RAPPORT

Executive summary for Billerud Carbon Footprint – overview documentation

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Preface

IVL Swedish Environmental Research Institute has, on behalf of Billerud AB, developed so called Carbon Footprints for Billerud's main products. The work has been performed as a co-operation project between Billerud and IVL where Billerud has delivered information concerning the products and processes, and IVL has reviewed data and developed the Carbon Footprints. The project has been carried out in a project group with the following members:

Patrik Bosander, Billerud, Stockholm
Bertil Lundberg, Billerud, Skärblacka
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Gothenburg, March 2009

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Contents

1 Introduction and background

A Carbon Footprint is a measure of the greenhouse gas emissions associated with an activity, group of activities or a product. Several different gases contribute to the greenhouse effect when emitted to the atmosphere. The most important greenhouse gas is carbon dioxide (CO_2) but other gases such as methane (CH_4) and nitrous oxide (N_2O) can also make a contribution in the forest industry.

The Carbon Footprint concept has emerged from the need of a tool to measure and communicate the climate change performance of an activity or a product. Framework methodology for Carbon Footprint calculations has been developed in e.g. the forest industry[1]. The methodology description is in the form of a general framework, why the details of the calculations have to be defined by each user of the framework. No detailed standard is yet in place for Carbon Footprint; a new work item on Carbon Footprint has just started within ISO, and is expected to be finished by 2011. Until then, it is important to describe the details and conditions for the method used. In this Executive Summary, the conditions and assumptions for the method used are presented. The detailed data and calculations are presented in the Carbon Footprint calculation sheet in Excel. The detailed results are presented in Annex 1.

2 Frameworks and standards used

This study uses the Carbon Footprint framework developed and proposed by CEPI Confederation of European Paper Industries[1]. Many similarities exist between Carbon Footprint methods and Life Cycle Assessment (LCA) methodology, since Carbon Footprints are in general considered as the climate change impact category of an LCA, measured as Global Warming Potential. There are also strong connections to Environmental Product Declaration (EPD) and to Product Category Rules (PCR). Within ISO a New Work Item on Carbon Footprint has started, expecting to have a final document finished in 2011. In this study, the CEPI Carbon Footprint Framework has been used, as well as the ISO 14044 on LCA. The requirements for EPD e.g. according to the General Programme Instructions have not been used extensively. As an example, EPDs do not include waste treatment more than as additional information; however in this study waste treatment is included, as well as a system expansion, in order to show the environmental impact of the whole life cycles of the Billerud products, from cradle to gate.

[1] Framework for the development of Carbon Footprints. For paper & board products (including separate appendices). CEPI Confederation of European Paper Industries, September 2007.

3 Objective and expected use

The study is divided into two parts, where the first part shows the Billerud product Carbon Footprints of all basic products from the Billerud group, and the second part covers Carbon Footprint case studies of two specific products over their complete life cycles.

The objective of the first part of the study is to calculate and verify the Carbon Footprints including both greenhouse gases and biogenic carbon dioxide flows for the Billerud products. IVL has also added upstream data on production of chemicals etc. The objective of the second part is to, by a simplified LCA and based on the Carbon Footprints, analyse the greenhouse gas emissions of two products based on Billerud paper. The results are compared to the results of products produced by a competing material. The selected products are paper and plastic bags, and paper and plastic sacks.

Billerud can use the verified results from this study for communication and presentations to customers and other interested parties. It will also give increased knowledge internally about the contribution from different parts of the product chain. The Carbon Footprints can also be used as a basis for further analyses and strategic improvements of the products and the production. It also shows a benchmark of climate performance as compared to competing products. The Carbon Footprints give increased knowledge about competing product total life cycle climate performance.

4 Description of the Billerud products

The Billerud group has three pulp and paper production plants in Sweden: Skärblacka mill, Gruvön mill and Karlsborg mill. The products from these mills that have been analysed are presented in the table below:

Production plant	Products
Skärblacka	Unbleached sack paper, MG/Kraft paper, fluting and market pulp
Gruvön	MG/Kraft paper, fluting and market pulp
Karlsborg	Bleached sack paper and market pulp

5 Description of the system boundaries and methodologies of the Billerud Carbon Footprints

The Carbon Footprint calculations have been based on an LCA methodology where the entire production has been covered from forest plantation and forestry through Billerud's production plants to the customer gate. The after use recycling and waste treatment is also included, however, as different scenarios, since recycling and waste treatment practices differ between markets, and since different methodologies may be used. The CEPI Framework calculation scheme has been used, including the ten items or life cycle phases described below (called toes). The Carbon Footprint can either be summarized from forestry to customer gate, or from forestry to recycling or waste treatment, where market specific scenarios should be selected. In that case, it is also relevant to include so called avoided emissions, since the recycled material and the heat of combustion is used and creates new functions (products). The avoided emissions scenarios used are described later in this chapter. In the table below, the overview structure of the calculations is shown.

Description of the Carbon Footprint ten toes	**Fossil CO_2 emission (GWP 100)**	**Biogenic CO_2**
Toe 1: Biogenic CO_2 net sequestration in forests		
Toe 2: Carbon in products as biogenic CO_2		
Toe 3: GHG emission from forest product production process		
Toe 4: GHG emission associated with producing the fibre (forestry)		
Toe 5: GHG emission from raw material production		
Toe 6: GHG emissions from purchased and sold electricity and heat		
Toe 7: Transport related GHG emissions		
Summary Cradle to customer gate		
Toe 8: Emissions associated with product use		
Toe 9: Emissions associated with end of life		
Summary cradle to grave		
Toe 10: Avoided emissions from the production phase and from end of life		
Summary cradle to grave including avoided emissions		

In the calculations of Billerud's products, all calculations have been performed and presented based on one tonne of product.

The Cradle to customer gate Carbon Footprint (toe 1 through 7) is built on data from Billerud. However, the toe 9 and 10 are based on scenarios, assuming recycling, incineration or landfill and potential benefits. This should be taken into consideration in the interpretation and use of the Carbon Footprints. It is recommended to include both toe 9 and 10 if end of life is included, however in a transparent way.

The calculations cover in principle carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). However, the emissions of CH_4 and N_2O are small in the main production change but can play a role in the waste handling system where the emissions have been included. Fossil and biogenic CO_2 emissions are presented separately. The product chain for pulp and paper products are complex and not all conditions can be described completely. Below, an overview of the calculations and assumptions performed in the project are presented.

Toe	Overview description of calculations, conditions and assumptions
1	**Biogenic CO_2 net sequestration in forests** Carbon sequestration in the growing forests has been calculated as related to the round wood bought by the company (timber volume, m^3 solid under bark, sub) for the production of pulp and paper. The fraction of imported timber has been subtracted. Statistical information from the Swedish Forest Inventory has been used on a regional basis (south Sweden as Götaland, middle Sweden as Svealand and north Sweden as Norrland) to calculate the yearly net increase (gross growth minus fellings) in the standing volume of forests within the region (all tree species). Biomass expansion factors have been used to convert between stem volume increase and the increase in total living biomass, including needles, leaves and roots. The yearly net increase in living biomass has then been converted to an increase expressed as CO_2 equivalents (CO_2 eq.) using standard methods. This value of yearly net increase in biomass in the forest, expressed as million ton CO_2/ha for the region, has been related to the timber bought by the company. This was done by estimating the area of forest needed to produce the volume timber bought by the company, from volume of yearly felling in the region per hectare. From these calculations, the yearly net carbon sequestration in the growing forest connected with the used timber could be calculated and expressed as ton CO_2 eq./volume bought timber (m^3 sub). By means of information of the volume timber used for each ton product, this could finally be expressed as kg CO_2 eq./tonne product. It is important to realize that these are calculations based on statistics valid for large regions. The basic assumption is that the volume timber bought by the company contributes to an economic market for timber, which in turn contributes to stimulate a sustainable and efficient forest management in Sweden.
2	**Carbon in products as biogenic CO_2** The carbon content in the product has been calculated based on the carbon content in the fibre assuming a carbon content of 50 % in dry fibre. The result is presented as CO_2.

3	**GHG emission from forest product production process** Here, the production process of pulp and paper is covered. Both fossil and biogenic emissions are presented. However, the bulk flow of lignin/bark/fibres etc. (that is combusted) is considered as a zero net contributor to the CO_2 balance and has for that reason been left out from the CO_2 calculations. Only the net balance of fossil fuels, biomass fuels and heat energy are shown in the calculations. Specific data have been used for each product at each production plant.
4	**GHG emission associated with producing the fibre (forestry)** In this part, the forest processes are covered. All processes from plantation activities to felling and transport to local road are included. General data from a Swedish research study have been used[2]. The emissions are mostly related to operation of different diesel driven machines. A Swedish average value of 82 MJ fossil fuels/m^3 sub (solid under bark) corresponding to 5.93 kg CO_2/sub.
5	**GHG emission from raw material production** CO_2 emissions from production of the main external raw materials (chemicals) and all fossil fuels have been covered. The chemicals included are: oxygen, lime (CaO), sodium chlorate ($NaClO_3$), sulphuric acid, sodium hydroxide and hydrogen peroxide. National electricity production mixes have been used for each production process of the used chemicals, depending on where they are manufactured.
6	**GHG emissions from purchased and sold electricity and heat** Billerud purchase electric power from Vattenfall on contract base. Vattenfall has calculated LCA data for their Swedish produced electric power. These calculations show a CO_2 emission of 5.8 g fossil CO_2/kWh produced electric energy. In addition, there are distribution losses of approximately 6 %. In total, this gives a CO_2 emission of 6.15 g fossil CO_2/kWh delivered electric energy.
7	**Transport related GHG emissions** Transport data for the Billerud group has been calculated both for incoming materials (forest products, chemicals etc.) and outgoing products. Product specific transport data have been calculated for Karlsborg plant and for Gruvön and Skärblacka, general average figures have been used.
8	**Emissions associated with product use** There are no emissions associated with product use for these paper products.
	After use scenarios:

[2] Berg, S., Lindholm, E-L. 2005. Energy use and environmental impacts of forest operations in Sweden. Journal of Cleaner Production 13 (2005) 33-42;327.

9	**Emissions associated with end of life** In order to give as high transparency as possible, the three existing after use treatment paths are presented as separate "building blocks" so that the respective treatment mix can be calculated for the respective market: • *Material recycling* (100 %) including the recycling process. In this case, the CO_2 emissions from the recycling process of one tonne/one product are presented. This will result in an additional product made of recycled paper. The process emission can either be allocated to the recycled product or to the virgin product. It can therefore be difficult to include this emission in a total sum of emissions from a virgin paper product. In reality, a paper product can also be recycled several times. One way of allocation is to allocate the virgin process emission to the virgin product and the recycling process emission to the recycled product. The emission from e.g. the final incineration of the product can then be share between the recycled and the virgin products. In the summary example in this study the emissions from the recycling process has been allocated to the virgin product but the virgin production has then been subtracted from the production as a avoided emission due to the recycling process. • *Incineration* (100 %), including combustion process and waste collection. The biogenic carbon is emitted as biogenic CO_2. • *Landfill* (100 %) including landfill processes and waste collection. A 100 years period has been used for the calculations. During this time, 70 % of the landfilled paper products and 3 % of the polyethene plastics are assumed to be degraded, into methane and CO_2.

10	**Avoided emissions from the production phase and from end of life** During the production phase, excess energy from the production is used for district heating in an area of small houses in the vicinity of the plant, replacing fuel oil. Also an excess of tall oil and turpentine can replace fuel oil outside the plant. The three after use scenarios as used in Toe 9 are used here as well, based on 100 % treatment of 1 tonne of product after use. If a mixture of the three is used, the same weight should be given to e.g. material recycling as for Toe 9. • *Material recycling* (100 %): The recycled material will be assumed to be sold and used for another product, in order that the use and production of other materials are avoided. Here, it is assumed that the recycled material replaces virgin material to 100 %, since it is the first recycling loop of the fibres. The electricity production used here is selected to be an approximation to a marginal power production on a five year basis. Efficient natural gas based electricity has been used assuming 380 g CO_2 eq./kWh. The avoided uptake of biogenic CO2 is also added here (since use of virgin material is avoided). For plastics, it has been assumed that 50% virgin material is replaced and 50% other recycled, which then goes to landfill. • *Incineration* (100 %) with energy recovery, assuming a European average waste incineration plant. We assume that 90 % of the plants have energy recovery (88.5 % in 1999 according to Bontoux, 1999). It is assumed that 1 kWh electricity is produced per kg of product incinerated and that the heat is not recovered which is common if no district heating system exist to distribute the heat to a user. (Magnus Schönning, 2007, ref to Carl Liliehöök Tekniska Verken Linköping 2002). It is also assumed that the electricity produced is substituting the production of electricity on the margin with around five years perspective, why electricity from natural gas has been assumed. The emissions factor is then 380 g CO_2 eq./kWh produced electric energy. • *Landfill* (100 %). The collected methane gas (assumed to be 45 % of formed methane gas, 0.227*0.45=0.10215 kg CH_4/kg fibre) is assumed to be utilized and substituting natural gas for different applications, where the avoided emissions are accounted for.

An average EU27 scenario for after use treatment can be constructed for each product, based on a weighted mix of the material recycling, incineration and landfill scenarios as given above. This is done for the case studies, see below.

6 Carbon footprints of the Billerud products

In this chapter, the carbon footprints for the products from Billerud are presented (Skärblacka mill in Table 1 and Gruvön and Karlsborg in Table 2). Each product from the different production plants is presented separately including the ten toes. The resulting sum for the production of each product is shown as "Cradle to customer gate" emissions. This calculation includes the sum of toe 1 and 3 to 7. In toe 9 the emissions from different waste handling alternatives are shown. The alternatives represent pure cases where the entire product is assumed to be handled in three different waste handling systems (incineration, material recycling and landfill). Notice that both the incineration and landfill alternative include the entire end of life for the virgin product while the material recycling alternative show the first recycling process of the virgin material and the final incineration of the product just to give information of the recycling process. This emission can very well be allocated to the product produced in the recycling process and not to the virgin paper product. In toe 10 the avoided emissions from both excess energy in the production and energy from the waste handling processes of the products are shown. Carbon footprints for all three waste handling alternatives are shown here as well. It is important to notice that the total carbon footprint for a product (the sum of the different toes) shall be calculated with great care and applicable toes shall be used.

Table 1 Carbon footprints for products from Billerud, Skärblacka mill.

Unit: kg CO_2/tonne product (t_{90})		Skärblacka							
		Unbleached sack paper		MG/kraft paper		Fluting		Market pulp	
Toe	Description of topic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic
1	Biomass carbon sequestration in forests		-2590		-2700		-1410		-2910
2	Carbon in products		-1650		-1617		-1650		-1650
3	Greenhouse gas emissions from forest products manufacturing	19.9	60.8	182.1	226.0	271.1	701.5	45.2	126.1
4	Greenhouse gas emissions associated with producing fibre	26.1		27.2		14.2		29.4	
5	Greenhouse gas emissions associated with producing other raw materials and fuels	29.9		61.7		15.1		53.9	
6	Greenhouse gas emissions associated with purchased and sold electricity, steam, heat and hot and cold water	4.7		5.1		3.2		1.2	
7	Transport-related greenhouse gas emissions	47.0		47.0		47.0		47.0	
8	Emissions associated with product use	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1 and 3 to7	***Summary Cradle to customer gate***	**128**	**-2 530**	**323**	**-2 469**	**351**	**-711**	**177**	**-2 786**
9	*Emissions associated with product end-of-life*								
Scenarios	Scenario: Incineration (100%) including transports	3.5	1 650	3.5	1 617.0	3.5	1 650.0		
	Scenario: Material recycling (100%) including electric power and transports	594		594.0		594.0			
	Scenario: Landfill (100%) including transports	1 930	902	1 892.7	884.1	1 931.3	902.2		
10	*Avoided emissions*								
Scenarios	Scenario: Incineration (100%)	-353		-366.4		-345.5			
	Scenario: Material recycling (100%)	-139	1589.2	-354.3	1424.0	-354.1	948.5		
	Scenario: Landfill (100%)	-264		-279.0		-256.3			

n.a.= not applicable

Table 2 Carbon footprints for products from Billerud, Gruvön and Karlsborg mill.

Unit: kg CO_2/tonne product (t_{90})		Gruvön						Karlsborg			
		MG/Kraft paper		Market pulp		Fluting		Bleached sack paper		Market pulp	
Toe	Description of topic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic
1	Biomass carbon sequestration in forests		-2 478		-2731		-1207		-1288		-1288
2	Carbon in products		-1617		-1650		-1650		-1650		-1650
3	Greenhouse gas emissions from forest products manufacturing	91.1	-202.5	87.9	-997.6	88.7	745.2	95.9	243.1	0.0	-35.8
4	Greenhouse gas emissions associated with producing fibre	27.9		30.7		13.6		29.7		29.7	
5	Greenhouse gas emissions associated with producing other raw materials and fuels	58.7		59.4		5.2		95.9		91.7	
6	Greenhouse gas emissions associated with purchased and sold electricity, steam, heat and hot and cold water	5.0		3.4		2.9		5.0		1.0	
7	Transport-related greenhouse gas emissions	47.0		47.0		47.0		52.8		64.7	
8	Emissions associated with product use	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1 and 3 to7	***Summary Cradle to customer gate***	230	-2 680	228	-3 728	157	-462	279	-1 045	187	-1 324
9	*Emissions associated with product end-of-life*										
Scenarios	Scenario: Incineration (100%) including transports	3.5	1 617.0			3.5	1 650.0	3.5	1 650.0		
	Scenario: Material recycling (100%) including electric power and transports	594.0				594.0		594.0			
	Scenario: Landfill (100%) including transports	1 892.7	884.1			1 931.3	902.2	1 931.3	902.2		
10	*Avoided emissions*										
Scenarios	Scenario: Incineration (100%)	-422.6	-50.9			-344.0	-50.9	-363.6			
	Scenario: Material recycling (100%)	-317.1	1801.5			-159.4	853.8	-300.9	1406.9		
	Scenario: Landfill (100%)	-335.2	-50.9			-254.8	-50.9	-274.4			

n.a.= not applicable

7 Description of the case studies

In addition to the products from Billerud (pulp and paper) the final application products can also be analysed in a life cycle perspective. This has been done in a case study covering two application products; a bag and a sack. Carbon footprints have been calculated for the two products and the finished products have also been compared to similar products in a competing plastic material. One unit of product (bag or sack) have been used as the calculation unit (g CO_2/bag or sack). The products analysed are shown below with a technical specification for the calculations.

Product	Technical specification
Paper bag	Weight of paper bag: 51 g with flat handles. Bleached kraft paper from Gruvön mill has been assumed. Electric energy for production of 1000 paper bags from kraft paper has been calculated to 7.6 kWh. OECD electric power production mix has been assumed. Natural gas heating is assumed to be used for drying of ink. 0.25 m^3 natural gas/1000 bags.
Plastic bag	Weight of plastic bag: 30 g, plastic material used is polyethene plastics, 0.56 kWh electric power/kg polyethene has been assumed for the production of plastic bags (conversion). OECD electric power production mix has been assumed. The same ink drying process as above.
Paper sack	Weight of paper sack: 169 g including 11 g of polyethene film. Bleached sack paper from Karlsborg mill has been assumed for the outer layer, while unbleached sack paper from Skärblacka has been assumed for the inner layer. Electric energy for production of 1 paper sack from sack paper has been calculated to 0.1 kWh. OECD electric power production mix has been assumed. The same ink drying process as above.
Plastic sack	Weight of plastic sack: 86.5 g, plastic material used is woven polypropylene plastics, 0.56 kWh electric power/kg polypropylene has been assumed for the production of plastic sacks (conversion). OECD electric power production mix has been assumed. The same ink drying process as above.

Transport data have also been included in the calculation model to cover typical production and customer locations. For the paper and plastic bags, a converter in Northern Italy and a customer in Frankfurt have been assumed. For the paper sack product a converter and customer in Morocco has been assumed. For the plastic sack a producer in Northern Italy and a customer in Morocco have been assumed.

8 Results for the simplified LCA case studies

In the case study, carbon footprints of four different application products have been calculated, two paper products and two plastic products. The entire results from the calculations are shown in Table 3 below. For the interpretation of the results it is important to point out that the landfill calculation is based on a 100 years perspective and that the degree of degradation of the plastic materials and the paper materials are different. Thus, only 3 % of the plastics are assumed to be broken down during 100 years while 70 % of the paper materials are assumed to be broken down. This will give an increased emission for the paper products. If a longer time period is considered, the emissions from the plastics will increase and with an infinite time period all the materials will be broken down. However, a 100 years perspective is a well established time period to analyse landfills.

In order to give an overview of the summary results for a real European case, a European average waste handling scenario has been used (CEPI 2008, and European Environment Agency, www), assuming 59 % recycling, 13 % incineration with energy recovery and 28 % landfill for the paper and 10 % recycling, 34 % incineration with energy recovery and 56 % landfill for the plastics products (Pilz et al, 2009). In Figure 1 and Figure 2 the results for the bag and sack products are shown, presenting the total greenhouse gas emissions divided into emissions per life cycle phases. Here the so called 50/50 method has been applied when the plastics is recycled, which means that it is assumed that the recycled product to 50 % substitutes the production of virgin plastics. It is assumed that the rest, 50 %, replaces other recycled plastic, which then goes to incineration with energy recovery. For the transport calculations of the products it has been assumed that the paper products are calculated by volume and the plastic products are calculated by weight.

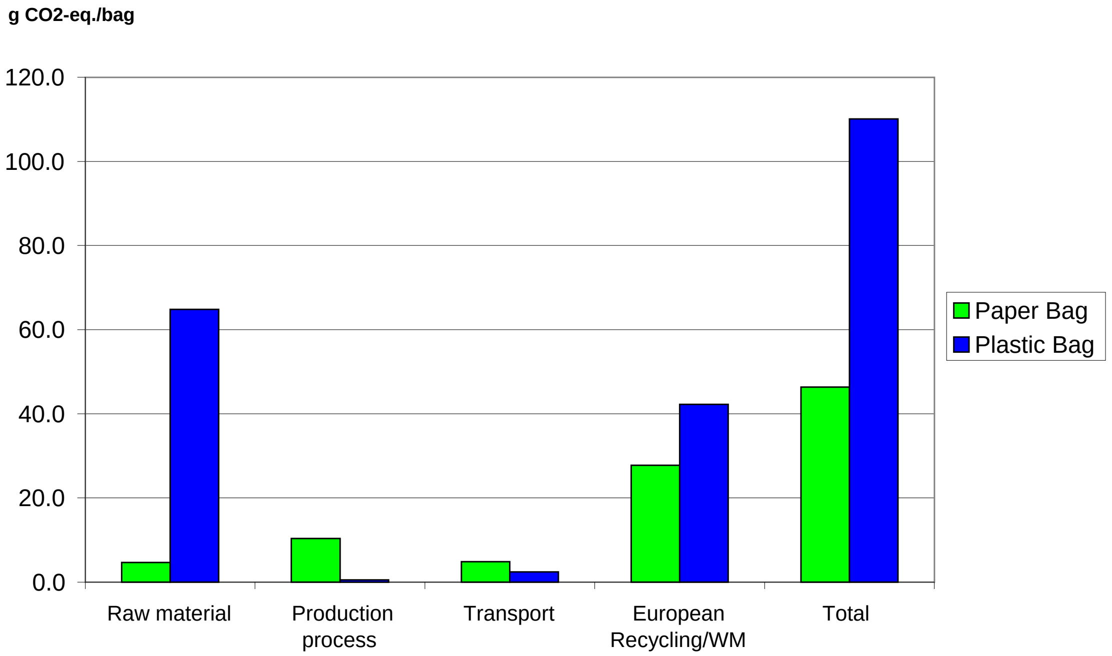

Figure 1 Greenhouse gas emissions from paper and plastic bags, with a European average waste handling scenario including recycling, incineration and landfill.

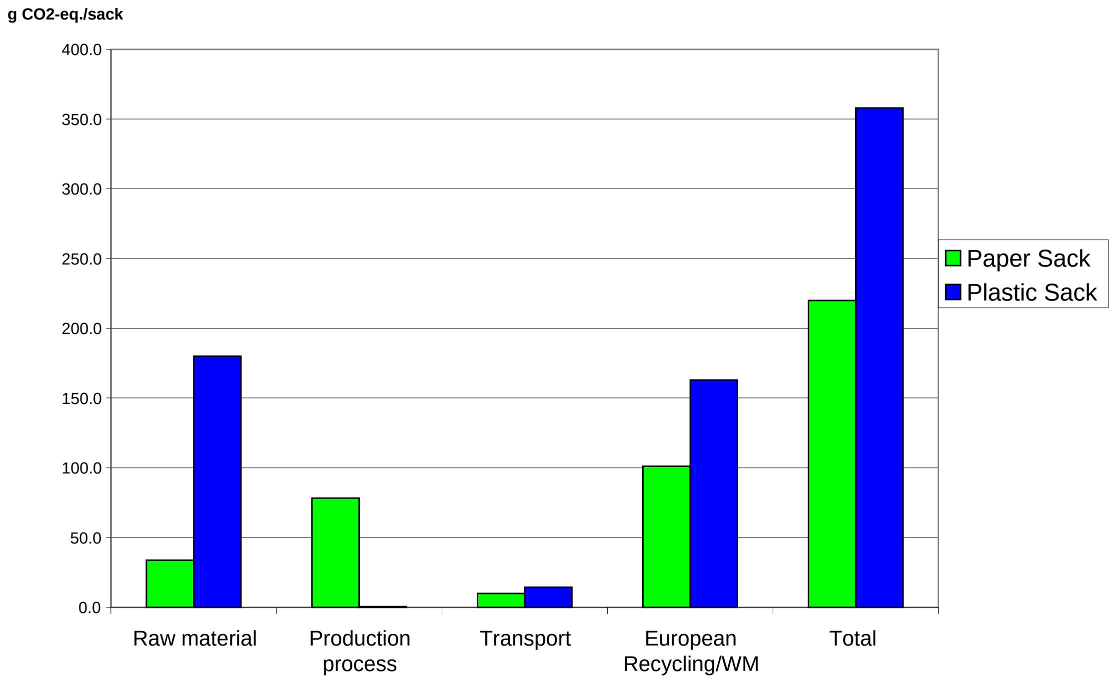

Figure 2 Greenhouse gas emissions from paper and plastic sacks, with a European average waste handling scenario including recycling, incineration and landfill.

The detailed Excel sheets for the Case studies are presented in Table 3 below.

The comparisons show that the plastic bags and sacks contribute more to the emissions of greenhouse gases for the studied products. It would be desirable to look more into the variations in product weight, but that was not possible within the scope of this project. The production of the virgin plastics is the single process that contributes most to greenhouse gas emissions for the plastic bags and sacks. For the paper products, it is the methane emissions at landfill that contributes most and the second largest source is the paper production. The emissions of CO_2 from incineration of plastics give a relatively high contribution as well.

Table 3 Carbon footprint results from the comparative case studies of paper and plastic bags and sacks.

Unit: (g CO_2/bag or sack)		Case study results (g CO_2/bag or sack)							
		Paper bag		Plastic bag		Paper sack		Plastic sack	
Toe	Description of topic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic	CO_2 GWP	CO_2 Biogenic
1	Biomass carbon sequestration in forests		-126.4				-306.3		
2	Carbon in products		-82.5	(-94.2)			-260.7	(-271.6)	
3	Greenhouse gas emissions from forest products manufacturing	10.4	-10.3	0.5		78.3	24.0	0.5	
4	Greenhouse gas emissions associated with producing fibre	1.4				4.4			
5	Greenhouse gas emissions associated with producing other raw materials and fuels	3.0		51.0		28.6		147.1	
6	Greenhouse gas emissions associated with purchased and sold electricity, steam, heat and hot and cold water	0.3		11.4		0.8		33.0	
7	Transport-related greenhouse gas emissions	5.5		2.5		10.6		14.4	
8	Emissions associated with product use	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
1 and 3 to7	***Summary Cradle to customer gate***	**21**	**-137**	**65**	**0**	**123**	**-282**	**195**	**0**
9	*Emissions associated with product end-of-life*								
Scenarios	Scenario: Incineration (100%) including transports	0.2	82.5	94.3		0.6	260.7	271.9	
	Scenario: Material recycling (100%) including electric power and transports	30.3		6.1		93.9		17.6	
	Scenario: Landfill (100%) including transports	96.5	45.1	10.7		305.2	142.5	30.7	
10	*Avoided emissions*								
Scenarios	Scenario: Incineration (100%)	-21.6	-2.6	-25.7		-56.6	0.0	-74.0	
	Scenario: Material recycling (100%)	-16.2	91.9	11.4		-34.7	236.7	29.7	
	Scenario: Landfill (100%)	-17.1	-2.6	-1.0		-42.5	0.0	-3.0	

n.a.= not applicable

Reference list

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Toe 2
Calculated by IVL based on carbon content in the materials.

Toe 3
Lundberg Bertil, Calculation based on energy and emission analyses at Skärblacka, Gruvön and Karlsborg mill. Billerud (2007/2008)

Toe 4
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Ecoinvent database for LCA data of chemical.

Toe 6
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