15; Miner 2009, 22). According to PAS 2050, all GHG emissions from fossil fuel sources should be included, while CEPI suggests that a suitable cut-off criteria is to include 90% of all emissions within the system boundaries, whereas the ISO 14044 states that the cut-off criteria should be set so that the objectives set in the definition of the scope will be fulfilled respectively (Nors er al. 2009, 46; The British Standard Institution 2008a, 12-14;CEPI 2007, 19; ISO 14044 2006, 27).

From the forest industry's point of view, fossil CO_2 emission is the most significant contributor to the overall carbon footprint and the level of the other GHG emissions are small compared to it. Biogenic CO_2 emissions are seen to be carbon neutral, meaning that it does not contribute the overall carbon amount in the atmosphere. Commonly other GHG emissions can be excluded from the carbon footprint with the default 90% cut-off criteria.(CEPI 2007, 29, 42, 49.) In the PAS 2050 guideline, biogenic carbon is also excluded. An exception to this rule is when the biogenic carbon occurs from the land use change, or when it is in a non-CO_2 form e.g. methane. (Nors et al. 2009, 46; The British Standard Institution 2008a, 9-11.)

An important aspect for wood products in PAS 2050, is that the carbon storage effect of the forest products is included in the cases when the carbon in the product remains removed from the atmosphere for a year or more. The maximum advantage is gained when the product stays in use for more than 100 years. The amount of stored carbon can be deducted from the overall carbon footprint caused by manufacturing. (Nors et al. 2009, 46.) Also the CEPI framework takes the carbon stored in the product into account, but the calculation principles are different. It does not include the product bound carbon directly in the carbon footprint, but instead reports it as a separate figure (CEPI 2007, 27-28).

Another important aspect in PAS 2050 guide is that it does not take the carbon storage in the forest into account. In practice, this does not differ from the CEPI approach, where in the standard situation, the forest influence on the carbon footprint is considered to be zero. (Nors et al. 2009, 46; CEPI 2007, 26-27; ISO 14044 2006. 39.)

Also, the allocation principles of GHG emissions among products and co-products differ between the CEPI framework and the PAS 2050 guideline. According to the CEPI framework, allocation should be done according to the guidance given in the ISO 14044 standard. According to the ISO 14044 standard, above all, allocation should be avoided. Normally the allocation of emissions is not needed in cases where only small quantities of the co-products are produced. If the allocation can not be avoided, it should be done primarily according to the physical relationship between the products and co-

products. If the physical relationship can not be used as an allocation procedure, other procedures that reflect the relationship between the products and co-products can be used e.g. the economic value. The PAS 2050 guide states that allocation should be avoided, and if this is not possible, the economic value should be used as an allocation procedure. (The British Standard Institution 2008a, 22-23; CEPI 2007, 16-17.)

The PAS 2050 guide does not include the voluntary carbon offset mechanisms as possible reductions of the carbon footprint. The CEPI framework states that the carbon offsetting can be added to the carbon footprint, and it can be reported as a separate figure. Nevertheless, the use of offsetting has to be very transparent, and additional information is needed when using it. Despite this possibility, the CEPI framework does not encourage the use of offsetting. (Nors et al. 2009, 46; CEPI 2007, 13, 20.)

It can be assumed that CEPI will continue developing their framework, and if the new ISO standard for carbon footprinting includes some new special requirements, those requirements will be adopted into the CEPI framework in one way or another. The main conclusion is that the CEPI framework suits as well for plywood, as it does for the other forest products. A notable feature is also the fact that the CEPI framework clearly categorises the amount of sequestrated and stored carbon as a separate figures from the emissions caused from the other life cycle stages. This is important in this stage of the standardization work when there are no common rules how to handle the stored carbon in the final carbon footprint. Another benefit is that when applying the CEPI framework to UPM plywood the carbon footprints are in line with UPM corporate level's approach to the issue.

4.3 Carbon footprint's comparability and weaknesses

When considering comparability even the LCAs done according to the standards ISO 14040 and 14044 are not necessarily fully comparable and leave some open questions e.g. allocation method alternatives. In practise, more detailed rules are required to assure the comparability of the results.

Due to the lack of a commonly accepted standardized calculation method, as well as product category rules, many issues can affect the comparability of carbon footprints. Many different calculation methods and system boundary settings are nowadays used. This leads unavoidably to results which are not comparable with each other. From a communication perspective, this is a major challenge.

Generally carbon footprint results can vary significantly as can the basic LCA results. Reasons for this can be found, for example, from the functional unit used, system boundaries, scope of emissions, cut-off criteria, allocation methods, mean values in modelling due to the lack of accurate data, or characterization factors used which can vary from one survey to another. The main point is that the size of the carbon footprint highly depends on what emissions from the product's or service's life cycle are included in the footprint calculation. Are the system boundaries set so that only the direct emissions from the company's activities are included, or are the indirect emissions from down and upstream from a life cycle perspective also included? Then again the aspects concerning the avoided emissions and offsetting are a whole different story, and how they are handled can significantly effect the overall carbon footprint. Emissions connected to the avoided emissions and carbon offsetting are especially difficult and need further regulations.

The key issue in carbon footprinting is transparency. The same basic requirement can be found from ISO standards for LCA, ISO 14040 and ISO 14044. This means that it should be clearly described what is the system being surveyed, how the system boundaries are set, and which is the used cut-of criteria is used. A critical review is compulsory for the initial data used as well as for the assumptions made. Also the allocation methods applied should be described carefully in order to evaluate the carbon footprint results. However even after all these actions the carbon footprint cannot be used as a comparative assertion.

In general, carbon footprinting can be seen as a simpler tool than a holistic LCA study. In fact, it is one impact category indicator from LCA. Surely it is one possible solution as a system analysis method that the market has been looking for, but if the issue is

observed from the sustainable development's perspective, it can be argued wether it is enough to focus only on one indicator like carbon footprint does. (Schmidt 2009, S6-S7.) In some cases, a simplified approach, which takes only GWPs into account, can lead in a completely false direction. It can be alleged that the carbon footprint is not a durable enough indicator alone to prove a product or a service to be environmentally friendly. (Weidema et al. 2009, 4.)

Even though the carbon footprint has a tendency to be simpler than the LCA, over simplification of carbon footprint models, for example by using solely mean values from the data sets instead of accurate data from the supply chain, should be avoided. This way the results stay reliable, problems will not be sifted outside the system boundaries by design and results will not mislead the decision makers. (Weidema et al. 2009, 3-4.) System defining for the overall carbon footprint is crucial by stating which emissions along the life cycle are included, and which are not. Too often it is unclear, how the carbon footprint is actually calculated, and how the final results are determined.

The way that the results are presented is an important issue. What is chosen to be the functional unit, and how transparently the results are communicated to the receiver must be done well. (Weidema et al. 2009, 5.) For example, differences in the local production conditions could lead to a totally different outcome of the carbon footprint survey for the same product in two different production plants. A typical reason for this could be the differences in energy sourcing between the production units. This is also a weakness in the CEPI framework and how it categorises the results of the carbon footprint. When the mill produces its own energy on site, the emissions from the energy sourcing are connected to toe three, which concerns emissions from the product manufacturing facility. Then again, when the mill purchases all the energy it is using the emissions from the energy sourcing are connected to toe six which deals with purchased energy. Due to this fact, different mills could have significantly different appearance in the carbon profiles which can be misleading from the receiver point of view.

The most significant issue that should be kept in mind when discussing the comparability of carbon footprints, is that the carbon footprint is an output of a model,

not a measured value. As well, the carbon footprint results include uncertainties and are affected by decisions made in the modelling stage. (Miner 2009, 23.)

4.4 Role in the communication

Carbon footprint seems to be a buzzword in the media today, even though it is not easy to use, or to communicate to the stakeholder groups. It is a concept which has widely attracted attention outside the research community, and it has potential to increase consumer awareness of life cycle thinking and a product's environmental impact (Weidema et al. 2009, 5-6). When compared to the pure LCA, its potential in getting the life cycle approach into a different decision making processes is significant (Finkbeiner 2009, 93).

Despite the open questions connected to carbon footprinting methods, the market's demand for carbon footprinting is notable (Finkbeiner 2009, 91). In external environmental communication the company should be careful with the claims that they make. It is obvious that without standardized and commonly accepted rules of carbon footprinting and communicating the results, all kind of claims can be made even within the valid advertising regulation (see Chapter 3.2). In the long term this could ruin the customers' confidence towards the issue. Solid, scientifically valid background, and transparent way to communicate are the best ways to increase customers' confidence.

The challenge is to communicate in a manner that the receiver understands the message, including the background of the carbon footprint modelling. The message passed to the receiver should be compact and easy to understand, but at the same time include the limitations of the results.

Carbon and climate change issues can be seen as an essential part of environmental marketing of wood products today. As long as the public focus, in the environmental issues, stays on the climate the companies in the forest industry have a reason to promote intensively the good qualities of their products. Then again, companies should not focus too intensively on carbon footprint marketing on other environmental aspect's

cost. As a summary, balanced communication on environmental issues is the most sustainable way to raise and maintain the environmental image of a company.

It is clear that the carbon footprint is a tool which suites very well to business to business communication situations where the aim is to communicate the upstream GHG emission to the downstream business. The problem comes in business to consumer communication. Even though it is a hot topic in the media only a few understand the meaning and the nature of the carbon footprint results. Carbon footprint results are always modelled not measured so they cannot be directly compared to each other, and this can be really confusing to the consumers. (Miner 2009, 22-23.) At this point, from the consumer point of view, a better message would be that the companies are measuring and taking their climate change effect into account, doing something to mitigate their effect, and gaining results from the actions taken. Overall corporate responsibility, transparency and balanced external communication are the base on which can be built sustainable business. (Kuvaja & Malmelin 2008, 28-31; 177-182.)

In chapter 5.3.2 the results of the case survey considering how other forest industry companies have used carbon footprints in their external environmental communications in the Internet are presented.

5 UPM CASE

In the following chapters a short company presentation of UPM-Kymmene Wood Oy, the plywood manufacturing process, and UPM-Kymmene Wood Oy's plywood mill specific carbon footprint, with its principles and limitations are presented. After this, in chapter 5.4 the results from the market inquiry to the sales offices, and the results from the Internet survey of how other companies in the wood product industry have used the carbon footprints in their external internet communication are disclosed. The final chapters describe the carbon footprint case study and its results.

5.1 Presentation of the company

UPM-Kymmene Wood Oy is the biggest plywood producer in Europe. It has six plywood mills, four in Finland, one in Russia and one in Estonia, and two veneer mills in Finland. All together their total capacity was over 1 million m^3 coated and uncoated plywood and veneer per year in 2008. UPM-Kymmene wood and veneer products are registered under the WISA trademark. Typical end use areas for WISA plywood products are building and construction solutions and the transportation industry. (UPM-Kymmene 2008, 36.)

UPM-Kymmene has adopted a life cycle approach into its operations in all fields of the business worldwide. In its operational principles the company is committed to continuous improvement, and it wants to stand out as a forerunner, also in environmental issues. Continuous eco-efficiency improvement is the driving force behind the environmental management. (UPM-Kymmene 2008, 48-50) In 2009 the company launched a new term, Biofore, illustrating the integration of bio and forest industries. The term symbolizes the company's aim of being the leader in new, sustainable, and innovatively integrated bio and forest industry markets.

5.2 Plywood manufacturing

The basic raw materials in Finnish plywood are birch and spruce. Also, mixed plywood where the inner veneer differs from the face layers is commonly produced. All plywood panels can be overlaid or coated. A typical coating material is a phenolic film, also other synthetic resin based coating materials are used in different customer specified applications. (UPM-Kymmene 2008, 36-37; Handbook of Finnish Plywood 2002, 14-15.)

Basic plywood is formed from three or more thin sheets of veneer, with a specific wood grain direction in each layer, which are joined together by an adhesive. Phenol-formaldehyde resin is the most commonly used adhesive. (Handbook of Finnish Plywood 2002, 5.)

The basic production process in plywood manufacturing is log storaging, soaking, log debarking and cross-cutting, peeling the log into veneers, drying, gluing, pressing under heat, optional coating and final plywood trimming and sawing. The basic flow chart of the plywood mill processes is presented in Figure 4. After the finishing stage, the plywood panels are packed, stored and loaded for transport.

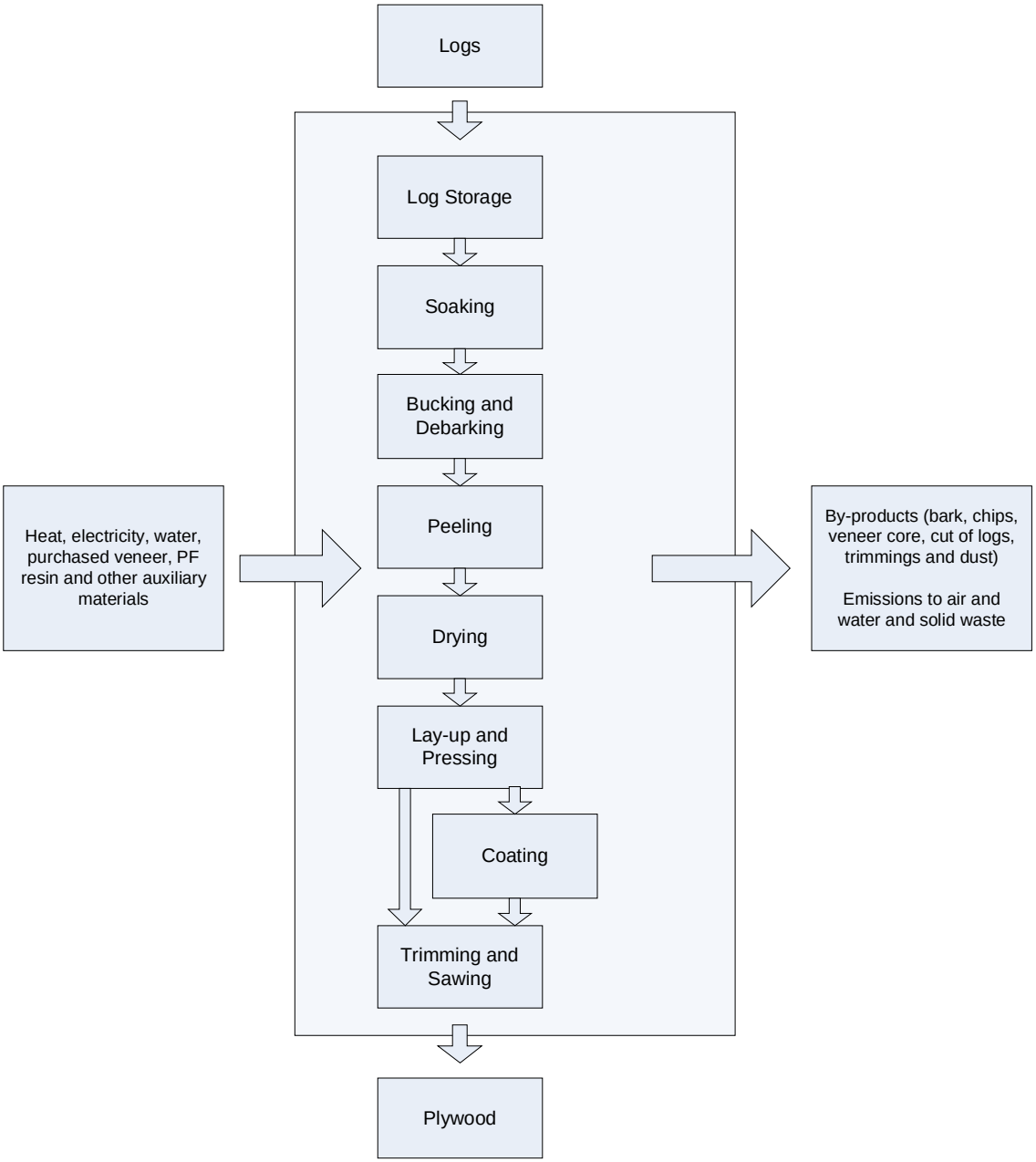

Figure 4 Flow chart of the plywood mill processes.

Roughly one third of the incoming raw material ends up in the end product. The rest of the wood raw material is in several by-products. In general it can be said that one third goes to energy recovery, and the final third is used as pulp chips. Bucking and debarking produces wood waste and bark which can be used for energy recovery. Peeling and drying are process stages which produce veneer cores and veneer clippings which can be turned into pulp chips. Trimming and sawing produces plywood cutting waste and sawdust which can both be used in energy recovery.

The amount of waste water is low in the plywood manufacturing process. Waste water comes mainly from the soaking water and it is typically changed only once a year. Water demand in other process stages is low, and for example the washing waters from the gluing stations is reused in the glue mixture. (Etelä-Savon ympäristökeskus 2006, 5-6, 10.)

From the climate change point of view, the most significant greenhouse gases are long-lived carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Also, the halocarbon gases containing fluorine, chlorine and bromine are effective greenhouse gases, and known to be destructive to the ozone layer. International regulations have helped to reduce the amount of halocarbons in the atmosphere (IPCC 2007, 135).In the LCA studies, CO_2, CH_4 and N_2O emissions are normally taken into account in the modelling.

When considering the plywood process, only the CO_2 emissions seem to be significant due to the following reasons. First of all, the mill site-generated emissions are mainly from the burned fuels, and if the bio based fuels are considered to be climate neutral, then the main emission sources are the combusted fossil fuels. Overall, the main source of CO_2 emissions in the forest industries is the combustion of fossil fuels, and in some cases the aeration basins in the biological waste water treatment plant (Saarinen et al. 2004, 38). Secondly, the methane emissions are minor in the processes and if they occur the source is most likely anaerobic waste water treatment, digestion in the landfill, or incomplete combustion (Saarinen et al. 2004, 41). Thirdly, the reason why N_2O emission are not relevant for plywood is that in the forest industry they occur in the boiler plants only when burning coal with non optimal NO_x removal from the flue gas with urea adding. This is not the case in plywood mills (Saarinen et al. 2004, 32).

These above mentioned claims are also supported in the Puettmann & Wilson (2006, 24-25) study of the wood products life cycle inventory (LCI) where they researched residential wood building materials from the cradle-to-gate perspective, and softwood plywood was one of the materials studied. The results of this study showed that the

cumulative CO_2 emissions allocated to one cubic meter of produced plywood were the most significant and covered over 98% percent of the emissions in mass basis.

5.3 UPM-Kymmene Wood's plywood mill specific carbon footprint, principles and delimitations

UPM-Kymmene has calculated its carbon footprints for the mills. Calculations are based on the principles of the CEPI framework for developing carbon footprints for paper and board products (Chapter 4.2.2). The first carbon footprints of UPM-Kymmene's paper mills were established in 2008. The first carbon footprints of UPM-Kymmene plywood mills were calculated during the summer of 2009.

The main purpose behind the calculations of the mill specific carbon footprints was to improve the capability to answer new questions from the market, and to strengthen the general communication ability concerning the products' environmental performance. Also, the key elements that form the carbon footprint, and how the company can influence those elements to improve its eco-efficiency were valuable points of interest. The first phase of the carbon footprinting project, the mill specific carbon footprints, included main fossil carbon dioxide sources from the raw material production to the mill gate (a cradle to gate system, Figure 5).

5.3.1 System boundaries and the functional unit

System boundary setting and selection of the functional unit are essential when considering the final carbon footprint results and their comparability. Cumulative system boundaries for the mill specific carbon footprints were set from the forest to the mill gate, and they are presented in the Figure 5.

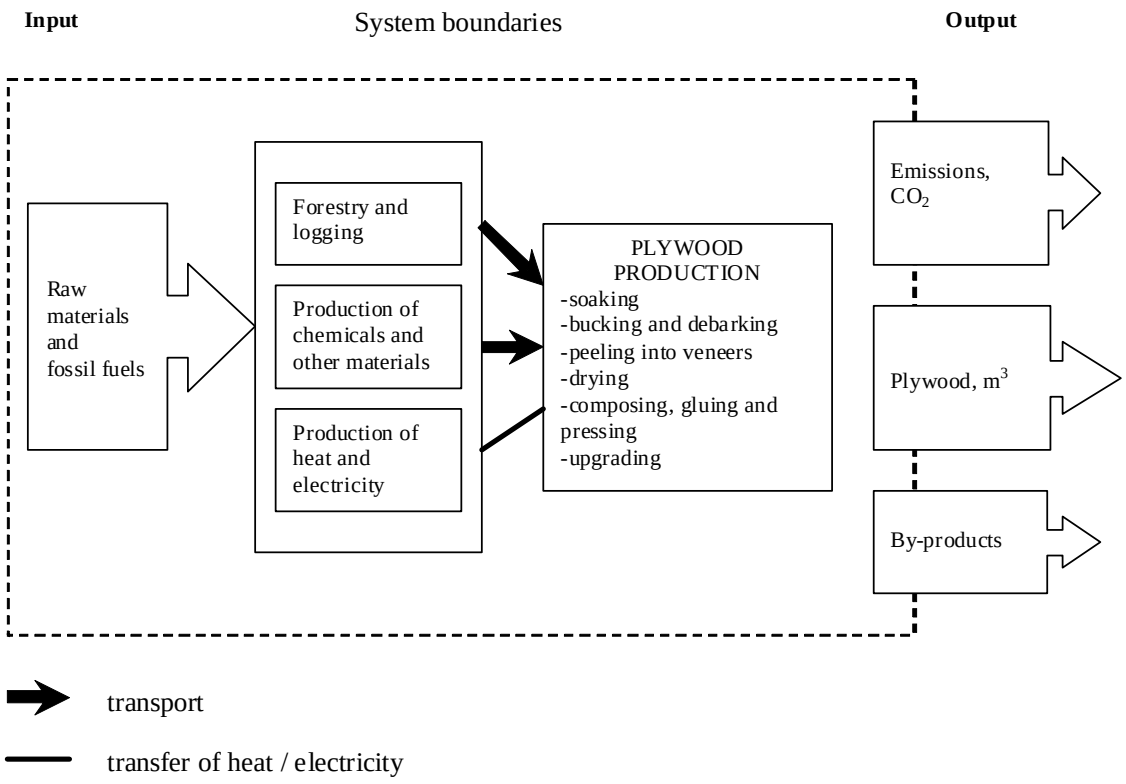

Figure 5 System boundaries.

The UPM carbon footprint model includes fully fossil carbon dioxide burdens from the forest management, harvesting and wood transportation to the mill site, auxiliary raw material manufacturing processes (phenol formaldehyde resin, coating films) and transportation to the mill site, the production and transportation of fossil fuels and use in the product manufacturing process, electricity and heat supply and selling. Excluded from the footprint were manufacturing and transportation of purchased veneer and other auxiliary raw materials e.g. filler, paints, and impregnates. The share of the other auxiliary raw materials in the final product was less than 5% mass weighted and left out from the carbon footprint.

The most significant aspect in the system boundary definition of the mill specific carbon footprints is that the footprint includes fully only the CO_2 emissions. As presented in chapter 5.1, NH_4 and N_2O emissions have not been seen to be relevant for the plywood manufacturing processes.

The functional unit used for the plywood product was one cubic metre of plywood. Manufacturing survey data was collected at the mill level from yearly environmental reports.

5.3.2 Life cycle inventory and mill specific carbon footprint

Life cycle inventory focuses on emissions from the plywood manufacturing process, and energy consumption of the production. Accurate mill specific data is collected from the mill reports. In Figure 6 the principles of material and energy balance behind the mill specific gate-to-gate carbon footprints are presented.

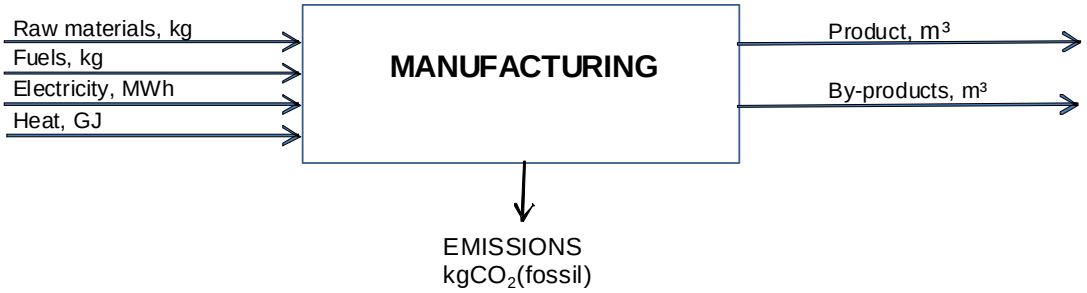

Figure 6 Principles of material and energy balances in UPM-Kymmene's plywood mill specific carbon footprint calculations.

A full scan of different sub-unit processes is time consuming and costly. Another problem is that all the necessary process data is not available from the sub process level at the mill. Therefore, it was decided to use the data which is already reported from the mills on a yearly basis in different reporting databases. Table 2 shows the inventory of material and energy flows of the plywood mill.

Table 2 Material and energy input and output flows in the plywood mill.

	Type	Variable	Quantity
Production figures	Output	Gluing production, net	m³/a
	Output	Deliveries, coated plywood	m³/a
	Output	Deliveries, uncoated plywood	m³/a
By-products	Output	Bark and fuel chips	m³/a
	Output	Veneer cores	m³/a
	Output	Dust	m³/a
	Output	Pulp chips	m³/a
Raw materials	Input	Resins	kg/a
	Input	Laminates	kg/a
	Input	Wood (incl. bark)	m³/a
Fuels	Input	Heavy fuel oil	MWh/a
	Input	Light fuel oil	MWh/a
	Input	Liquefied petroleum gas	kg/a
Energy	Input	Heat	MWh/a
	Input	Electricity	MWh/a

The chemical supplier supplied the phenol formaldehyde resin's carbon footprint, while other resins were left out of the study at this point. Also, the most commonly used coating material's carbon footprint was supplied by the laminate producer.

Allocation is only used for the wood raw material procurement, including forest management, harvesting, and transportation to the mill. All other emissions from the different life-cycle stages are pointed entirely to the selected functional unit. The allocation procedure used was based on physical mass relations between the products and by-products.

Emission factors were collected from different data sources e.g. from the Ecoinvent database and 2006 IPCC Guidelines for National Greenhouse gas inventories. Some notable special features connected to the applied emission factors are presented in the following paragraphs.

The CO_2 equivalent emission from harvesting is from UPM-Kymmene Forest department's own calculations including CH_4 and N_2O emissions. The emission factor is based on yearly average emissions from the wood harvesting in Finland by UPM-Kymmene. (Wende 2009a)

Notable in the fuel production emissions is that the liquefied petroleum gas (LPG) is assumed to be produced in Finland, and the emission factor for the fuel production was applied according to the final research report of Lewis (1997) in the MEET Project: Methodologies for Estimating Air Pollutant Emissions from Transport, that was funded by the European Commission under the Transport RTD programme of the 4th framework programme.

Transport related emissions are calculated separately for wood transport from the forest to the mill site, and for the resin and laminate from the supplier to the mill site. Wood transport calculations are based on average travel distances for the wood transport to saw and plywood mills in Finland in 2008 (Wende 2009b). For the resin and laminate transportation, the distances from the supplier to the mill are estimated from the distance tables maintained by the Finnish Transport Agency or from the Google Maps mapping service.

A significant part of the electricity used in the UPM plywood mills is sourced from UPM's internal trade. UPM's own emission characterization factor, established by the UPM Energy department, is used for this electricity. The factor describes the fossil CO_2 emissions taking the different electricity sources into account. (Wende 2009b.) In some specific cases, when this factor cannot be used, the country specific emission factors from the IPCC are used instead.

Emissions from the purchased heat are calculated using lower heating values of the fuels and fuel specific emission factors from the IPCC.

One example of the mill specific carbon footprint and its explanation sheet is presented in Appendix 2.

5.4 Market survey

The following two chapters present the methods used in the survey, the results of the survey, what kind of role the carbon footprint calculations have in the wood product markets today as well as discussion covering the topic. The situation was observed from

two different perspectives. The first step was to investigate, how the company's own sales operations had come across with the demand of product carbon footprinting.

The second step was to look into the overall situation in the forest industry. It was done by getting acquainted systematically with several companies' external environmental communication in their Internet sites. In the survey the focus was that what the other actors in the forest industry have done this far in carbon footprinting, and how they have presented the results.

5.4.1 Inquiry to the sales offices

The market survey was made for the whole market area of UPM-Kymmene Plywood. The survey was carried out with open questions that were sent via e-mail to the person responsible for environmental questions in all sales offices. With the inquiry a short description of the aim of the inquiry was sent. This was done in order to find out how the organization has faced the rising demand for carbon footprint information in their every day actions.

Every sales office has an environmental marketing contact person to whom the environmental marketing issues are directed. Then the inquiries are forwarded to the person who has the qualification to answer them. These contact persons in the sales offices were selected to be a suitable target group with the best knowledge on the issue.

The survey was sent to 13 sales offices and they all answered the questions. The sales offices were asked to track down inquiries from the customers which had come within the past year, and were linked to carbon footprint or climate change issues. The aim was to discover the most common inquiries connected to climate change, carbon footprints, CO_2-emissions, greenhouse gas emissions, life-cycle analysis etc. that the sales offices face from their everyday customer contacts. Interesting subjects were: Which customers make the inquiries, what do they ask, and what is the driving force behind the inquiries. The following five questions were presented to the sales offices.

1) How many inquiries you have got within the past year? (CO_2 and carbon footprint issues)
2) Who asks? Customer type, name and country? Distributor [on behalf of himself or on behalf of an industrial customer] or an industrial customer? To which product are the questions connected?
3) What kind of questions have you got from the customers?
4) One aim of the carbon footprint project is to produce suitable info and material to help you so that you are able to answer the questions that customers pose. Now is your chance to influence. What kind of extra material or info would be useful?
5) Comments?

Only the sales offices in UK, Germany, Italy and in the Benelux countries have received several inquiries connected to these topics within the past year. The other sales offices had not received any. The one in Germany had received three direct inquiries and in Italy a couple while the office in UK had received 7 inquiries. The Benelux countries' sales office regularly receive inquiries connected to carbon footprints and other topics connected to CO_2 emissions. In addition, the sales offices mentioned that the customers are interested in, for example, FSC and PEFC certificates, product disposal instructions, and environmental labels e.g. swan mark.

Other interesting issues that came out in the inquiry responses were that the price seemed to have more influence on buying decisions than the products environmental credits. This feature was also found in the literature, discussed in chapter 3.2., where the effect of environmental consciousness on consumer behaviour was discussed.

It should also be noted that the sales offices in Norway and Italy pointed out that the wood origin certificates were the most commonly inquired items from the customers. If this is a trend also in the other areas, it can be assumed that such a label is not enough to differentiate from the competitors in the future.

Another interesting viewpoint from the Danish sales office was that the overall environmental performance of the Nordic products is assumed to be on a high level without questioning or even asking about it. It can be argued whether this is the real situation, or is this a mark of an environmentally inflexible market as discussed in chapter 3.2, or has not enough been done concerning the external environmental communication, and the whole potential of environmental marketing is unexploited?

"PEFC and FSC are the most commonly asked." - Norway

"During the building exhibition Bygg Reis Deg in September there was, however, a strong focus on Green Values and the SWAN ecolabel, and the response was much higher than expected. Until now the SWAN has not been very common or demanded in the building industry in Norway, but during Bygg Reis Deg a lot of new applications for SWAN ecolabel were received and the interest for green values was stronger than ever."-Norway

"Customers focus on price, price, price and price again"…"As long as panels are CE marked customers are satisfied"…" Guess they (customers) believe a Finnish product fulfils all important things." - Denmark

It came often out that the questions were posed by distributor customers, whose own customers demand certain environmental performance from the product. Another group posing the questions was the customers who are working globally and their management level targets demand certain environmental performance.

Common opinion among the sales offices was that carbon footprints could be a good marketing and sales argument in the future. The product's environmental performance should be highlighted to be able to stand out, and differentiate with tightening competition. It can be assumed that the importance of green values in buying decisions will not disappear, and the meaning will be emphasized in the future. The need for suitable arguments is real. A suitable tool for the offices could be, for example, a list of frequently asked questions answered by a specialist.

It is notable that even though the general discussion in the media concerning climate change and carbon footprints is active, the discussion has not reached the business to business communications yet. This does not change the fact that the situation can change rapidly and customers' interest in climate issues can rise fast. Also notable is that the significance of environmental issues can vary between countries, and also the focus of the public discussion can be different.

The amount of people taking part in the market survey was rather small. Sales offices environmental coordinators were estimated to have the best knowledge of the situation in the UPM-Kymmene plywood product markets, and were selected as the target group. The survey covered the whole sales area, and it can be seen as valid for disclosing the current situation in the field, concerning the customer inquiries connected to environmental aspects.

5.4.2 The Internet survey - External environmental communication in the forest industry

External environmental communication in the forest industry sector was studied by observing the companies Internet sites. Observing was chosen to be the suitable research method to get the direct information concerning other organizations external environmental communication actions. Observation was carried out systematically, and the results were documented into a matrix form.

Even though the main focus was to find carbon footprint related material, and observe the ways the companies communicated it, other issues were also observed in order to get a bigger picture. The first observed issue was, how does a target company calculate its product's carbon footprints, and on what level does it disclose the climate issues in its external communication in the Internet. Another object of interest was whether the company has any publicly available environmental reports or some commonly known LCA based ecolabels such as Nordic swan label, EU-flower or Der Blaue Engel certificates. The final observed issue was about wood origin certificates, especially the FSC and the PEFC certificates.

The survey included 38 companies in the forest industry sector. These companies were already observed and followed by UPM-Kymmene Wood's communication department. The target group was chosen according to the recommendations of UPM-Kymmene Wood's business segments. (Kullaa 2010.) 36/38 of surveyed companies operate in the wood product industry, and 23 of those also produce plywood. Two companies in the target group did not have an updated Internet site. The target groups head offices' geographical locations are presented below in Table 3. In addition to this, a simplified matrix table from the results is presented in appendix 3.

Table 3 The geographical location of surveyed companies' head offices.

Oceania	1
Asia	6
Europe	15
South-America	7
North-America	9

It was noticed that the environmental issues were mostly at the corporation level Internet sites while the wood product divisions Internet sites were focused more on the product presentations. Also notable was that in the case of smaller companies, or single wood product divisions, the Internet sites could include links to either corporations' sites discussing sustainability issues or to independent organizations and authorities Internet sites which included more general information connected to that specific topic.

17 of 38 companies reported their environmental performance figures in a publicly available environmental report. Eleven of those had a sustainability report, that also included other than environmental issues connected to sustainable development. Six companies had included environmental issues in their annual reports. Typical LCA based type I environmental labels such as Nordic swan label or EU flower were not found from any of the observed companies. Also self declared comments of products contributing to the green building certification points were stated only a few times.

Statements of wood origin and forest certification such as FSC and PEFC were common. 32 of 38 companies mentioned the wood origin issues. Existing certificates

were highlighted, and even if the company did not yet have a certificate, they informed the state of the certification process as well as certification objectives.

Climate change and carbon footprint issues were far less commonly stated than, for example, forest certificates. It was typical that the companies discussed climate change issues on a general level in their Internet sites. In addition, two different communication styles were clearly observed. An educational approach that included general info of wood's climate change effects, as well as conventional environmental claims connected to wood. Another approach to the issue was to communicate with the help of key figures.

Eleven companies reported their greenhouse gas emissions publicly, usually on a corporate level as total yearly emissions. Five of the observed companies proclaimed to have the carbon footprints determined, and one company told that they have started to develop product specific carbon footprints. One of the five companies, Weyerhaeuser, maintained a self-declared product specific EPDs, and one other company, Egger, a third party verified product group specific EPDs. Both these EPDs included the product carbon footprint as one impact assessment class. The three remaining companies did not indicate results of the carbon footprint calculations publicly in the Internet.

If the communication about climate change issues is based only on a general knowledge approach, it is not very informative or reliable from the stakeholder group’s perspective. The general knowledge is available all around, and in order to add some value to the consumer, some measurements and hard facts about the process are needed. In contrast, only communicating with figures and modelled values such as carbon footprints without necessary background information can also lead to an unwanted situation where the customer is overwhelmed with the information and is not able to assimilate the content. Therefore a balanced combination of these two approaches is needed.

This part of the study was mainly a qualitative case survey, but also included quantitative aspects. Concerning the reliability of the study it can be stated that the observed group of companies was a rather comprehensive sample. It was estimated that

this target group was a good representative sample of the actors in the forest industry. Also the size of the target group turned out to be adequate for drawing conclusions about the trends in the observed subjects.

5.5 Case study – Possibilities to extend the mill specific carbon footprints

The following chapters include background of the case studies done including goal and scope definition, description of functional unit and selected system boundaries, results from the case studies, discussion, and conclusions.

5.5.1 Materials and methods

The CEPI framework for carbon footprint calculations and its extension for assessment of transport carbon footprint were applied. Inventory data for transport related emissions were collected from the real supply chain with the help of the distributor customer.

Goal and scope definition

The case study includes two parts. The main goal of this case study is to determine plywood manufacturing's transport related emissions, as well as, the emissions from disposal at the end of the life cycle, from the mill gate to the grave perspective. These reviews generate information which can estimate if it is suitable to adapt into toes seven, nine and ten of the CEPI framework (transport related GHG emissions, emissions associated with product end-of-life and avoided emissions) which is another goal of the study. Toe eight (emissions associated with product in use) is excluded because it is assumed that the plywood does not generate emissions during use (see Chapter 4.2.2). In practice, this means that the scope includes the product life cycle's transport stage after the mill gate, and the product end of life stage impact. Transport related emissions are compared to the cradle-to-gate carbon footprint done for the product.

Functional unit and system boundaries

Suggestions for the case product were requested from the sales offices, and suggestions were discussed in the thesis' steering group, where the final case product was decided. Basic uncoated spruce plywood was chosen to be the case product. The functional unit in the study was one cubic metre of plywood. The same functional unit was used in previous carbon footprint calculations in UPM-Kymmene plywood mills (Chapter 5.2.1). The system boundaries for the case study are presented in Figure 7.

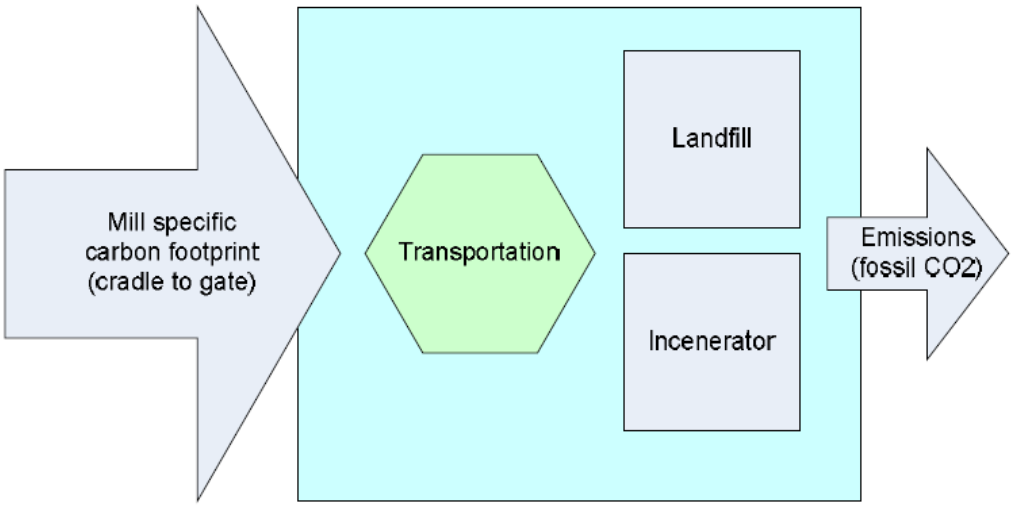

Figure 7 Target system and its boundaries.

Transportation phase after the mill gate includes several different transports. Different transport vehicles and hauls are described in Figure 8.

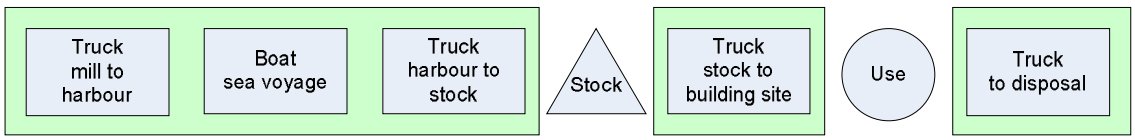

Figure 8 Final product transportation after the mill gate. (from the gate to grave perspective)

Data quality and simplifications

The selected case product, WISA-Spruce plywood, is developed for packaging and construction applications. The density of 1 m^3 of spruce plywood is 520 kg/m^3 including resin and average moisture. The moisture content was assumed to be 10% and

adhesive content 4% of the total weight of the functional unit. The moisture content was subtracted from the total weight and product's dry weight was used in the calculations. UPM-Kymmene has defined fuel values for its products and for WISA-Spruce plywood it is 2.2 MWh/m³. The energy content for bark and fuel chips were estimated to be the same as in the burned residues mix at the Pellos mill in 2008, 18,6 MJ/kg (Kunnari 2010). The average density value of 404 kg/m^3 for industrial spruce chips, calculated from the saws and plywood mills in Finland, was used as a conversion factor. (Lindbland & Verkasalo 2001, 429).

From the stub to the mill gate carbon footprint of the Pellos mill from 2008 was used as a reference value.

The use phase of the product life cycle was excluded from the study due to the selected functional unit. It was assumed that the selected functional unit of plywood itself does not cause emissions during the time it is bonded to the building structure (see Chapter 4.3.1). Also emissions from the building phase were excluded because those were assumed to be approximately the same regardless of the building material used.

CEPI recommends that the emissions from the transport of the final product should be determined from the manufacturer to the first customer who can be a distributor, a converter, or a user. (CEPI 2009, 8.) In this case study the whole life cycle was looked at more closely.

Emissions from transportation were estimated based on the transport routes and travelled kilometres, mode of transport and assumed emissions per travelled kilometre. In practice, the travelled kilometres (km) are multiplied by tonnes of goods transported (t) in order to the get value for tonne kilometres (tkm). After this the tkm value is multiplied by a specific unit emission factor ($kgCO_2$/tkm) depending on the mode of transport. (VTT 2010.) Emissions from different transportation steps are summed up and divided for the selected functional unit. In this case, emissions were allocated to a net weight of 1 m^3 of the product.

The case transportation route was selected to be from the Pellos mill in Finland to the plywood markets in the Netherlands. All transports were estimated to have a full load and the return of empty vehicles was not taken into account. It was also estimated that the most direct routes were used in transports.

Emission factors, applied in the UPM-Kymmene mill specific carbon footprints, were also applied in the after the mill gate transport related emission's determination. For road transportation the emission factor was 0,034 $kgCO_2$/tkm, which corresponds well with the value given by the Technical Research Centre of Finland (VTT), in their LIPASTO dataset for traffic's unit emissions, for full trailer combination (mass 60t, pay load capacity 40t) in highway driving. For the rail transportation, the emission factor used was 0,00945 $kgCO_2$/tkm which corresponds with VTT's factor for electric train transportation including shunting. (VTT 2010.) For the sea voyage the adapted emission factor used was 0,0194 $kgCO_2$/tkm.

Biogenic CO_2 emissions were treated according to the CEPI framework (see Chapter 4.3.1) and excluded from the emission totals. Biogenic emissions do not increase the total amount of atmospheric carbon and can be seen as climate neutral.

End of life –stage, scenarios

The service time of plywood depends on the application where it is used. Also the disposal methods vary depending on the application, and the country where the plywood is used due to variations in local legislation. The common disposal methods for used plywood panels are burning, landfilling, composting and recycling. (Finnish Forest Industries Federation 2002, 64). Even though recycling is the preferred way to dispose the products, it is still quite rare. On the other hand, composting is a also rare way to dispose of the used plywood nowadays. Landfilling and incineration were chosen to be the tested product end of life scenarios.

5.5.2 Results and discussion

According to the scope of the case study, the subject is approached from three different perspectives. In this chapter the results from the case studies, as well as, discussion and conclusions are presented.

CASE 1: EFFECTS OF TRANSPORTATION AFTER THE MILL GATE

The first steps in the transportation route were under the control of plywood's manufacturer and thus easy to track down. The third step from the harbour to the distributor's several distribution centres caused substantial deviation. Results from the first three steps of the transportation related emission are presented in Table 4.

Table 4 Transport related emissions from the mill to the first customer.

Route	**Vehicle type**	**Emission factor kg CO_2/tkm**	**Distance km**	**CF kg CO_2/m^3 plywood**	**Cumulative CF kg CO_2/m^3 plywood**	**Data source for distances**
Pellos -Kotka, pretransport	Electric train	0,00949	114	0,56	0,56	Calculated
Kotka - Amsterdam	Ship	0,0194	2 180	21,99	22,55	Calculated
Amsterdam – distributor's stock	Truck 60t Euro III	0,034	10 - 400	0,18 - 7,07	22,73 -29,62	Calculated
Stock – use	-	-	0	0	22,73 -29,62	Estimated
Use - disposal	Truck 60t Euro III	0,034	10 - 400	0,18 - 7,07	22,91 -36,69	Estimated

The sensitivity of the first three transport steps of the calculation was checked by substituting part of the sea voyage by road transport. The new route was Pellos-Kotka-Rostock-Amsterdam, where the Rostock-Amsterdam transition was done with trucks (60t, Euro III). This did not have significant effect on the overall cumulative carbon footprint and increased the overall emissions between Pellos and Amsterdam by only 3,9%.

The last two transportation steps could not be observed and therefore were estimated. It can be assumed that the final customers will collect the products from the closest distribution centre and thus this step in the transportation route will not effect the overall carbon footprint significantly, and can be left out of the scope. Considering the distances inside the Netherlands the final transportation step (from use to disposal) is not likely over 400 km and due to this, the overall cumulative transport related carbon footprint from the mill gate to the disposal site is approximately 40 $kgCO_2/m^3$ plywood when the transportation vehicle was assumed to be the same in the final transportation step (60t, Euro III). If this figure is compared to the mill specific carbon footprint, which in 2008 was 80 $kgCO_2/m^3$ plywood, the significance of the emissions caused by the final product transportations can be seen.

It should be noted that the transportation steps from the distributor's stock via the use phase to the disposal phase includes significant assumptions and the figures can be used only as a estimated values. A better and more reliable value for the comparisons is the cumulative carbon footprint from the mill gate to the distributors stock which can be considered to be the first customer. For that route, transportation modes are known as well as are the distances, and the transport related emission can be calculated in a reliable way. In this case the cumulative carbon footprint from the mill gate to the distributor's stock varies from approximately 23 – 30 $kgCO_2/m^3$ plywood. If these figures are compared to the Pellos mill specific carbon footprint from 2008 it still can be noted that the effect of post-mill transportation to the overall carbon footprint is remarkable.

The results also show also that in this case the most significant global warming potential is connected to final product transportation from the mill to the first customer, in comparison to the transportation steps connected to the remaining life cycle. This is due to the fact that the transportation distance from Finland to the Netherlands is significantly longer than the post distributor transport distances inside the Netherlands.

In a hypothetical situation in which the distributor ordered the plywood from a Brazilian plywood manufacturer located in Rio De Janeiro, instead of Finland, and the emissions

were modelled with the same emission factors and estimates, the overall carbon footprint would be significantly higher. In this scenario, only the sea voyage itself would cause a carbon footprint of 100 $kgCO_2/m^3$ plywood. Table 5 presents the results from the sea voyage from Rio De Janeiro to Amsterdam.

Table 5 Emissions from sea voyage from Rio De Janeiro to Amsterdam

Route	Emission factor kg CO_2/tkm	Nautical miles	Km	Tkm/m^3 plywood	CF, kg CO_2/m^3 plywood
Rio De Janeiro - Amsterdam, sea voyage	0,0194	5329	9869,31	5132,04	99,56

It should be remembered that emissions from the final product transports are case-specific and cannot be included in the overall carbon footprint figures as such because of the varying transportation routes. As a conclusion from this part of the case study it can be stated that in some cases these post mill transport emissions could be a significant part of the whole carbon footprint of a plywood product and that is why this information should be available to the customers on request.

CASE 2: ENERGY RECOVERY

The effect of the energy recovery can be reviewed from two different viewpoints. Firstly, the energy recovery potential of plywood products at their end of life stage of their life cycle, and the possible fossil fuel substitution effects. Secondly, the energy recovery potential of the by-products (processing residues such as bark and fuel chips) generated during the plywood manufacturing at the mill, and the substitution potential connected to this aspect. The net calorific values and emission factors used in the calculations are from the IPCC.

Concerning the combustion of disposed plywood, in the ideal situation 444-840 kg of fossil CO_2 emission can be avoided by burning one cubic metre of disposed uncoated spruce plywood instead of fossil fuels. Results from energy substitution effects of disposed plywood utilization in energy recovery are presented in Table 6.

Table 6 Substitution effect potentials from the disposed plywood's combustion.

Fossil fuel	Net calorific value GJ/kg*	Emission factor $kgCO_2/GJ$**	Avoided emission $kgCO_2/m^3$ plywood
Natural gas	0,048	56,1	444
Light fuel oil	0,043	74,1	587
Heavy fuel oil	0,040	77,4	613
Coal	0,026	94,6	749
Peat	0,010	106	840

*Net caloric value source: (IPCC 2006a)
** Emission factor source: (IPCC 2006b)

Considering the possible substitution effect on a mill level, the effect is significant. In 2008 the Pellos mills substitution effect could have been 118 000 -223 000 tons of CO_2. Even though this figure is not suitable to be included in the carbon footprint figure, it should be considered if there is a different context where it can be utilized. Results from the energy substitution effects of the Pellos mill process residual utilization in energy recovery are presented in Table 7.

Table 7 Substitution effect potentials from the combustion of wood based process residues

Fossil fuel	Net calorific value GJ/kg*	Emission factor $kgCO_2/GJ$**	Avoided emission, case Pellos mill tCO_2/a
Natural gas	0,048	56,1	118197
Light fuel oil	0,043	74,1	156121
Heavy fuel oil	0,040	77,4	163074
Coal	0,026	94,6	199313
Peat	0,010	106	223332

*Net caloric value source: (IPCC 2006a)
** Emission factor source: (IPCC 2006b)

Considering the mill specific carbon footprints, and toe ten in the CEPI model, the case of avoided emissions is really difficult. Even though there could be really beneficial aspects to be included in the carbon footprint, the enormous variety of different alternatives makes this impossible to implement. This is also the situation with energy recovery of disposed plywood and wood processing residue. Among other possible aspects, the substitution effect has great potential to promote the good qualities of wood from a climate change standpoint, but it should be communicated via another tool than the mill specific carbon footprints.

CASE 3: LANDFILLING

As discussed in Chapter 2.2. landfills could have a remarkable carbon pool effect on the global carbon cycle. Notable also is that due to the solid woods lignin content, it is very durable in anaerobic conditions and the methane emission is rather low. In this case, the emissions from landfills are not included due to the bio based origin. The potential energy substitution effect can be determined based on the methane potential of wood. The methane formed can be collected and burned as a substitute for fossil fuels. It is obvious that the emissions from the landfills are highly site specific and depend on the local conditions.

The carbon content of dry wood is approximately 50%, with approximately 30% from the lignin content. The lignin can be assumed to be non-degradable in an anaerobic environment (Pipatti et al. 1996, 56-57). The lignin content is taken into account in the methane potential and it does not give a contribution to it. For wood waste, the potential methane yield is 0,013-0,022 grams of methane per gram of dry wood. (Micales & Skog 1997, 150)

From this follows that in the optimal landfill conditions 5,8 – 9,8 kg of methane is formed from the decay of one m³ of plywood. In reality, not all the methane formed in the landfills is transferred to the atmosphere. Some of the formed gas is oxidized into CO_2 and water on the surface layers of the landfill. Among other factors also the oxidation effect is highly dependent on the local conditions and the research results are contradictory. The deviation of the oxidation factor in the research has been 0-10%. (Pipatti et al. 1996, 19.)

If the oxidation factor is assumed to be 0% and if it is assumed that 100% of the methane is collected and burned as energy, the substitution effect varies between 16 – 52 kg CO_2/m³ of plywood. In reality the recovery rate for methane varies between 20-50% (Pipatti et al. 1996 23), so the overall substitution effect can, in the ideal situation, be a maximum of 8-26 kg CO_2/m³ of plywood.

In addition, it can be concluded that if 3% of dry wood becomes landfill gas, according to Micales & Skog (1997) study, the remaining 97% corresponds 433kg of dry wood which stays in the ground slowly forming humus and contributing to the lands carbon stock.

The case study showed that the potential of methane generated from waste plywood's landfill disposal is highly hypothetical and minor compared to the possible benefit gained from the utilization of disposed plywood in energy recovery. In addition, in many cases the political guidance is restricting the landfilling of energy wastes. From these reasons, it cannot be recommended to include a landfill scenario as a possible source of avoided emissions into a carbon profile model.

6 RESULTS OF THE STUDY

The aim of this study was to respond to the market and customer demand of plywood environmental performance from the climate change viewpoint, increase the company's knowledge of their products environmental performance and to find the tools to increase the knowledge externally via more versatile communication in the future. Another objective of the study was to find the most innovative ways to make the most of the carbon footprint calculations in external environmental communication and marketing. The aim was to find the best practices in the field, review those critically, and adapt methods which best suit the company. The third objective was to clarify the stage and possible effects of global climate policy for wood products, and find the viewpoints which could be beneficial for plywood products in the future. The aim was to review the possible effects of the international climate agreements, standardization issues, and development of carbon footprint calculation methods, as well as to discuss critically what kind of effects the increase of overall environmental consciousness could have for the plywood business.

From these objectives, four main research questions were derived. In this chapter the answers to the research questions based on the study are presented. Further conclusions and recommendations for concrete actions are presented in Chapter 7. The study included four individual parts, a literature review, an inquiry to the sales offices, the Internet survey and a small case study concerning the possibilities to widen the scope of the mill specific carbon footprints.

Question 1) How to bring out the good qualities of plywood in the climate change issues?

The literature review showed that the good qualities of the wood and wood products have been widely recognised and accepted. Among other actors, also the IPCC and EU have recognized the possibilities connected to the use of wood products from climate change perpective. However, a general model of how the carbon stored up by the wood

products or the energy substitution potential should be calculated and weighed has not thus far been developed. In the future the carbon sink property, and the energy substitution potential will most likely be somehow included in the politically set guidelines and this way to the national legislation. For example, in Britain and France, wood based construction is already endorsed by legislative guidelines, and it is safe to assume that this kind of guidance will increase in the near future. Also, several voluntary based standards concerning the issue are under development.

Concerning the plywood and the carbon footprint calculations, the carbon profile model developed by CEPI suits well to bring out the good qualities of the plywood especially in business to business communication situations. Energy production and the fuels used have an important role in the overall carbon footprint. In the UPM-Kymmene case, local energy profiles and high use of biogenic energy sources is a clear benefit compared to the others.

Question 2) How ”hot” is the carbon footprint topic from the sales offices perspective, and what are the needs of the sales offices for external communication on the issue?

It became clear from the inquiries sent to the sales offices that the topic is not very commonly asked by the customers. Even though, in some regions (UK, Germany, Benelux) the customers interest toward the issue seems to be increasing. The needs that the sales offices have, in order to be able to use this topic in external communication, are for example, suitable communication tools as well as training to learn to use the arguments correctly. Overall, the topic was commonly seen as a potential way to differentiate in the markets, and the interest towards the study was positive.

Question 3) How can the mill specific carbon footprint calculations be used in external communication and marketing, and what are the best practices?

The Internet survey proved that not much has been done thus far by the other companies in the forest industry sector. Even though, some of the competitors have already presented the carbon footprints for their products. The quality of the carbon footprints

presented varies, and here would be a good possibility to differentiate with transparent and detailed figures which backgrounds are properly presented.

An open, transparent, and message of continuous improvement is the key in building a trusting environment. The carbon footprint has to be an integral part of the environmental communication and marketing, and it has to be developed and updated, in order to profit from it.

For business to business use, it is reasonable to develop and maintain carbon footprints and environmental product declarations which are defined from the cradle to gate perspective. In these cases, the main purpose is to transfer information related to the GHG emission so that the next actor in the supply chain can determine its own carbon footprints.

For common discussion on the issue, and for use in business to consumer communication, the overall approach of the cradle to grave perspective is also justified. Even though the sources of uncertainties rise due to the fact that all the emission sources are not under the company's control and more generalized values from the databases are forced to be used in the modelling.

Concerning the best practices in the field, a combination of detailed carbon footprint figures with general information on the issue would be the best way to approach the subject. The general information could include, for example, background information on the carbon footprint calculations, information about the harvested wood products climate change effect, the company's environmental policy as well as the environmental action plan with it achievements.

Question 4) What possibilities are there to extend the scope of the carbon footprint calculations and is it possible to compare existing calculations to other carbon footprints?

From the sustainable communication point of view, the only reasonable way to extend the carbon footprint, with the resources that the company has at the moment, is to include the emissions from the final product transportation to the overall mill specific carbon footprint. This does not mean, for example, that the avoided emissions from the utilization of the disposed products in energy recovery, should be left out of the scope of communicated issues, but it is recommended to communicate it as a separate issue and in a separate context.

When the comparability is considered, it is critical to understand what the carbon footprint consists of and what the modelled figure stands for. UPM-Kymmene's mill specific carbon footprints are not comparative assertions and they should not be used as such.

The lack of harmonization in carbon footprint methodologies as well as different environmental labelling schemes create a situation where there is a demand for several different labels for different markets. From the business' perspective this can be problematic. The best solution would be to find the best possible combination of labels and declarations to be used in external communication. A good example of such a situation can be found e.g. from the plywood markets. UPM-Kymmene has made its own carbon footprint calculations, and additionally, for the British markets, an Environmental Profile which includes the climate change effect has been done by BRE. Even though the carbon footprint made by UPM-Kymmene, and the climate change effect calculated by BRE basically mean the same thing, the results are not comparable because of the differences in the methods used. The BRE result is valuable in its own market area where it is mainly used as part of the building sustainability assessment (BREEAM). It does not decrease the value of development work of other carbon footprints, EPDs or mill specific environmental profiles to be used in other market areas if the market situation demands.

7 CONCLUSIONS AND RECOMMENDATIONS

The driving forces behind the whole carbon footprinting issue are: growing market demand and increasing political control. The key issue is to learn how to use carbon footprints in environmental communication as an efficient sales argument underpinning the new Biofore Company brand. Another aspect is that the cooperation with different stakeholders should not be underestimated. An accurate analysis of stakeholder's needs and demands is the right way to start to develop sustainable communication. Being unnecessarily careful and cautious in environmental communication does not work. It only leads to a situation where the advantage of being the front runner is lost and the possibility to differentiate and to stand in the spotlight of the markets is handed to a competitor.

The most notable communication challenge is that the knowledge of the customers in climate issues and carbon footprinting is deficient, and the effect that it has on the purchasing decision is rather low. An exception is the procurement in public buildings. The good qualities of plywood, and other wood products, should be emphasized with proactive communication. One way of doing this could be an educational approach to climate and environmental communication, with which it would be possible to influence the customers to ask the right questions. This would raise another challenge to keep ahead of the customers and have the answers ready. It would require continuous development of the company's internal environmental knowledge, as well as the internal and external communication. Once the carbon footprint is done, it can be utilized with efficient communication, but one has to be ready to react, and adapt the communication to the ever changing environmental focus and discussion.

It has to be kept in mind that not all are uneducated about the subject, and therefore at least two kinds of material is needed. One should contain more specific information intended for professionals, and the other more generalized informative content. The calculated carbon footprint and carbon profiles give a strong base for the environmental arguments used to support sales, especially in the business to business context. As an

addition to the carbon footprints and profiles, and from customer request, the company can also include the emissions associated with the final product transportation to the first customer, in order to help them to assess their own carbon footprint. For that purpose, a suitable calculation tool should be created.

In business to consumer communication the focus should be more on the general level information concerning the carbon footprint. The marketing and communication material could include a case example of a carbon profile, which aims to illustrate what the carbon footprint consists of. The communicated message has to be simple, easy to understand, and in this context the potential of a third party verified type I environmental labels, such as the Nordic swan, should be kept in mind. Also, the effect of the company's overall positive environmental image should not be forgotten.

Concerning the comparability of the UPM-Kymmene carbon profiles, from the LCA's viewpoint, comparing plywood as a single product to other products is difficult if the comparison has not been done within the same study. The problem is the fact that, the carbon footprints are modelled figures and a convergent modelling method has not been yet developed. In this situation, a better way to communicate is to present the results transparently, and highlight the improvements in the carbon footprint results. Existing carbon profiles as such, should not be used as comparative assertions in direct product comparison unless there is a certainty that the calculations are done exactly the same way.

One should remember that focusing only on the carbon footprints and climate change issues can lead in to a distorted overall picture of the environmental performance. External environmental communication should be comprehensive and continually improved, and climate change issues as well as carbon footprint should be an integral part of it. The best way to avoid using misleading marketing claims, is to highlight the transparency of the methods and calculations used in the carbon footprints. It is a key issue when the calculation methods are not standardized and verified. Also, it is the only way to prove to stakeholders that principles of communication are sustainable and calculations are done properly.

Suitable channels for communicating the environmental, and climate issues are, for example, corporate web pages, and brochures. Also taking part in exhibitions, and cooperation with NGO's and other stakeholders in their projects, would give the products more general coverage.

Developing the environmental know how of the sales network is crucial in order to get the message through to the customers. Making the material is not enough, if it is not properly used. It is recommended to create a system of cooperation between company's environmental, marketing and communication departments concerning the environmental issues to ensure the flow of needed information in the organization. Environmental communication strategy planning and developing, as well as planning of environmental trainings should be done in cooperation with these actors. The coordination of environmental marketing has to be a continuous cooperation between the environmental and the marketing departments in order to combine the expertise of both of the groups. The marketing department has to actively pass on the demands of the markets to the environmental department which has the know how to answer the demands. Also it has to be kept in mind that the environmental marketing has to be done persistently because the results will show only after a rather long time span.

One possibility in upgrading the existing communicational materials and the mill specific carbon profiles is creating broader mill specific environmental profiles. Existing mill specific environmental information and the calculated carbon footprints, could be combined as an environmental profile of the mill. Another option is to broaden the carbon footprint calculations into complete EPDs. EPDs could be created for single products or product groups. This would most likely require the use of LCA software e.g KCL-ECO or Gabi 4.2 to carry out the full LCA reviews.

A great possibility inside the UPM-Kymmene, is to cooperate between different divisions in the environmental area. There is no point in reinventing the wheel, if some other sector of the company has already developed the needed tools. Cooperation inside the corporation between the different business units should be increased. The know how in environmental and climate issues should be distributed as efficiently as possible. A

good example of the benefit received from the corporation is the ”Carbon life” virtual presentation. On the other hand it should be kept in mind that, if the external environmental communication of a division is too heavily generalized as the corporate level environmental communication, the important individual aspects of a separate division’s environmental performance can become blurred.

Concerning the ongoing standardization work, the new ISO carbon footprint standard’s congruence with CEPI’s model has to be determined, especially the similarities of the limitations in the footprint calculations done for UPM’s plywoods. Based on this comparison the need for corrective action to the carbon footprint has to be assessed. The new ISO standard will very likely be applied rather widely, and therefore it would be beneficial if UPM’s footprints are convergent with the ISO standard.

The growth potential of wood construction also applies to plywood. For example, LEED in the United States, and BREEAM in Britain guide the public procurement heavily. Even though these green building rating systems do not directly give credits for harvested wood products, they include aspects which encourage using wood. Wooden building products are likely to benefit from the increasing preference of ecological building in both public and private projects.

The debate around climate change is very active, and all kinds of opinions are presented in the public forum. In any case it is clear that the politically set guidelines will continue to push for climate change solutions, and there is a chance for wood products to benefit. As with all public debate, the environmental discussion will also lessen at least momentarily. Therefore the wood product industry should put effort on open and informative external communication to activate the discussion also during the more quiet times. It is very likely that the debate on climate issues will dramatically increase before the Mexico City convention in December 2010. One cold winter in the northern hemisphere is not enough to change the direction of global climate policy.

7.1 Evaluation of the quality of research

The reliability and validity of the study is ensured by explaining the execution of the study as accurately as possible. Also, all the observation done during the study is documented objectively, and conclusions explained adequately. Regarding the literature study, the newest and the most competent sources of information have been used, and the sources are documented comprehensively in the list of references.

Regarding the practical part of the study there are also few viewpoints which are worth noticing in this context. The first part of the market survey was carried out with open questions which were sent to the receiver via e-mail. The material received from this method turn out to be relatively small. A wider body of material could have been collected, for example, with direct personal interviews or involving a bigger target group. The weakness in this kind of open question based e-mail inquiry turned out to be the difficulty in determining how the personal opinions and attitudes of the receiver effected the given answers.

The second part of the market survey was carried out with an Internet survey that aimed to find out how companies communicate environmental issues externally in the forest industry sector. When discussing the external environmental communication and the results of this survey, it should be kept in mind that the Internet is only one channel to communicate the environmental information to the stakeholders. It was assumed that the Internet is the most commonly used external communication channel nowadays. The chosen research method's biggest weakness is that it includes only this one communication channel. This brings uncertainties and the results can be seen only as suggestions as no real statements can be made. However, from this thesis' objective point of view the accuracy of gained results is enough. The aim was to scan the overall situation and get a general view, and for those reasons the chosen research method was justified.

The case studies related to the mill specific carbon footprints were also relatively light, but from the thesis aim's viewpoint they were sufficient. It should be noted, especially

in the transportation and energy recovery studies, (cases 1 and 2) that those were only for the Pellos mill. Generally these results are site and case specific just like carbon footprints. Even though these case studies were light they can help to understand the carbon footprint concept and plywood's environmental impacts better. They also gave a direction of how to develop the site specific carbon footprints in the future which fulfilled the aim that was set for the case studies.

Altogether this study gives a good general insight for the issue and succeeded to answer all the research questions. During the process the author has maintained objectivity and transparency in all stages of the research work. Critical reviewing of the research as well as self-criticism are seen as a part of the research process and carried out through the whole study.

7.2 Further research needs

First of all, the mill specific carbon footprint calculations need to be developed further. At this point, the profiles represent the carbon footprint figures credibly only for uncoated plywood. Pressure should be put on the raw material suppliers to give the needed information, so that the carbon footprints of the coated plywood's could also be represented with adequate trustworthiness. Also, the effect of sourced veneer should be included to the calculation.

Secondly, there are several issues connected to communication which needs further study and development. There is a definite need for an environmental communication policy and strategy. First, the environmental elasticity of the company's target markets should be surveyed. How the environmental performance of a product affects customers' buying decision in reality, and what are the features in the environmental performance which have the biggest effect? After this, the company will have better understanding of its markets, and it can develop an efficient environmental communication and marketing action plan. The second aspect to be researched should be the level of environmental knowledge of the marketing and communication departments. What are the weaknesses in the current knowledge and how the external

environmental communication has been used in the past? After this, environmental training plans, as well as tools for ensuring the flow of internal environmental information through the whole organization can be developed.

The third issue worth surveying are the possibilities concerning the end-of-life stage of the product. The traditional approach to plywood manufacturing is that the company produces the products, and the manufacturer's responsibility ends after the product is sold. In the future, this can change. For example, in the EU region the trend is to change the traditional "acquisitive society" towards to a more like "recycling society", and also the use of bio based fuels is promoted extensively. This opens up possibilities also for the plywood manufacturers to develop new service concepts. One example could be re-buying the used plywood to be further processed, or utilized in the energy recovery. There is always room for out of the box thinking.

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APPENDIXES

APPENDIX 1.	Standards and frameworks discussed in the thesis.
APPENDIX 2.	Example carbon profile for UPM-Kymmene plywood mill and remarks and explanations to the ten elements of CEPI Framework applied
APPENDIX 3.	Results from the Internet survey (simplified matrix table)

ISO 14040:2006	Environmental management - Life cycle assessment – Prin ciples and framework
ISO 14044:2006	Environmental management - Life cycle assessment - Requirements and guidelines
ISO 14020:2000	Environmental labels and declarations – General principles
ISO 14021:1999	Environmental labels and declarations – Self-declared environmental claims (Type II environmental labelling)
ISO 14024:1999	Environmental labels and declarations – Type I environ mental labelling – Principles and procedures
ISO 14025:2006	Environmental labels and declarations –Type III environ mental declarations – Principles and procedures
ISO 14063:2006	Environmental management - Environmental communication - Guidelines and examples
ISO 21930:2007	Sustainability in building construction – Environmental declaration of building products
ISO 14067-1	Greenhouse gases – Carbon footprint of products – Part 1: Quantification (under preparation)
ISO 14067-2	Greenhouse gases – Carbon footprint of products – Part 2: Communication (under preparation)
CEN/TC 350	Sustainability of construction works (under preparation)
• prEN 15804	Sustainability of construction works - Environmental product declarations – Product category rules
• WI 350005	A Standard - Sustainability of construction works – Envi ronmental product declarations• Communication formats
• WI 350006	A Technical Report – Sustainability of construction works - Environmental product declarations - Methodology and data for generic data
PAS 2050:2008	Specification for the assessment of the life cycle greenhouse gas emissions of goods and services. (by British Standards Institution)
CEPI Framework	for the Development of Carbon Footprints for Paper and Board Products (by The European Coordination of Inde pendent Producers)
GHG Protocol Corporate Standard	for companies and other organizations for GHG emission inventory development (by the World Resource Institute and the World Business Council for Sustainable Development)

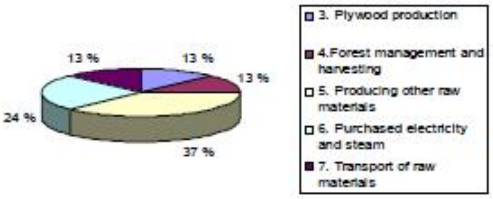
CARBON PROFILE

Company	**UPM-Kymmene Wood Oy**
Site	**Pellos**
Products	**Spruce Plywood**

Information gathered from **1.1. 2008** to **31.12.2008**

Carbon Footprint

- UPM calculates the Carbon Footprint of its plywood products based on the ten elements of the Carbon Footprint Framework for Paper and Board Products developed by CEPI (the Confederation of European Paper Industries). Detailed information on the CEPI Framework can be found at www.cepi.org.
- The data used in the calculation are based on annual averages for a mill.
- GHG = greenhouse gas. UPM figures refer only to emissions of fossil CO_2.



Note that the wood products are biogenic CO_2 stores and can replace fossil fuels in energy production in the end of their life cycle!

1 m^3 of spruce plywood stores 810 kg of biogenic CO_2

Ten elements of the CEPI Framework (See next page for remarks and explanations)	Fossil CO_2 (kg/m^3 of plywood)	Biogenic CO_2 (kg/m^3 of plywood)
1. Carbon sequestration in the forest		0
2. Carbon stored in the product		-810
Net sequestration of biomass carbon		**-810**
3. GHG emissions from plywood production	10	
4. GHG emissions associated with producing wood material	10	
5. GHG emissions associated with producing other raw materials *)	30	
6. GHG emissions associated with purchased electricity and steam **)	20	
7. Transport-related GHG emissions (excl. delivery to customer)	10	
Total fossil CO_2 emissions	**80**	
8. GHG emissions attributable to product use	-	
9. GHG emissions attributable to end-of-life-management of products	-	
10. Avoided emissions	-	

*) Includes only emissions from fossil fuel manufacturing which are used in plywood production. Other raw materials will be added later. **) The CO_2 factor used for purchased power is 98 kg CO_2 per KWh.

Remarks and explanations to the ten elements of CEPI Framework

1. Carbon sequestration in the forest

- In line with the CEPI Framework, carbon sequestration is currently not included in product level carbon footprint calculations.
- For UPM, forest certification and traceability of wood raw material supply using certified Chain of Custodies ensures the sustainable management of forests, and the long-term sequestration of carbon in them via the process of photosynthesis.

2. Carbon stored in the product

- Biogenic carbon is stored in products produced from wood. The IPCC (International Panel on Climate Change) formula is used to determine the amount of CO_2 that is stored in the plywood.
- Through recycling the carbon stored in products is retained within the carbon cycle.

3. GHG emissions from plywood production

- UPM includes data on fossil CO_2 emissions from combustion of fossil fuels at plywood manufacturing facilities. In addition fossil fuels used in forklifts in plywood manufacturing are included.

4. GHG emissions associated with generating the supply of wood

- Includes fossil CO_2 emissions from forest management and harvesting activities.

5. GHG emissions associated with producing other raw materials

- Includes fossil CO_2 emissions generated during the manufacturing of non-wood-based raw materials (e.g. coatings and chemicals which are used in an amount above 1 % per m^3 of plywood) and fuels.

6. GHG emissions associated with purchased electricity and steam

- Includes fossil CO_2 emissions associated with purchased electricity, steam and heat used for plywood production.
- Due to differences in fuel mix used to produce electricity there are significant differences in the emission factors used to convert grid electricity to it's equivalent CO_2. UPM uses country specific emission conversion factors which are based on the real power supply to UPM mills in each respective country. The factor used is given below the table on the previous page.

7. Transport-related GHG emissions

- Includes fossil CO_2 emissions associated with in- and outbound transports of raw materials and final products from the plywood mill, along the value chain.
- At UPM, this figure includes the transportation of wood, coatings and chemicals to UPM mills. CO_2 emissions from wood transports are allocated mass based among products and by-products.
- CO_2 emissions from transportation of plywood to the customer is not included since this depends on the transportation modes used and distances to specific customer locations. This part of the element can be calculated for a specific case on request.

8. GHG emissions attributable to product use

- This element is not included within UPM's scope as a plywood manufacturer.

9. GHG emissions attributable to end-of-life-management of products

- This element is not included within UPM's scope as a plywood manufacturer.

10. Avoided emissions (e.g. superior energy efficiency or carbon offsetting measures)

- This element is not currently included in UPM's scope.

Company	Country	Environmental report	Wood origin certificates	Carbon footprint	Comment
1	Finland	X	X	X	Corporate environmental report, carbon footprints for products
2	Russia		X		
3	Chile	X	X		
4	Chile	X	X	X	Corporate environmental report, GHG emissions on corporate level (GHG Protocol)
5	Indonesia				No environmental related material on web pages
6	USA	X	X	X	Corporate environmental report, GHG emissions on corporate level (no results in the Internet)
7	Canada	X	X	X	Corporate environmental report, GHG emissions on corporate level
8	Germany	X	X	X	Corporate sustainable report, verified EPDs for products
9	Spain	X	X		Corporate environmental report
10	Brazil				No web pages
11	USA	X	X	X	Corporate environmental report, carbon footprints for products under development
12	Brazil		X		
13	Russia	X			Corporate environmental report
14	USA		X	X	GHG emissions on corporate level
15	Finland		X		
16	Russia				No environmental related material on web pages
17	UK		X	X	Carbon footprints for product groups
18	Latvia				No web pages
19	USA	X	X	X	Corporate environmental report, GHG emissions on corporate level
20	Canada	X	X	X	Corporate environmental report, GHG emissions on corporate level

Company	Country	Environmental report	Wood origin certificates	Carbon footprint	Comment
21	Russia				No environmental related material on web pages
22	Germany	X	X		Corporate environmental report
23	China	X			Corporate environmental report
24	USA		X		
25	Malaysia	X	X		Corporate environmental report
26	Brazil		X		
27	Japan				No environmental related material on web pages
28	Portugal		X		
29	Finland	X	X	X	Corporate environmental report, carbon footprints for product groups
30	Brazil		X		
31	Switzerland		X		
32	Russia				No environmental related material on web pages
33	Russia		X		
34	USA	X	X	X	Corporate environmental report, EPDs for products
35	Japan	X	X	X	Corporate environmental report, carbon footprints for product groups (own carbon footprint label)
36	India	X	X		Corporate environmental report
37	Australia		X		
38	USA		X		