European Database
for Corrugated Board
Life Cycle Studies

FEFCO

GROUPEMENT Ondulé

EUROPEAN CONTAINERBOARD ORGANISATION

Contents

Foreword

This database is part of an environmental project undertaken by FEFCO (Fédération Européenne des Fabricants de Carton Ondulé), GO (Groupement Européen des Fabricants de Papiers pour Ondulé) and ECO (European Containerboard Organisation).

The purpose of the project is to provide the industry and its customers the up-to-date knowledge, based on facts, concerning the impact of the industry on the environment. This knowledge helps to integrate environmental affairs into decision making. It is the basis for product and process improvements, thus enabling a responsible and pro-active attitude of the industry towards the environment.

Through this report the industry aims to make a contribution to the need for basic environmental data for LCA studies, available in a transparent way.

For this project technical experts from the industry have worked together with LCA experts to provide a database that is based on both technical knowledge of paper production and corrugated board production as well as requirements for LCA studies.

The first step of the project was the establishment of a questionnaire for the collection of environmental data from the mills and the plants.

The data are collected and processed by the industry and are available from the industry itself in the form of this report, a European database for life cycle studie.

The report contains environmental data

- of the production of corrugated base papers from primary fibres: Semichemical Fluting and Kraftliner (data from European Containerboard Organisation)
- of the production of corrugated base papers from recovered papers: Testliner and Wellenstoff (data from Groupement Ondulé)
- of the production of corrugated board sheets and boxes (data from FEFCO).

The database handles the production sites as a black box: neither the details of the different processes in the production site nor the emissions etc. originating from energy production outside the mill, transport and waste treatment are included.

The data in this fifth edition represent the weighted averages of the inputs and outputs from the production sites per ton net saleable product (paper and corrugated board) for the year **2002**. Some additives that contribute less than 0,5% of the weight of the net saleable product have not been updated. For these additives the data for 1999 are reported.

The questionnaire was simplified in this way because looking at previous data collections the amounts showed little change over the years. Therefore the data that are reported can still be considered representative for the year 2002.

Data on packaging and cores were not updated for 2002 for the same reason.

The report is available for interested parties with the restriction that the data in this report may only be used for environmental studies such as Life Cycle Inventory Analysis, Life Cycle Impact Assessment as separate steps or as a whole Life Cycle Assessment.

The three Associations intend to update the database at regular intervals, at least every third year. **The user of the database should therefore inquire with any of the three Associations whether this is the latest edition of the database report before using the information from this report.**

The database may only be used for environmental studies regarding product development and improvement and the comparison of the entire system of corrugated board packaging with that of other materials. **The database may not be used for comparisons between the production of primary fibre and recovered fibre based materials as such.**

According to ISO 14041, allocation of the impacts of primary fibre production (the cradle) and waste treatment (the grave) of wood fibre to the phases in between the cradle and the grave of the life cycle should be avoided, wherever possible. In our case this is done by expanding the product system and considering the expanded system with a closed-loop approach.

To bring LCA within easier reach of the members of the Associations, a software tool has been especially developed for corrugated board. The software tool is based on SimaPro, using the most recent data from the "European Database for Corrugated Board Life Cycle Studies" and the closed-loop approach that is described in it. It enables the user to enter data according to his personal situation e.g. box design, logistics, waste management etc. and analyse or compare different options. This software can be purchased from FEFCO and a demo version of the software is available on www.fefco.org.

We are grateful for the positive response and useful comments we have received from users of the previous editions of the Database reports.

We welcome comments on this report and experiences from users of the database as a contribution to the regular updates!

December 2003

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1. Description of production system

1.1. Paper production, a brief description of the process

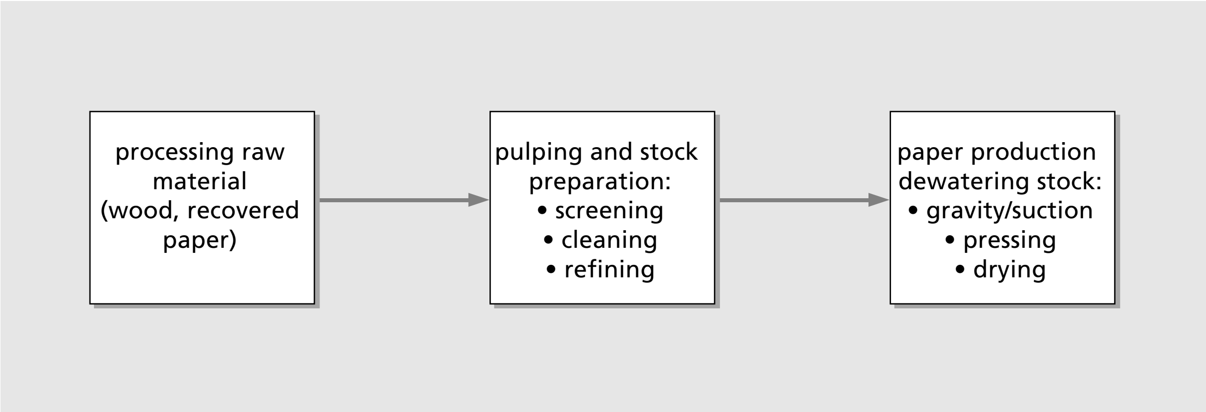


Figure 1a. Outline of paper production process

Raw materials processing

Wood

The process for the production of Kraftliner and Semichemical Fluting starts with wood coming from the forest to the mill. Most of the wood is delivered to the mill in the form of pulpwood logs but also a substantial part is bought as wood chips from saw mills nearby. The pulpwood logs have to be debarked and chipped before further processing. Therefore the logs have to pass through a barking drum and a chipper.

The chips produced are screened to take away wood dust formed as well as oversized chips and knots. The oversized chips are reprocessed to get proper chip dimensions and brought back to the chip flow. The chips are stored in a chip pile before processing in the pulp department.

Recovered paper

The raw material for Testliner and Wellenstoff, recovered paper, is delivered as bales, and kept on stock by grade.

With a pre-selection method, it is possible to determine the suitability of a certain recovered paper mix for the stock preparation and paper process. The stock preparation is done in accordance with a recipe for each paper grade and grammage. The grades of recovered paper are put on the conveyor to the pulper in the ratio mentioned in the recipe.

Pulping and stock preparation

Pulping and stock preparation of primary fibres

The wood chips are normally cooked to pulp for Kraftliner production by the kraft cooking process. It is a highly alkaline cooking process with caustic soda and sodium sulphide as active cooking chemicals. The cooking takes place in a digester at high pressure and a temperature of 150 - 170 °C. The pulp yield is normally around 55% i.e. 1000 kg of dry wood gives 550 kg of pulp.

For fluting production the wood chips are cooked to pulp by the semichemical cooking process. It is a slightly alkaline cooking process with sodium sulphite and sodium carbonate as active cooking chemicals. The pulp yield is normally around 80%.

The spent cooking liquor is drained off and washed out from the pulp. It contains the wood substance dissolved during the cooking together with the spent cooking chem-

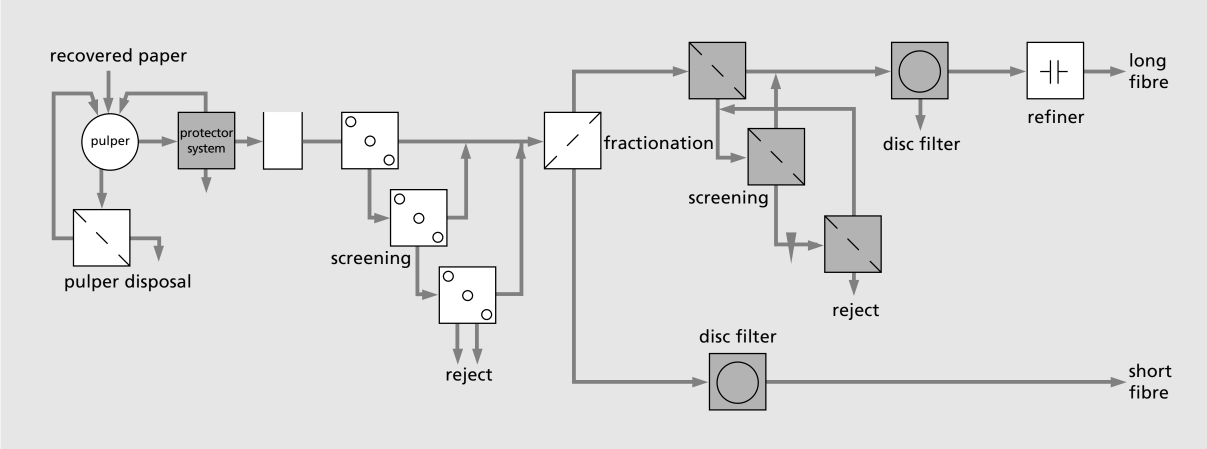


Figure 1b. Example of stock preparation in recovered paper processing

icals. The spent liquor is concentrated and burnt for steam production and recovery of cooking chemicals.

The pulp produced is defiberized in refiners, screened and washed before being sent to the paper mill.

In the paper mill the pulp is mechanically treated in beaters to improve fibre-to-fibre bonding and strength of the paper. The pH level of the pulp slurry is adjusted with acid and some additives are added to facilitate the paper production. Functional chemicals, fillers and other pulps i.e. recovered paper pulp may also be added to give the final paper the properties required. Finally the pulp slurry is screened and diluted before being sent to the head box of the paper machine.

Pulping and stock preparation of recovered fibres

In the pulper the blend of dry, baled paper is converted into a pumpable suspension of fibres. This is achieved by submerging the bales in water and agitating the mixture so that the paper is wetted and broken up to form a suspension.
Large contaminants, which do not readily break up, can be removed from the pulper using a "ragger" or "junker" which is a tool to remove large pieces of textiles, plastics etc., which are caught on the original wires of the bales.

Remaining undesirable elements in the raw material are eliminated from the pulp by screening and cleaning. After that the pulp may undergo a disperging treatment. For this treatment the pulp is dewatered by wire or screw presses and concentrated to 25-30% and heated by steam to 80-110 °C. The hot pulp is passed through a type of deflaker (kneads the pulp) moving through the gap between a stationary and a rotating disk with a lot of teeth.
During the treatment contaminants such as hot melt, wax, ink and coating binders loosen from the fibres and together with small fragments of paper are reduced to fine particles ("disperged") which therefore are no longer visible. The disperging treatment also has a positive influence on certain paper characteristics and fibre bonding capability.

Pulp for recovered fibre based paper for corrugated packaging does not normally undergo a de-inking process.

The dosage of additives can either take place during the stock preparation process, just before/or in the headbox, on the wire section (e.g. by spraying) or by surface treatment on the size press.

Paper production

The stock passes through one or two head boxes onto the paper machine. The paper

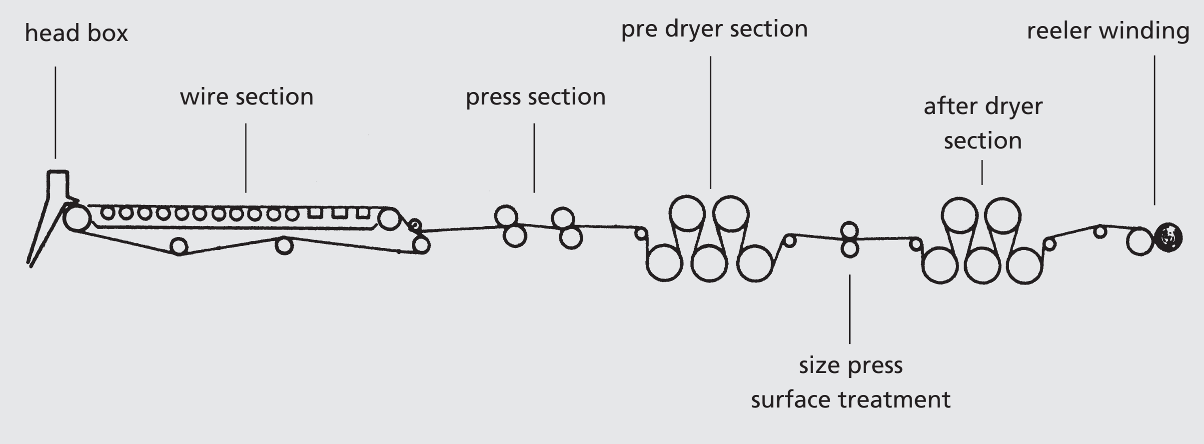


Figure 1c. Example of paper machine for containerboard grades

is formed from the head box onto the wire and dewatered through the wire primarily by the action of gravity and suction. Further dewatering by mechanical means takes place in the press section where water is taken out of the sheet by pressing between felts. The final drying takes place in the drying section of the machine where the sheet runs against steam heated cylinders to get its final dryness of 91-93%. The collected water is reused for diluting the thick stock coming from the stock preparation.

Semichemical fluting is a paper with just one ply and therefore the paper machine only has one head box and one wire. Kraftliner is normally a two ply product and therefore requires a paper machine with two head boxes and normally also two wires. The base brown ply contains recycled paper pulp and the internal machine broke pulp in addition to wood fibres from the integrated pulp production. The top ply is normally wood pulp from the integrated pulp production that is more refined and cleaner to give the top surface the right characteristics and printability. For white surface grades bleached fibres are of course used for the top ply.

Testliner mostly consists of two plies of paper. Depending on the type of Testliner the fibre composition of mixes of types of recovered paper can be different in each layer. In general a better grade of mix is used for the upper layer for reasons of appearance and strength. In order to increase its strength Testliner receives a surface treatment in the size press. This involves the application of a starch solution to one or both sides of the sheet. The top ply of Testliner is given an even, mostly brown colour by colouring the mass or by means of the size press treatment. The addition of special additives (in the mass or by means of the size press) makes it possible to produce Testliners with special properties such as extra water-repellent, low-germ and anti-corrosion grades.

Wellenstoff can be a one ply or two ply product. Usually a size press treatment with a starch solution is applied in-line on the paper machine in order to obtain sufficient strength and stiffness properties.

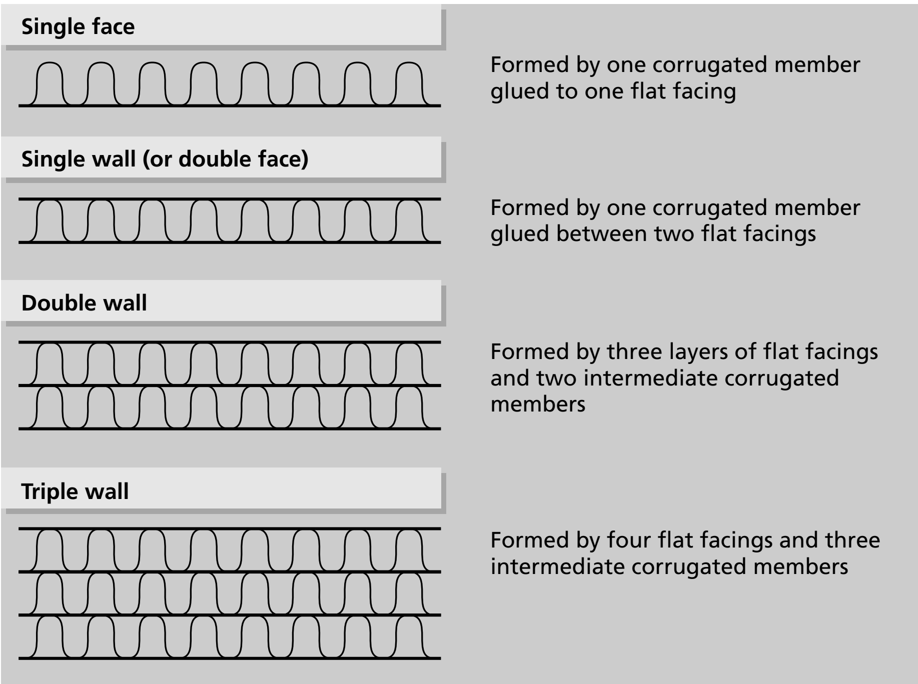
The most common surface treatment of recovered fibre based corrugated board materials is done by size press. Essentially a size press comprises two revolving rubber covered rolls, pressed together, through which the paper web passes. In the nip formed by the rolls there is a starch solution. The paper absorbs some of this solution, is pressed between two rolls and goes into the "after dryer" section of the paper machine in order to evaporate from the paper excess water absorbed from the starch solution in the size press.

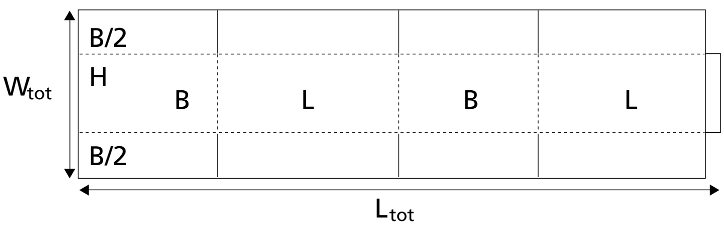
After the paper machine there is a slitter winder where the big jumbo reel from the paper machine is rewound and cut down to customer reel formats according to customer orders. Finally the reels are weighed, marked, labelled and prepared for shipment to the customer, the corrugated board industry.

1.2. Corrugated board production

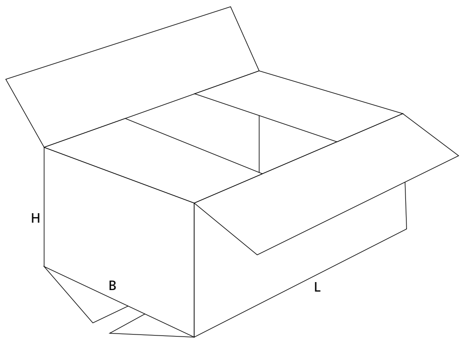
Corrugated Board is manufactured from a number of specially conditioned layers of recycled and/or virgin papers, called Fluting Medium and Linerboard. Reels of Fluting Medium and Linerboard are fed into a machine called a Corrugator. The Fluting Medium paper is conditioned with heat and steam and fed between large corrugating rolls that give the paper its fluted shape in the Single Facer. Starch is applied to the tips of the flutes on one side and the inner liner is glued to the fluting. The corrugated fluting medium with one liner attached to it is called single face web and travels along the machine towards the Double Backer where the single face web meets the outer liner and forms corrugated board. A number of layers of single faced web may be built up to produce double and triple wall corrugated board. The corrugated board is slit into the required widths and cut into sheets where it is then stacked or palletised.

Various structures are:





Box blank



The final stage of the process consists of printing and then slotting, folding and gluing the corrugated board to manufacture a corrugated box.

Most boxes are also printed in one or more colours to identify the product they are going to contain, the product manufacturer, the box manufacturer and also bar codes providing other information regarding the distributed goods. Different operations are carried out according to the customer's specification and according to the type of packaging. The two main categories are the regular slotted box and the die-cut box . The latter concerns packaging that requires a very precise cutting and which can have a complex design.

Most of the regular slotted boxes are produced with an in-line flexographic Printer/Slotter/ Folder/Gluer which, in one operation, prints, cuts, folds and glues the blank into its final shape.

The die-cut boxes are manufactured on a die-cutter (rotary or flatbed) which cuts and creases the board.

After converting the corrugated packaging is put on a pallet and delivered to the customer.

A corrugated box is composed of layers of paper: liner (linerboard) and fluting (corrugating medium). The four major paper grades used for the production of corrugated board boxes are Kraftliner, Testliner, Semichemical Fluting and Wellenstoff (recycled fibre based fluting) for which the data are found in the database.

The composition of the corrugated box depends on the function that it has to fulfil.

The consumption of liner and fluting can be calculated from the dimensions of the box, grammage of the liners and fluting, what kind of flute i.e. wave shape is used and weight of the sheet before die cutting. Different wave shapes lead to different heights of the corrugated layer. In table 1 approximate figures are given for different flute types.

The take-up factor gives the amount of fluting per sqm of corrugated board: i.e. for a C-flute the amount of fluting in the corrugated board will be about 1,4 sqm/sqm corrugated board.

Table 1. Flute types

Flute	Height of the corrugated member* mm	Flutes/m length of the corrugated board web	Take-up factor	Glue consumption g/sqm, glue layer
A	4,8	110	1,50-1,55	4,5-5,0
B	2,4	150	1,30-1,35	5,5-6,0
C	3,6	130	1,40-1,45	5,0-5,5
E	1,2	290	1,15-1,25	6,0-6,5
F, G, N	0,5-0,8	400-550	1,15-1,25	9,0-11,0

* facings excluded

Example:

box weight:	650 g,
dimensions:	575 x 385 x 225 mm (L x B x H) corrugated board C flute
facings:	Kraftliner 175 g/sqm, Testliner 175 g/sqm
corrugating medium:	Wellenstoff 140 g/sqm

The composition of the corrugated board is then:

		g/sqm
Kraftliner		175
Wellenstoff	1,43 x 140 =	200
Testliner		175
Glue	2 x 5 =	10
Grammage		560

The corrugated board manufacturer can give the weight of the sheet before die-cutting. For a standard type construction the weight can also be calculated using the International Fibre Board Case Code published by ESBO and FEFCO. In this code the form of the box blank is shown and by using the box dimensions it is possible to calculate the total length and width of the blank. Adding a 20 mm broad strip to the edges of the blank gives a fair estimate of the sheet area before die-cutting.

In the example L tot = 1,95 m and W tot = 0,61 m. The dimensions of the sheet are:

A_{sheet} = (1,95 + 0,04) x (0,61 + 0,04) = 1,2935 sqm

and the weight:

M_{sheet} = 1,2935 x 560 = 724 g

Assuming 3 % as corrugator losses (i.e. $\eta_{corrugator}$ = 0,97, a common value for modern corrugators), the consumption of liner and fluting can be calculated as follows:

		g/box
Kraftliner	175 x 1,2935/0,97 =	233
Wellenstoff	200 x 1,2935/0,97 =	267
Testliner	175 x 1,2935/0,97 =	233
Glue	10 x 1,2935/0,97 =	13
		746

Total losses = 746 – 650 = 96 g/box = 12,9% of the input.

Please note that this is only an example of a particular box of a certain standard type construction. Corrugated board boxes are far from standardised. They show a huge variation in composition, design and appearance. Boxes are tailor made to fit the box users need and requirements set by the product to be packed.

Table 2 shows examples of different boxes.

Since standard boxes do not exist, the database is set up in a flexible way giving the user the possibility to make calculations for any composition he wants and using his own assumptions on transport distance, waste management scenario's etc.

Table 2. Examples of boxes

Corrugated Board dimensions grammage (g/m²) product in box	Box weight, box dimensions	Consumption of paper and glue (g/box)				
		Kraftliner	Semi-chemical Fluting	Testliner	Wellenstoff	Starch glue
1. FEFCO code 0411 **blank dimensions 1410 x 1810 mm** **for 4 boxes** **grammage 840 g/m²** fruit and vegetables weight of content 6 kg	Box weight 304 g outside dimensions 400 x 300 x 145 mm	115	160	58	-	12
2. FEFCO code 0411 **blank dimensions 1190 x 1950 mm** **for 2 boxes** **grammage 1028 g/m²** fruit and vegetables weight of content 14 kg	Box weight 654 g outside dimensions 600 x 400 x 180 mm	404	344	-	-	22
3. FEFCO code 0201 **blank dimensions 585 x 1790 mm** **for 1 box** **grammage 755 g/m²** 500 g powder milk cartons weight of content 24x0,5kg = 12 kg	Box weight 739 g outside dimensions 490 x 385 x 200 mm	307	-	246	206	13
4. FEFCO code 0406 **blank dimensions 979 x 1154 mm** **for 2 boxes** **grammage 808 g/m²** 6x750 ml champagne bottles	Box weight 411 g outside dimensions 335 x 256 x 211 mm	79	-	201	162	15
5. FEFCO code 0459 **blank dimensions 1012 x 1510 mm** **for 8 boxes** **grammage 492 g/m²** 24x250 ml beer cans	Box weight 82 g outside dimensions 365 x 244 x 63 mm	25	-	34	27	2
6. FEFCO code 0201 **blank dimensions 481 x 837 mm** **for 1 box** **grammage 390 g/m²** 12x16 ml tissue handkerchiefs	Box weight 154 g outside dimensions 251 x 160 x 332 mm			93	60	5

2. Methodology questions

2.1. Boundaries

This report gives the inputs and outputs from the paper mills and the corrugated board plants separately. Inputs and outputs from the processes mentioned in the grey boxes in fig. 2 are included in the Database.

To make a complete LCA study supplementary data are needed (outside the grey boxes, text in italics in fig 2) such as environmental impacts of precombustion, electricity production for the public grid, transport and waste treatment.

The use of the corrugated box (transportation, protection and identification of the product it contains) is not included in the Database. The user has to use the design of

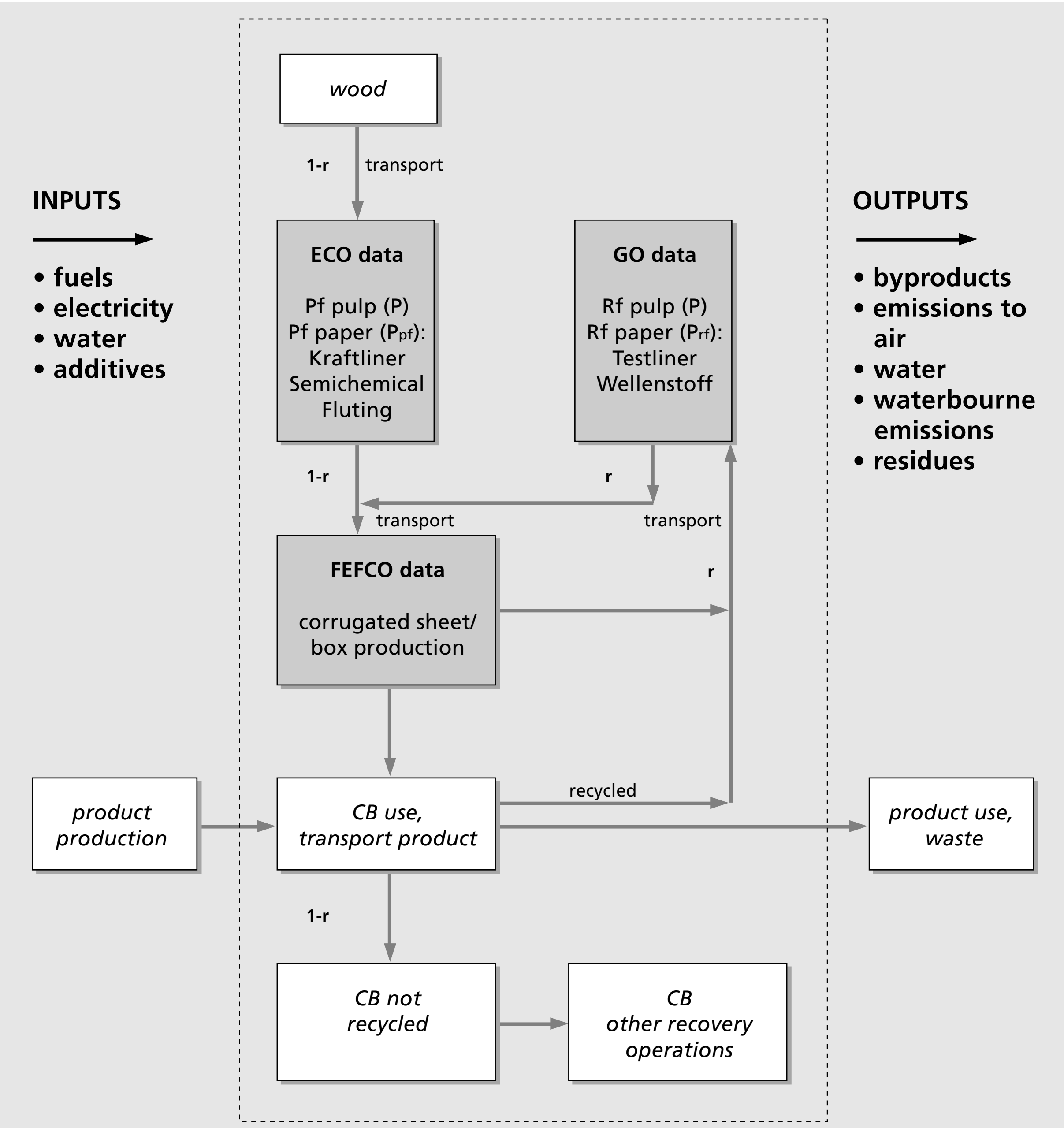


Figure 2. Pf paper: primary fibre base paper production
Rf paper: recovered fibre base paper production
CB: corrugated sheet and box production

the box and details on its transportation containing the product to calculate the full life cycle of the box.

2.2. Closed-loop approach

When performing environmental studies such as Life Cycle Inventory Analysis for products made from wood fibres, the whole life cycle of the fibres must be evaluated from the fibre production until the fibre is lost as waste, normally after having been recycled several times.

Recycling may either be characterised as a closed-loop or an open-loop process. Closed-loop recycling returns the material to the original process and open-loop recycling refers to a product or component going from one system to another for use as raw material in the production of a different product.

To study and analyse an open-loop system, the inputs and outputs from the linked systems have to be studied. This however is not practical in the case of paper recycling, since the linked systems are extremely complex and very difficult to survey.

To simplify the system recycling of corrugated board may be looked upon as processing of the primary fibre after use in corrugated board or as raw material processing for the secondary product, also used in corrugated board. At present this is a fairly just simplification seeing that the main raw material for the recovered paper mills is used corrugated board, though flows in and out of the system of other kinds of paper are ignored.

The problem that remains after this simplification is that choices have to be made to allocate the impacts of the primary fibre production and the final waste to the primary fibre paper and the recovered fibre paper. However the need for allocation can be avoided (as advised by ISO 14041) by carrying out the calculations as if the recovered material is used in the same life cycle, i.e. by considering the recycling system as a closed-loop.

A closed-loop approach requires that the total system is considered. A simplified system for a closed loop corrugated board packaging system is given in figure 2.

2.3 Examples of calculation with a closed-loop approach, considering the total system

In the closed-loop system, assuming the ideal case that no fibres are lost and the fibre quality remains constant due to the reprocessing of the fibres, the average fibre age is calculated as 1/(1-r) where r = the recovery rate. It is also assumed that the fibre age increases by 1 every time the fibres are passing a paper machine. The first time the fibres are passing a paper machine it is in a primary fibre paper mill and the following times in recovered fibre paper mills. This means that in the system "(1-r)" primary fibre base paper and "r" recovered fibre base paper is used to produce 1 corrugated box and "(1-r)" of the fibres is lost as waste.

If the pulp mill is denominated P, the primary fibre paper mill by P_{pf} the recycled paper mill by P_{rf}, the corrugated board plant by CB and waste treatment by W, the environmental impacts from the system can be calculated as:

$$(1-r) \times (P + P_{pf}) + r \times (P + P_{rf}) + CB + (1-r) \times W$$

If for instance the recovery rate is 75%, giving an average age of the fibres of 4, the above expression will be

$$1/4 \times (P + P_{pf}) + 3/4 \times (P + P_{rf}) + CB + 1/4 \times W$$

The following example illustrates the use of the database and the closed-loop approach.

To calculate the total input and output for a corrugated box the following information is also needed:

- Recycling rate (r), indicating the recycled fibre flow in the closed-loop system
- Weight of the consumed paper and glue and % liner (ln), % fluting (fl) of the total weight of the consumed paper and glue
- $\eta_{corrugator}$ ($\approx$ 0,97)
- Weight of the corrugated sheet (ws)
- Weight of the box (wb)

The principle of calculating with the closed-loop approach is that corrugated board is built up out of two principal grades of paper: liner and fluting. The recycling rate is used to take into account the proportion between primary fibre based paper and recycled fibre based paper in liner and fluting.

This leads to the following calculations for inputs and outputs:

for fluting: (1-r) SCF + r WS
for liner : (1-r) KL + r TL

SCF (Semichemical Fluting), WS (Wellenstoff), KL (Kraftliner), TL (Testliner) and CB (Corrugated Board) are the inputs and outputs per net ton saleable product reported in the database. The data for corrugated board are only the data for the corrugated board production sites. They do not include the production of the papers that are used in the process.

To complete the LCI, information on the following are also needed:
- Transport distance of the box, using the weight of the box (wb)
- Input and outputs for energy production (inputs and outputs from electricity production for the public grid, precombustion of natural gas etc.), transport and waste management

The fibre composition in the containerboard consumption in Europe 2002 (table 3) amounts to 5,4 million tonnes of primary fibre and 17,0 million tonnes of recycled fibre, therefore it seems reasonable to assume a recycling rate of 75%, so r = 0,75.

Table 3. Base Paper Consumption for Corrugated Board in Europe 2002

		Fibre composition	
Million tonnes	**Total**	**Primary**	**Recycled**
Kraftliner	4,6	3,6	1,0
Testliner	6,7	–	6,7
Other recycled liner (Schrenz)	1,9		1,9
Semi-chemical Fluting	2,0	1,8	0,2
Recycled medium (Wellenstoff)	7,2	–	7,2
Total	22,4	5,4 24%	17,0 76%

Taking as an example the first box in table 2 (CB grammage 840 g/sqm) the inputs and outputs for the box (ws = 346 g; wb = 304 g) the calculation is as follows:

The environmental load for the corrugated box can then be calculated as follows:

Weight x [liner production + fluting production + corrugated board production] =

$(ws/\eta_{corrugator})$ x [ln{(1-r) KL +rTL} + fl{(1-r) SCF + rWS)} + CB]

Consumption of paper and glue for the sheet:

	g/box	%
Kraftliner	115	33,3
Semichemical Fluting	160	46,4
Testliner	58	16,8
Glue, starch	12	3,5
Total ws	345	100

Therefore liner = 33,3 + 16,8 = 50,1% and fluting = 46,4% of the weight of the corrugated board sheet.

Filling in the data for total fossil fuel in MJ (which can be found in the table on page 27) for the 4 boxes:
0,345/0,97 x [0,501{(1-0,75) x 2,6 + 0,75 x 7,8)} + 0,464{(1-0,75) 7,3 + 0,75 x 7,8} + 1,1]

For a total energy input at the sites the electricity input and the fuel input have to be added up.

The average transport distances for wood and recovered paper are reported in paragraph 3.6. These data have been used to calculate the transport data in tonkm in chapter 4.

In paragraph 3.6 it can be found for example that 58% of the wood that is used for Semichemical Fluting production is transported by truck over 93 km.
The wood consumption (also to be found in chapter 4) is 0,96 bone dry ton wood per ton net saleable product. Since bone dry weight equals 45% of the transported weight, the transported weight of hardwood logs by truck equals 0,58 x 0,96 x 100/45 = 1,24 tonnes per ton net saleable product. This is transported over 93 km, so the transport is 1,24 x 93 = 116 tonkm.

Assuming this is transported by a truck with a loading capacity of 40 tonnes this means that this figure has to be used in combination with data on inputs and outputs for transport by a 40t truck (for example from a generic database like Ecoinvent 2000).

Please note that emissions from the transports are not included in the "emissions to air" in chapter 4.

The amount of corrugated board that is not recycled leaves the closed-loop system and is lost as waste. For the above mentioned recycling rate of 75% this means that of each ton of corrugated board production, 0,75 tonnes is recycled within the closed-loop system and 0,25 tonnes is lost as waste. This figure has to be used in combination with a module for waste treatment/other recovery operations (incineration etc.).

3. Data Description

3.1. Participating paper mills and corrugated board plants

The data in this report are based on weighted average data for 2002 of the production per ton net saleable paper and corrugated board sheets and boxes.

The data for the production of the four major paper grades: Semichemical Fluting, Kraftliner, Testliner and Wellenstoff as well as for the production of corrugated board were collected directly from the producers and checked by technical experts.

The data for Semichemical Fluting and Kraftliner represent more than 70% of the total annual production of corrugated base papers from primary fibres in Europe. These paper grades are produced in large modern mills, located in Austria, Finland, France, Portugal, Slovakia and Sweden. Their total production was 3.374.000 tonnes net saleable paper in 2002. The mills each have an annual production of 84.000 - 620.000 tonnes net saleable paper.

The data for the production of Testliner and Wellenstoff were collected from mills, together producing about 52% (8.200.000 tonnes) of the total annual production of corrugated base papers from recovered paper in Europe (EC). They were provided by paper mills in Austria, Belgium, Denmark, France, Germany, Italy, the Netherlands, Spain, Switzerland and Great Britain. The mills each have an annual production of 40.000 - 685.000 tonnes net saleable paper based on 100% recovered paper.

The data on corrugated board production are based on 111 plants in Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Great Britain, Hungary, Italy, the Netherlands, Norway, Spain, Sweden and Switzerland.
Together they produce 4.023.000 tonnes net saleable product, which is 20 % of the total annual production of corrugated board in Europe.
The production sites have an average annual production of corrugated sheets and boxes of 36.200 tonnes, varying from 14.600 - 87.800 tonnes each.

3.2. Questionnaire, definitions, allocation of inputs and outputs to different paper products produced in the same mill.

The questionnaires are available through the three Associations as a supplement to this report. A list of definitions is included in this report.

The questionnaire treats the paper mills and corrugated board plants as a black box, asking for annual inputs to and outputs from the mill or plant.

Differentiation between the processes within the site, such as power generation, pulping, paper production, wastewater treatment, has not been made.

For those paper mills producing more than one grade of paper it is necessary to allocate inputs and outputs to the different paper grades. Mill people who did fill in the original questionnaire have done the allocation according to causality.

> Example:
> For a mill producing both Semichemical Fluting and Kraftliner the total input of wood to the mill site has been reported as well as an allocation %-figure telling how much of the total wood consumption should be allocated to Semichemical Fluting and how much to Kraftliner.

Details on allocation are described in the following paragraphs of this chapter.

Checking of the data and the allocation percentages

The collected annual data were calculated to inputs to and outputs from the paper mills for the production of 1 ton net saleable paper for each paper product, using allocation percentages in case more than one product was produced at one mill.

The following calculation was made in most cases:

$$\frac{\text{annual in(out)put x allocation \%}}{\text{tonnes nsp}^1\text{ produced in 2002}}$$

Some mills have reported waterborne emissions in g/m^3 waste water and for those mills the following calculation was made:

$$\frac{g/m^3\text{ waterborne in(out)put x allocation \% x } m^3\text{ water}}{\text{tonnes nsp produced in 2002}}$$

[1] nsp: net saleable product

To increase the quality of the database the results were checked as follows.
The data per ton nsp for each paper product were compared by technical experts from the participating mills to investigate if variation of the data could be explained by differences in the applied technology. Data that could not be explained were rechecked to make sure that data from the individual mills were correct.

For the recycled fibre based papers a mass balance of dry material inputs and outputs were calculated for the individual mills. If the input and output of material did not balance (within a range of + or - 5%) mills were asked to investigate their data and give a corrected figure.

3.3. Weighted averages, "Best Average Environmental Practice"

The database gives the weighted averages of the inputs into and outputs from the sites per ton net saleable product (paper, corrugated board sheets and boxes) for 2002 from the participating paper mills and corrugated board plants. Annual inputs and outputs include periods of shut down, so these periods are included in the figures per ton net saleable paper.

It is important to understand that the figures do not represent a certain mill with a certain technology. On the contrary the figures represent a virtual "mill" utilising different technologies.

The technology, which is applied in the participating paper mills and corrugated board plants, is not the same.

For example: not all mills use a combined heat power generation, wastewater treatment is not always internal, a large variety of additives is used. In some cases this leads to a large variation of inputs and outputs between the mills. Also different inputs and outputs are strongly interrelated, so a mill can be high in one input compared to the others but low in another input, but a mill cannot be low or high for both. Therefore no range of the data is given to prevent that studies could be made using a false combination of highest and lowest data.

Because of confidentiality requirements by the mills it is not possible to split inputs and outputs to data per country. Weighted averages of different technologies are not so meaningful, but also for confidentiality reasons a split in applied technologies was not possible.

For this report a compromise was found for the production of Testliner and Wellenstoff as follows.

When a certain technology is used to produce Testliner and Wellenstoff by the majority of the participating mills and this technology will be used in more mills within the near future, the weighted average of the data of the mills using this technology has been calculated in stead of the weighted average of all the mills. Thus the weighted averages represent a "Best Average Environmental Practice" (BAEP). Details are given in the following paragraphs of this chapter. When there is no technical reason for differences between Wellenstoff and Testliner, the weighted average of the data for both grades has been reported.

A few of the requested data could not be supplied by all the participants. In this case the weighted average may not be representative, because it is based on a limited number of data. They are marked with an *.

3.4. Material input and output

3.4.1. Material inputs

Raw Material

The wood input has been reported as total transported wood including bark and water. A pulp yield (oven dry pulp/oven dry wood) of 54-56% is normal for Kraftliner.
A high pulp yield of of 75-80% is normal for Semichemical fluting.

The input of recovered paper has been reported as total weight including moisture and other materials (sand, metal objects, plastics, wood etc.). In European countries the water content of recovered paper is generally assumed to be about 10%. The total input of recovered paper is given but the total input is also split between the 5 main recovered paper grades according to the CEPI (Confederation of European Paper Industries) list, which conforms to the standard EN 643:

Group 1:	ordinary grades
Group 2:	medium grades
Group 3:	high grades
Group 4:	kraft grades
Group 5:	special grades.

The complete list is available on request through the Associations and CEPI.

The content of other materials in the recovered paper varies between 8 and 12%. These materials are eliminated from the pulp as rejects during the pulping. It is estimated that 25% of these materials originate from the former use of the paper, such as tags, labels etc. The remaining 75% has no relation with the former use of the paper.

The main raw material inputs for corrugated board production are different grades of paper. The liners are used for the surface layers of the corrugated board, fluting is used for the corrugated layers.

As pointed out in chapter 1 there are endless possibilities for the composition of a corrugated box. The amount of the different grades of paper and glue used as input for the corrugated board production varies accordingly. These inputs should be considered when the LCA of a certain box is studied. Examples are given in chapter 1.

This should be kept in mind when considering the averages for the paper consumption and the additives for corrugated board production in chapter 4.

Chemical inputs

Chemicals are mainly given as dry weight.

Some of the chemicals have been reported grouped together after their function in the mill. One such example is lubricants that consists of a number of mineral oils, greases, fats etc. but are reported with only one figure.

The functional additives, mainly starch, influence the properties of the paper; process additives are used to guarantee that the process of paper production runs smoothly or to increase the production.

Water treatment additives include additives used for all water treatment on the site, including the treatment of water for the power station, the paper production and waste water treatment if this is done internally. The different mills use a large variety of process and water treatment additives. Those that are commonly used are mentioned in the database.

A very limited quantity of other additives, e.g. synthetic polymers (polyethylenamine, polyacrylamide, polyvinylamine) are being used.

The main input for corrugated packaging is starch, small amounts (less than 0,5 kg/ton nsp) of caustic soda, borax, modified starch and wetstrength are also used. Only a few plants laminate the board and/or add a protective coating. All plants that print the board use the flexo printing technique. For boxmaking cold glue and small amounts (< 0,1 kg/ton nsp) of hot melt, tape (paper or plastic), water glass, plastic tearstrip and stich wire are used.

Packaging

All packing materials have been reported. Packaging amounts to relatively small inputs of tape, wrappings of paper or plastic film, steel bands and pallets used as packaging of the saleable product. Pallets are used to a great extent in the logistic operations of the corrugated board industry. However the reported data on the use of pallets are confusing because of the complexity of the matter. Pallets can be returnable or one-way, only used internally in the plants and produced of wood, plastic or paper/wood combinations. Some plants have reported their use in number of pallets while other have reported in kilogram pallet per ton net saleable product. Therefore it is not meaningful to report any figure because of poor data quality. For the next update of the database, preliminary foreseen for year 2005, the matter of use of pallets will be dealt with in a better and more reliable way.

Allocation to paper grades when a mill produces more than one paper grade

The basic data for raw material and chemical inputs are mainly based on recipes used for the production. When allocation was necessary, this was done according to mass production of the different papers.

3.4.2. Material outputs

The main output from the paper mills is of course paper. This includes about 2 kg of cores and plugs per ton paper, which are considered and weighed as part of the net saleable product. The corrugated board plants produce corrugated board and boxes.
The average moisture content of the saleable product is 9 % for Semichemical Fluting and 8 % for Kraftliner, 7,5 % for Testliner and Wellenstoff, 7-8% for corrugated board.

Saleable by-products from the production of Kraftliner, are tall oil and turpentine. These are included in the report.

A saleable by-product from the production of Testliner and Wellenstoff is fuel pellets of organic substances other than wood fibres (e.g. string fibres, plastics and textiles) in recovered papers. The pellets have the calorific value of coal and are used in large industrial ovens at temperatures above 800 ˚C. This includes use in cement ovens, lime kilns, rock wool ovens, coal fired boilers and blast furnaces.

Residues

All solid residues if possible are reported as water free waste separated according to their basic nature. Solid residues are reported irrespectively if they are deposited internally within the site or externally, in the latter case normally at a deposition cost.

EWC (European Waste Catalogue) numbers have been used as far as possible to identify the different solid residues.

Of the residues from the recycled paper mills, mainly rejects from the pulp preparation, about 75% consist of waste that is not due to the previous use of the paper. The previous use of the paper and properties of paper cause the other 25% of the rejects: paper clips, tags, adhesive labels, fibres etc. The average dry mass of the rejects is about 55%.

Primary sludge from wastewater treatment in the mills producing Testliner and Wellenstoff are recycled in the process and mostly do not leave the site.

For corrugated board the main waste stream is paper/board, which is recycled and thus should not be called waste but recyclable material.

Allocation of residues to paper grades when a mill produces more than one paper grade
Data for material outputs are based on measurements. These have to be done because the mills have to pay for landfill and incineration, or get paid for residues that are reused or recycled, like lubricants, according to the weight. When allocation was necessary, this was done according to mass of the different paper production.

There is no technical reason for differences in residues between Testliner and Wellenstoff. However the weighted averages for each paper grade do show differences because different mills are included in the samples. To prevent misunderstanding, the same amounts for residues for both paper grades are reported as their weighted average.

3.5. Energy input and output

Fuel inputs to the sites have been reported in GJ. The lower calorific heat values have been used to calculate GJ from m3 or tonnes of fuel. Fossil fuel and biomass fuel have been reported separately.
The energy figures for the sites include both energy for process and energy for infrastructure. No attempts have been made to differentiate between these two types of energy usage because process energy is so totally dominating (98% or more). Light fuel oil is used for heating during mill stops or shutdowns.

Input of electricity into the sites is also reported. The electricity that is produced at the site itself is not reported. Some mills are selling energy externally in the form of electricity, steam or warm water. This is reported separately.

The production sites are treated as a black box in the database, giving data on inputs and outputs only. Because no information is given about what happens within the box it is not possible to calculate an energy balance with the data in the database.

Within this box, energy is recovered through the burning of black liquor and bark from the wood coming in at production sites for primary fibre based paper production. Most of the energy used in the process comes from internal burning of the black liquor. This inherent energy is not reported as part of the fuel input. The total energy input for the process including the black liquor burning is around 15 GJ/ton. Energy from internal incineration of rejects at the site is also not reported as part of the energy input.

Combined heat power generation is applied at the production sites for recycled fibre based paper, but not always in the same way. The combined heat power generation can cover all or part of the steam consumption (figure 3). When it covers only part of the steam consumption, then additional boilers also produce steam.

The process always uses more heat (steam) than electricity. Therefore, when the installation is designed to cover the whole steam consumption more electricity is generated than what is needed for the process. The excess of electricity is sold to the public grid.

There are two possibilities of treating this excess electricity in an LCA.

a. The production of electricity is an integral part of the paper production: it would not be produced if the paper were not produced. Paper is thus considered as the only "product" of the process. In an LCA this would mean that electricity generation for the public grid is "saved" when an excess of electricity is produced at a paper mill is sold to the public grid. Thus environmental inputs and outputs are saved since combined heat power installation produces electricity with a higher efficiency than the public grid.

b. Another possibility is to consider the paper and excess electricity as co-products. Paper and electricity are then both "products" from the process. In an LCA this would require allocation of inputs and outputs to both products.

The first possibility seems to be the most frequently applied. Also the quality of the measured data is better than the data that are the result of the allocation between paper production and electricity that is sold to the public grid. Therefore the inputs and outputs for paper production that are reported include the production of electricity that is sold to the public grid. The data do not include savings on electricity production elsewhere. These depend on the electricity module that is used in combination with the database.

The weighted average for mills using combined heat power generation (65% of the participating mills producing Wellenstoff and Testliner) is given for the input of fuels and corresponding emissions to the air. These figures are regarded to represent BAEP (Best Average Environmental Practice).

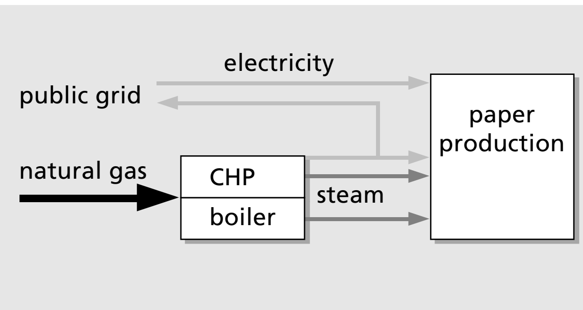


Figure 3. CHP, combined heat power generation

Diesel or gasoil/LPG used for internal transports are reported.

Most of the energy consumed by the mills producing Semichemical Fluting and Kraftliner are by-products from the process and thus originates from the trees i.e. have biomass origin.

Allocation of energy to paper grades when a mill produces more than one paper grade

The energy is measured, because it is paid for. Allocation for fuels and electricity input is calculated according to energy (heat and electricity) required for the production of the different paper grades. Allocation of the other fuels, such as diesel oil used for internal transportation, was calculated according to mass production of each paper grade.

There is no technical reason for differences in energy consumption between Testliner and Wellenstoff. However the weighted averages for each paper grade do show differences because different mills are included in the samples. To prevent misunderstanding, the same amounts for energy consumption and emissions to air for both paper grades are reported as their weighted average.

3.6. Transport

The transport distances of wood raw materials from the harvesting sites in the forests to the mills have been reported separately for trucks, rail and ships. The trucks and rail wagons are normally loaded to full capacity but go back empty. The trucks seem to carry 40-44 tonnes of wood but the figures are uncertain because many mills were unable to give any information.

For recovered paper the transport distances from recovered paper dealer to the mills have been reported. Generally the lorries are loaded to full capacity. On the return trip it is estimated that 40% of the trucks return empty.

Transport of the residues was not included in the questionnaire as this was seen to be part of the residue treatment. During the discussions with the technical experts it became clear that the transport of rejects is mainly to near by landfill, 3-30 km.

Allocation of transports to paper grades when a mill produces more than one paper grade
No record is kept by the mills to register this kind of information, so the data are based on estimations.

Transport distances and means of transports of raw paper materials to the corrugated board plants are not included in chapter 4. The range of the collected data is so large, that establishing average data is not meaningful. The complexity is due to the fact that raw paper materials from very many different suppliers are used in a corrugating plant. In practice this should be considered case-by-case. In the LCA software-tool that was developed for corrugated board this is one of the parameters that can be varied according to the specific situation.

Internal transport is included in the energy input (paragraph 3.5).

3.7. Emissions to air

Emissions from fuel combustion (transport, electricity generation for the public grid) outside the mill are not included in the data.

Emissions to air from the sites have been reported. For dust, TRS (H2S), NOx and SOx the figures from the paper mills are mostly based on measurements. For CO_2 the figures reported are based on calculations and reported separately for fossil and biomass origin.
Only few corrugated board plants have given emission data based on measurements. Therefore the reported emission data originating from fuel combustion and internal transport are based on calculations. The following emission factors were used for the calculations:

The calculated data were always higher when they were compared to the real measured data (between 10% and 100%).

Emissions to air in the flue gas from the power station are given for the mills producing Testliner and Wellenstoff that use combined heat power generation. Emissions from incineration of rejects with energy recovery at the mill are included.

Transport raw material		Semichemical Fluting	Kraftliner	Wellenstoff and Testliner
wood by truck	km	93	127	
	%	58	67	
wood by rail	km	284	252	
	%	30	22	
wood by boat	km	610	930	
	%	12	11	
recovered paper by truck	km	197	185	188
	%	72	38	93
recovered paper by rail	km	382	926	617
	%	28	55	6
recovered paper by boat	km		1556	223
	%		7	1

These data have been calculated to tonkm for chapter 4.

	unit	natural gas	oil heavy	oil light	diesel
CO_2 (fossil)*	kg/GJ	56	78	74	74
CO **	g/GJ	14	15	10	446
Dust **	g/GJ	0,22	50	0,12	28
NO_x (as NO_2) **	g/GJ	65	160	60	1451
SO_x (as SO_2) **	g/GJ	1	1200	65	61

* Source IPCC (Intergovernmental Panel on Climate Change)
** Source BUWAL 250/300

Table 4. Default factors for calculating emissions to air.

Emissions in the steam from the drying section of the paper machines are not included.

When mills have anaerobic wastewater treatment on the site, biogas originating from this process is used as a fuel by the mill. The emissions to air originating from the use of biogas as fuel are included.

Volume of the total flue gas stream was not asked in the questionnaire or the means of flue gas treatment.

Some mills producing Semichemical Fluting and Kraftliner could report emissions of CO but most of the mills were unable to give reliable information and therefore CO figures have been omitted for those two paper grades.

The mills were unable to report any figures for emissions like N_2O, NH_3, CH_4, aldehydes, Pb, Hg etc. because there are no measurements. Databases on energy production can be used to get an indication of the emissions that can occur due to combustion of different fossil fuels. Together with the amount of fossil fuels used in the processes (chapter 4), an estimate can be made of the order of magnitude of these emissions. These substances are not expected to be emitted from integrated pulp and paper mills based on wood as a raw material.

Allocation of emissions to paper grades when a mill produces more than one paper grade
Emissions to air are calculated from measurements, applied technology, permit values or from the input of fuels. Necessary allocation was done in the same way as for energy input.

3.8. Emissions to water

Water that is taken in has to be treated before it is used in the process, and it is again treated after the process before it is released as effluent to a recipient. The substances in the effluent after wastewater treatment are reported.

All mills have some sort of effluent water treatment either mechanical treatment by sedimentation or in addition also biological anaerobic and aerobic or chemical treatment of the effluent.

A few mills send their effluent water to an external communal treatment plant.
The volume of effluent water is reported separately for polluted (chemically polluted effluent) and non polluted (including thermally polluted effluent, e.g. cooling water). All mills have reported the figures for outgoing effluent water to the recipient i.e. effluent water after final treatment.

The amount of substances (COD, BOD, suspended solids) per m3 of effluent from the different mills show very little variation when the efficiency of the waste water treatment station is the same. The amount of substances per ton paper production may however vary according to the amount of effluent, depending on specific circumstances in the paper production process in the different mills.

In the questionnaire filled in by the mills a number of other emissions were asked for like oils, nitrates, acids, AOX, chlorate, chlorides, borates, phenol, Hg, Pb etc. Few mills were able to report figures probably because there are no or too few measurements. Therefore only COD, BOD5, suspended solids, total nitrogen and total phosphorus are based on data from most mills in addition to the total volume of effluent waters. Other emissions, marked with "*" are based on data from a limited number of mills. When no or only very few mills gave data for a certain substance, these are marked as N.A.

For the production of Testliner and Wellenstoff the weighted average of the mills with internal waste water treatment using biological anaerobic and aerobic waste water treatment with a high efficiency (>95% for COD, >99% for BOD5, >90% for suspended solids) and mills with zero effluent are given. For the future it is expected that mills will start to close their water system more and more, using internal water treatment, so emissions to recipients are expected to decrease.

Due to the water treatment it is possible that the content of certain substances per m3 is higher if the water is taken in from a river than in the effluent to the river. In an LCA this would mean that in this case the production of paper could be credited for the reduction in substances. This is illustrated in figure 4.

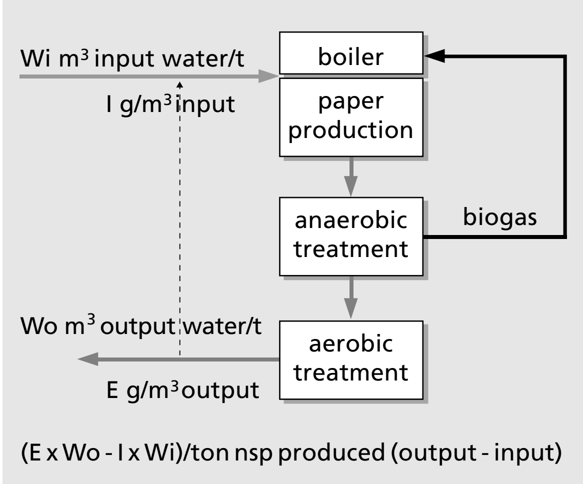


Fig. 4 Credit for reduction of substances in the in effluent water

Wi: input water in m³

Wo: output water in m³ (effluent)

I: amount of substances in input water

E: amount of substances in output water

However since only a few mills analyse their incoming water the available data cannot be considered as representative. Therefore only data for the emissions to the recipient are given, without taking into account the substances in the incoming water.

Most of the corrugated board plants have internal waste water treatment. The data are related to effluent after internal waste water treatment and before external treatment.
Besides the substances reported in chapter 4, very few plants have also given data on some of the following emissions: metals (Cadmium, Chromium, Lead, Nickel, Iron, Boron, Aluminium), AOX, Chlorine and Phosphorus. The amounts are below 0,001 kg/ton nsp.

Allocation of emissions to paper grades when a mill produces more than one paper grade
As far as waterborne emissions per m³ are measured for a mill, these data are well documented.

The figures reported are based normally on continuous measurements according to control programs set by official authorities. Given emissions to water are measured according to standard methodology.

Where necessary, allocation between paper grades is done according to mass of produced paper grade. There is no technical reason for differences in water consumption, effluent and emissions to water between Testliner and Wellenstoff. However the weighted averages for each paper grade do show differences because different mills are included in the samples. To prevent misunderstanding, the same amounts for water consumption, effluent and emissions to water for both paper grades are reported as their weighted average.

4. Data

		Semichemical Fluting	Kraftliner	Wellenstoff	Testliner	Corrugated Board
PRODUCT	ton net saleable	1	1	1	1	1
SOLD BYPRODUCTS						
Tall oil	kg/ton nsp	0	19,3	0	0	0
Turpentine	kg/ton nsp	0	1,2	0	0	0
Fuel pellets	kg/ton nsp	0	0	2,3	2,3	0
Electricity	GJ/ton nsp	0,083	0,007	0,66	0,66	0
Thermal energy	GJ/ton nsp	0,59	0,59	0,01	0,01	0
RAW MATERIAL						
Wood	*as bone dry weight (= 45% of tranported total wet weight)*					
Softwood logs	ton/ton nsp	0,02	0,71	0	0	0
Hardwood logs	ton/ton nsp	0,79	0,22	0	0	0
Saw mill residues, softwood	ton/ton nsp	0,02	0,42	0	0	0
Saw mill residues, hardwood	ton/ton nsp	0,12	0	0	0	0
Total wood	ton/ton nsp	0,96	1,36	0	0	0
Recovered paper	*as wet weight*					
Category						
1	ton/ton nsp	0,04	0,22	0,98	0,93	0
2	ton/ton nsp	0	0	0,0008	0,0027	0
3	ton/ton nsp	0	0	0,00004	0,00012	0
4	ton/ton nsp	0,021	0,046	0,073	0,156	0
5	ton/ton nsp	0,007	0	0,011	0	
Total recovered paper	ton/ton nsp	0,07	0,27	1,07	1,09	0
Purchased pulp	*as wet weight*					
Brown pulp	ton/ton nsp	0	0	0	0	0
Bleached pulp	ton/ton nsp	0	0,028	0	0	0
Paper consumption for corrugated board production						
	as wet weight					
Total	ton/ton nsp	0	0	0	0	1,11
Others						
Cores	kg/ton nsp	2,9	1,6	2,2	2,4	0
Core plugs	kg/ton nsp	0,05	0,06	0,04	0,05	0

* = not representative
N.A. = not available
0 = no inputs or outputs
nsp = net saleable product

		Semichemical Fluting	Kraftliner	Wellenstoff	Testliner	Corrugated Board
TRANSPORT OF RAW MATERIAL						
Wood						
Wood with truck	tonkm	116	257	0	0	0
Wood with rail	tonkm	182	167	0	0	0
Wood with boat	tonkm	156	309	0	0	0
Recovered paper						
Recovered paper with truck	tonkm	9	15	187	191	0
Recovered paper with rail	tonkm	18	112	40	40	0
Recovered paper with boat	tonkm	0	24	2	2	0
ENERGY INPUT						
Steam	GJ/ton nsp	0	0	0	0	0,038
Fossil fuels						
Natural gas	GJ/ton nsp	1,4	0,9	7,0	7,0	0,82
Heavy fuel oil	GJ/ton nsp	1,7	1,7	0	0	0,15
Light fuel oil	GJ/ton nsp	0,001	0,027	0,001	0,001	0,073
Diesel oil	GJ/ton nsp	0,018	0,008	0,002	0,002	0,016
LPG	GJ/ton nsp	0	0	0	0	0,063
Coal	GJ/ton nsp	1,3	0	0,36	0,36	0
Lignite	GJ/ton nsp	0,38	0	0,43	0,43	0
Peat	GJ/ton nsp	2,5	0	0	0	0
Total fossil fuel	GJ/ton nsp	7,3	2,6	7,8	7,8	1,1
Renewable fuels						
Bark	GJ/ton nsp	0,24	0	0	0	0
Biofuel	GJ/ton nsp	0,27	0,68	0	0	0
Wood chips	GJ/ton nsp	0,15	0	0	0	0
Total renewable fuel	GJ/ton nsp	0,66	0,68	0	0	0
Total fuel	GJ/ton nsp	8,0	3,2	7,8	7,8	1,1
Electricity						
Bought electricity	GJ/ton nsp	1,7	2,3	0,23	0,23	0,42
WATER INPUT						
Ground water	m3/ton nsp	0,073	0,42	2,6	2,6	0,07
Surface water	m3/ton nsp	51	45	3,1	3,1	0,03
Network water drinkable	m3/ton nsp	0,01	0,47	0,14	0,14	0,47
Network water non drinkable	m3/ton nsp	0	0	0,28	0,28	0,01
Input total	m3/ton nsp	51	45	6,1	6,1	0,58

		Semichemical Fluting	Kraftliner	Wellenstoff	Testliner	Corrugated Board
ADDITIVES INPUT, dry mass						
Alum (Al2(SO4)3	kg/ton nsp	0,10	9,9	0	0	0
Biocides	kg/ton nsp	0	0,17	0,03	0,04	0,0046
Borax	kg/ton nsp	0	0	0	0	0,32
CaCO3	kg/ton nsp	0	1,8	0	0	0
CaO	kg/ton nsp	2,9	5,3	0	0	0
Chelating agents	kg/ton nsp	0	0,14	0	0	0
Cl2	kg/ton nsp	0,0070	0	0	0	0
Colorants	kg/ton nsp	0	0,013	0	0,4	0
Defoamer	kg/ton nsp	0,17	0,89	0,22	0,28	0
Fillers	kg/ton nsp	0	9,6	0	0	0
Glue, cold	kg/ton nsp	0	0	0	0	0,60
H2O2, peroxide	kg/ton nsp	0	3,3	0	0	0
H3PO4	kg/ton nsp	0,097	0	0,13	0,16	0
H2SO4	kg/ton nsp	1,4	15,4	0	0	0
HCl	kg/ton nsp	0,53	0,32	0,08	0,09	0
Ink, flex-ink	kg/ton nsp	0	0	0	0	2,5
Lubricants	kg/ton nsp	0,026	0,16	0,08	0,09	N.A.
MgO	kg/ton nsp	1,0	0	0	0	0
NaClO3	kg/ton nsp	0	1,3	0	0	0
Na2CO3	kg/ton nsp	2,7	1,6	0	0	0
Na2SO4	kg/ton nsp	0	1,6	0	0	0
NaOH	kg/ton nsp	20,8	11,9	0,30	0,35	0,96
NH3	kg/ton nsp	12,0	0	0	0	0
Oxygen, O2	kg/ton nsp	0,19	2,4	0	0	0
Pitch despergents	kg/ton nsp	0,75	0,15	0	0	0
Retention agents	kg/ton nsp	0,64	0,90	0,59	0,90	0
S	kg/ton nsp	12,9	0	0	0	0
Sizing agents	kg/ton nsp	0	2,7	0	1,0	0
SO2	kg/ton nsp	1,3	0,026	0	0	0
Starch	kg/ton nsp	0	9,5	33,6	35,5	26,1
Urea	kg/ton nsp	0	0	0,35	0,22	0
PACKAGING MATERIALS INPUT						
Pallets	kg/ton nsp	0	0	0,01	0,01	N.A.
Paper, board	kg/ton nsp	2,6	0,19	0	0	4,2
PE	kg/ton nsp	0,006	0	0,01	0,02	0,32
Steel	kg/ton nsp	0,023	0,013	0,03	0,06	0,17
Strapping	kg/ton nsp	0	0	0	0	0,78

		Semichemical Fluting	Kraftliner	Wellenstoff	Testliner	Corrugated Board
EMISSIONS TO AIR						
Dust	kg/ton nsp	0,55	0,45	0,006	0,006	0,011
CO2 (fossil)	kg/ton nsp	518	201	474	474	66
CO2 (biomass)	kg/ton nsp	563	1630	16	16	0
CO	kg/ton nsp	0,78	1,7	0,29	0,29	0,02
NOx (as NO2)	kg/ton nsp	1,6	1,3	0,83	0,83	0,27
SOx (as SO2)	kg/ton nsp	2,9	0,58	0,05	0,05	0,19
TRS (H2S as S)	kg/ton nsp	0,12	0,05	0	0	0
EMISSIONS TO WATER						
Water output						
Thermally polluted	m^3/ton nsp	6,0	13,8	0,3	0,3	0,2
Polluted	m^3/ton nsp	26,5	29,0	3,9	3,9	0,3
Water output total	m^3/ton nsp	32,5	42,8	4,2	4,2	0,5
Waterborne emissions						
COD	kg/ton nsp	15,7	15,6	0,78	0,78	0,26
BOD 5	kg/ton nsp	7,6	7,5	0,09	0,09	0,080
Suspended solids	kg/ton nsp	3,8	1,9	0,17	0,17	N.A.
Total Nitrogen	kg/ton nsp	1,3	0,13	0,034	0,034	N.A.
Ammonia*	kg/ton nsp	1,3	0	0,012	0,012	N.A.
Nitrates	kg/ton nsp	0	0	0,033	0,033	N.A.
AOX*	kg/ton nsp	0	0,010	0,0007	0,0007	N.A.
Total Phosphorus	kg/ton nsp	0,028	0,016	0,004	0,004	N.A.
Chlorides*	kg/ton nsp	N.A.	N.A.	1,1	1,1	N.A.
Sulphates*	kg/ton nsp	N.A.	N.A.	0,66	0,66	N.A.
Cu*	kg/ton nsp	N.A.	N.A.	0,000036	0,000036	0,00052
Zinc*	kg/ton nsp	N.A.	N.A.	0,0008	0,0008	0,00052
TOC	kg/ton nsp	5,7	4,2	N.A.	N.A.	N.A.
RESIDUES (EWC number)						
Bark, wood (03 03 01)	kg/ton nsp	58	12,8	0	0	0,91
Calcium Carbonate (03 03 09)	kg/ton nsp	0	2,3	0	0	0,92
Ink residues (08 03 07)	kg/ton nsp	0	0	0	0	0
Inorganic ashes (10 01 01)	kg/ton nsp	23,2	6,6	1,1	1,1	0
Inorganic sludges (03 03 02)	kg/ton nsp	3,0	5,7	0	0	0
Organic sludges (03 03 10 and 03 03 11)	kg/ton nsp	17,5	1,1	5,3	5,3	5,5
Paper, board, recycled	kg/ton nsp	0	0	0	0	149
Plastics	kg/ton nsp	0	0	0	0	0,56
Rejects, paper related (03 03 07)	kg/ton nsp	5,0	0	10,5	10,5	0
Rejects, other (03 03 07)	kg/ton nsp	8,2	9,5	31,5	31,5	0
Starch, glue (wet weight)	kg/ton nsp	0	0	0	0	1,8
Lubricants and oil (13 02 08)	kg/ton nsp	0,045	0,072	N.A.	N.A.	0,074

5. Final Remarks

For all three Associations the project is considered to be of major importance. To assure the maintenance of the database a Reference Group has been formed, with representatives from FEFCO, the Groupement Ondulé and the European Containerboard Organisation. The main task of this Reference Group is to initiate updates and evaluate and develop the use of the database.

5.1. Updates

In the future a regular update of the database will be made, allowing an adaptation of the database to new developments in LCA standards.

The next update of the report is foreseen for 2006, containing data for 2005.

6. Definitions

Allocation
Technique for partitioning the inputs and outputs of a system amongst products

Effluent
Water leaving the mill after treatment

Incineration + energy
Incineration of residues with energy recovery

Fluting
Paper grades used for the corrugated layer of corrugated board

Functional additives
Additives that influence the properties of paper

Liner
Paper grades used for the surface layer of corrugated board

Life Cycle Assessment
Compilation and evaluation, according to a systematic set of procedures, of the inputs and outputs and the potential environmental impacts of a product system throughout its life cycle

Life Cycle Impact Assessment
Phase of the life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system

Life Cycle Inventory Analysis
Phase of the life cycle assessment involving compilation, and the quantification of inputs and outputs, for a given product system throughout its life cycle

Packaging materials
Materials bought and used for the packaging of the saleable product (wrappings, pallets)

Primary Fibre
Virgin fibre, fibres that have not been recycled before use in paper production

Process additives
Additives that are used to guarantee that the process of paper production runs smoothly or to increase the production

Rejects
Other material in recovered paper, which is eliminated during the pulp preparation

Transport distance of recovered paper
Distance from recovered paper supplier to the paper mill

Transport distance of wood
Distance from harvesting site to the paper mill

Wellenstoff
Recycled fibre based Fluting