European Commission

JRC SCIENCE FOR POLICY REPORT

Revision of the EU Ecolabel criteria for: Copying and Graphic Paper, Newsprint Paper and Tissue Paper

Draft Preliminary Report

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Executive summary

Policy context

This draft Preliminary Report has been produced as one of the first steps in the revision process for the revision of EU Ecolabel criteria for the following three product groups: Copying & Graphic Paper, Newsprint Paper and Tissue Paper. It will act as a basic reference point to support discussions on future criteria and rationale that will be presented in upcoming Technical Reports that are also published during the same revision process, which is expected to be completed in the first half of 2017.

Main findings

An assessment of relevant technical standards, legislation and policy instruments shows that the pulp and paper industry finds itself at the heart of many major policy challenges such as climate change and the shift towards renewables and towards a circular economy and make a key contribution to all three.

The pulp and paper market has undergone some major shifts in the last decade or so due to a major decline in demand for graphic paper and especially newsprint paper as digital alternatives take over. Other end-products such as tissue and packaging board have continued to grow and are becoming more and more important to the industry as many mills convert their production from graphic paper to tissue or packaging. Margins are very thin in the market due to strong international competition although final tissue conversion is somewhat insulated from global competition due to the low bulk density of the product which makes long transport uneconomical.

The main environmental hot-spots in the paper production process were the use of energy in pulp mills, electricity in paper mills and the production and use of process chemicals (mainly for chemicals used in chemical-pulp processes). Replacing virgin fibre with deinked fibres from recovered paper has environmental benefits so long as transport involved in the collection and delivery of recovered papers is not too high.

Industry front-runners are already demonstrating the main improvements that can be made which include, but are not limited to:

- Switching from fuel oil or coal to natural gas in onsite CHP and/or secondary boilers.
- Switching from natural gas to biomass in onsite CHP and/or secondary boilers.
- Replacing recovery boilers with degasification units for bark/black liquor processing.
- Reducing bleaching chemical consumption with optimised sequences and/or enzymes.
- Washing of lime sludge to remove sulfur prior to the lime kiln.
- Increasing the quantities of fibres sourced from sustainably managed and third party certified forests and/or locally available recovered paper.

Related and future JRC work

In parallel to this report, a first Technical Report is also published (version 1.0) which will contain specific proposals and supporting rational for product group scopes and definitions, ecological criteria and corresponding assessment and verification text.

These Technical Reports will be discussed with stakeholders both in physical meetings and via an online platform and subsequent versions will be published to reflect the ongoing developments and inputs to the revision process.

1. Introduction

The EU Ecolabel is an element of the European Commission's action plan on Sustainable Consumption and Production and Sustainable Industrial Policy (SCP/SIP) adopted on 16 July 2008. This is a voluntary scheme established to encourage manufacturers to produce goods and services that are environmentally friendlier. The EU Integrated Product Policy (IPP) formed a key element of the Action Plan, which proposes a combination of voluntary and mandatory instruments seeking to reduce the environmental impacts arising from products and services along all the phases of their life-cycle. Two important voluntary policy instruments within the IPP and highlighted by the SCP/SIP are the EU Ecolabel and the EU Green Public Procurement (GPP); both are intended to promote products and services which demonstrate lower negative environmental impacts when compared with functionally alternative options belonging to the same product/service group. Both promotion schemes will help address the wider objectives of competitiveness and green growth within the EU.

The Roadmap for a Resource-Efficient Europe, published in September 2011 and integrated into part of the Europe 2020 Strategy, reinforces the role of the EU Ecolabel and EU Green Public Procurement (GPP). The goal of the Roadmap is to move the economy of Europe onto a more resource efficient path by 2020 in order to become more competitive and to create economic growth and employment. The role of the Ecolabel and GPP are highlighted as key actions that will help improve manufactured products and change consumption patterns to help drive resource efficiency. Accurate information based on the life-cycle impacts and costs of resource use is needed to help guide consumer decisions. Consumers can save costs by avoiding personal waste and buying products that last or can easily be repaired or recycled. New entrepreneurial models where products are leased rather than bought can satisfy consumer needs with less life-cycle resource use.

The EU Ecolabel promotes the production and consumption of products with a reduced environmental impact along the life cycle and is intended to be awarded only to the best (environmental) performing products in the market. The EU Ecolabel flower logo facilitates consumers and organisations (i.e. public and private purchasers) to recognise the best environmentally performing products and making environmentally conscious choices more easily. A product (good or service) awarded with this label must meet high environmental and performance standards. The EU Ecolabel covers a wide range of products, and its scope is constantly being widened. The consultation of experts and all interested parties is a key point in the process of establishing the criteria.

The SCP/IP highlights the EU Ecolabel role as complementing the information provided to consumers and acting as a 'label of excellence' that signals to consumers that labelled products perform better environmentally over the whole product life-cycle. By design, the Ecolabel criteria development process also provides useful information for other policy instruments, such the expanded Ecodesign Directive proposed within the Roadmap for a resource-efficient Europe.

An important part of the process for developing or revising EU Ecolabel criteria is the involvement of stakeholders through publication of and consultation on draft technical reports and criteria proposals. This is achieved by stakeholder involvement in working group meetings and written consultation processes managed via an online platform.

The EU Ecolabel currently covers a wide, and expanding, list of products and services. This study was carried out by the Joint Research Centre's Institute for Prospective Technological Studies (JRC-IPTS) with the support of EUNOMIA consultancy, in cooperation with all interested stakeholders. All the results are presented on a dedicated website: http://susproc.jrc.ec.europa.eu/Paper_products/

This preliminary report addresses the requirements of the Ecolabel Regulation No 66/2010 for technical evidence to inform criteria revision and sets the scene for the discussions planned to take place at the first working group meeting planned in June

2016 but will continue to be relevant right through to the end of the criteria revision process, which is expected to occur 2017. The revision process takes the existing criteria document as the starting point and seeks to update these, taking into account technological and economic changes in the European market, relevant legislative changes and improved scientific knowledge. The report is split into 4 primary tasks, which are described as follows:

- **Task 1: Scope and definitions.** This involves the identification of relevant background information, including definitions of different types of pulp and paper and a description of the legal framework which applies to paper products in the EU. Stakeholder survey is also briefly analysed.
- **Task 2: Market analysis.** This involves an analysis of key market data relating to pulp and paper production and should link well to the choice of paper product definitions. Trends at least over the last 5 years should be considered as well as the potential emergence of new product types/classifications. The underlying reasons behind the most significant trends should be considered and linked to potential impacts on the demand for EU Ecolabel paper products if possible.
- **Task 3: Life Cycle Assessment (LCA) evidence.** This task involves a review of relevant available evidence relating to the environmental impacts of paper products generated across the entire life cycle of the product (cradle to grave or cradle to cradle). Suitable evidence may include full LCAs, studies that focus on particular aspects of the paper production process and on environmental product declarations (EPDs). Results should be considered in the context of any existing product category rules (PCRs) and each study should be evaluated according to minimum quality requirements and scored according to the quality and degree of relevance to the revision process for EU Ecolabel criteria. The overall aim of Task 3 is to identify the stages in the paper life cycle where the major environmental impacts occur so that EU Ecolabel criteria are targeted to these areas as far as is practical.
- **Task 4: Technical analysis.** The material sourcing, production and possible recycling processes are broadly considered from a purely technical perspective, highlighting those areas where existing or potentially new EU Ecolabel criteria could apply. A more detailed technical analysis will be included in the subsequent technical reports for Tissue Paper and for Copying & Graphic and Newsprint paper.

Bringing together the information from Tasks 1-4 and the more detailed technical analysis in the Technical Reports, a set of proposed EU Ecolabel criteria will be included in the Technical Reports, together with supporting rationale.

Both the Preliminary Report and the first versions of the Technical Reports will be published approximately one month ahead of the 1st Ad-Hoc Working Group meeting in June 2016 and act as the main basis for discussion.

2. Task 1: Scope and definition

The overall purpose of this chapter is to provide a background to the legal, policy and technical framework in which Copying and Graphic Paper, Newsprint Paper and Tissue Paper lie as well as comparing the existing EU Ecolabel scope and definition for each product group with those of industry and other ecolabel schemes. The chapter is split into the following sections:

i. Paper industry terminology and classifications
ii. Scope, definition and context of each of the EU Ecolabel product groups.
iii. Legal framework.
iv. Policy framework
v. Technical framework.

2.1 Paper industry terminology and classifications

2.1.1 CEPI grading system and definitions

Paper products have many different grades and varieties and so it is prudent to first reproduce the CEPI definition of the term "paper".

"*Paper is a generic term for a range of materials in the form of a coherent sheet or web, excluding sheets or laps of pulp as commonly understood for paper making or dissolving purposes and non-woven products, made by deposition of vegetable, mineral, animal or synthetic fibres, or their mixtures, from a fluid suspension onto a suitable forming device, with or without the addition of other substances. Papers may be coated, impregnated or otherwise converted, during or after their manufacture, without necessarily losing their identity as paper. Whereas board / paperboard is a generic term applied to certain types of paper frequently characterized by their relative high rigidity*".

The primary distinction between paper and board is normally based upon thickness or grammage (g/m^2), though in some instances the distinction will be based on the physical characteristics (e.g. rigidity) and/or end-use (e.g. book covers vs packaging).

The distinction between paper and board lied in different intended functional use. Board is used mainly in packaging while paper can be used to store, collect and distribute information (Copying and Graphic Paper and Newsprint Paper) or for hygienic purposes (Tissue Paper) amongst others. CEPI grade graphic and newsprint papers as follows.

Table 1. Harmonised grading for Paper and paper boards

Grade	Fibre content	Format	Use	Weight (g/m2)	Brightness and colour
Newsprint	0. Not defined; 1. Mechanical; 2. Recovered paper; 3. Chemical Pulp	0. Not defined; 1. Reels; 2. Sheets	0. Not defined; 1. For Newspapers; 2. Catalogue and Magazine Printing; 3. For other Kinds of printing	0. Not defined; 1. <40; 2. 40-45; 3. >45 – 48.8; 4. >48.8	0. Not defined 1. White; 2. ISO Brightness < 59; 3. ISO Brightness: 60-68; 4. ISO Brightness: 69-71; 5. ISO Brightness 60-71; ISO Brightness: >72; 7. Coloured
Graphic papers	0. Not defined; 1. Mechanical; 2. Recovered paper; 3. Chemical Pulp; 4. Others	0. Not defined; 1. Reels; 2. Sheets; 3. Folio Sheets; 4. Cut Size Sheets	0. Not defined; 1. Rotogravue printing; 2. Offset Printing; 3. Digital Printing; 4. Office Papers (incl. white envelopes); 5. Papers for converting; 6. Hand made papers; 7. Art Papers; 8. Thin Papers; 9. Book Printing Papers	0. Not defined; 1. ,28; 2. 28-40; 3. 40-72 4. 73-150; 5. 151-180; 6. 181-225; 7. >225	0. Not defined 1. White; 2. ISO Brightness: 60-68; 3. ISO Brightness: 69-71; 4. ISO Brightness 60-71; 5. ISO Brightness: >72; 6. Coloured; 7. Opaque; 8. Transparent

Table 2 shows no upper or lower limit for the grammage of either graphic or newsprint paper set by CEPI. For specific terminology, CEPI uses the following definitions.

Table 2. Paper and board definitions according to CEPI (CEPI, 2014)

Graphic papers	
Newsprints	Paper mainly used for printing newspapers largely made from mechanical pulp and/or paper for recycling, with or without a small amount of filler. Products in this category are generally manufactured in strips or rolls of a width exceeding 36 cm or in rectangular sheets with one side exceeding 36 cm and the other exceeding 15 cm in the unfolded state. Weights usually range from 40 to 52 g/m2 but can be as high as 65 g/m2. Newsprint is machine finished or slightly calendered, white or slightly coloured and is used in reels for letterpress, offset or flexo printing.
Uncoated printing and writing papers	***Mechanical*** : Paper suitable for printing or other graphic purposes where less than 90% of the fibre furnish consists of chemical pulp fibres. This grade is also known as groundwood or wood-containing paper and magazine paper, such as heavily filled supercalendered paper (SC) for consumer magazines printed by the rotogravure and offset methods. It excludes wallpaper base. ***Woodfree***: Paper suitable for printing or other graphic purposes, where at least 90% of the fibre furnish consists of chemical pulp fibres. Uncoated woodfree paper can be made from a variety or furnishes, with variable levels of mineral filler and a range of finishing processes such as sizing, calendering, machine glazing and watermarking. This grade includes most office papers, such as business forms, copier, computer, stationery and book papers. Pigmented and size press "coated" papers (coating less than 5 g per side) are covered by this heading. It excludes wallpaper base.
Coated Printing and Writing Papers	Printing and writing papers, except newsprint, which have been coated on one or both sides with coating materials such as clay (beneficiated kaolin), calcium carbonate, barium sulphate, gypsum or zinc oxide, often supplemented with supercalendering, etc. It includes coated paper produced at the paper mill from base paper manufactured for own use or purchased, together with all paper made and coated in a single operation on the papermaking machine. It includes raw carbon and self-copy paper in rolls or sheets. It excludes other copying and transfer papers. ***Mechanical:*** made of fibres produced mainly (90%) by a mechanical pulping process and are also known as coated groundwood. ***Woodfree:*** Made of fibres produced mainly (90%) by a chemical pulping process and are also known as coated freesheet.
Packaging Papers	
Packaging Papers(1)	Mainly used for wrapping and packaging purposes. Products in this category are generally manufactured in strips or rolls of a width exceeding 36 cm or in rectangular sheets with one side exceeding 36 cm and the other exceeding 15 cm in the unfolded state. It excludes unbleached kraft paper and paperboard that are not sack kraft paper or Kraftliner and weighing more than 150 g/m² but less than 225 g/m²; felt paper and paperboard; tracing papers; not further processed uncoated paper weighing 225 g/m² or more. It is reported in metric tonnes.
Sanitary and Household	
Sanitary and Household	Tissue and other hygienic papers for use in households or commercial and industrial premises. Some tissue is also used in the manufacture of baby nappies, sanitary towels, etc. The parent reel stock is made from virgin pulp or recovered fibre or mixtures of these. It is reported in the production statistics at parent reel weight before conversion to finished products. Import and export statistics however take into account trade in both parent reels and finished products. Includes types of creped and uncreped papers such as disposable tissues, facial tissue, napkin, sanitary wadding, toilet tissue towelling, and wiper stock.
Other Paper and Board	
Other Paper and Board(1)	Other papers and boards for industrial and special purposes. It includes cigarette papers and stock of filter papers, as well as gypsum liners and special papers for insulating, roofing, waxing, asphalting and other specific applications or treatments; wallpaper base; unbleached kraft paper and paperboard that are not sack kraft paper or kraftliner and weighing more than 150 g/m² but less than 225 g/m²; felt paper and paperboard; tracing papers; not further processed uncoated paper weighing 225 g/m² or more; and raw copying and transfer papers, in rolls or sheets except carbon or self-copy paper. It excludes all composite, not coated, paper and paper board of flat layers stuck together; coated paper and paperboard not uniformly bleached throughout the mass; and paper and paperboard covered or coated with plastics (excluding adhesives).

(1) *General description of the paper grade without further sub-classification*

For the lay reader, it can seem confusing that separate gradings are applied to graphic papers and newsprint papers yet newsprint paper by definition in Table 2 is simply a sub-type of graphic paper. Furthermore, although board is generally has a higher grammage than paper, there is no fixed boundary and there is some overlap where the heaviest paper grades (e.g. blotting paper, felt paper and drawing paper) would have a higher grammage than lighter board products (e.g. corrugating raw materials) used in packaging applications.

Papers are also divided according to their raw-materials into mechanical and woodfree grades. Mechanical Paper or Board contain mechanical woodpulp as an essential constituent of its fibre composition, whereas woodfree paper or board contains, in principle, only chemical pulp in its fibre composition. In practice, it may contain a small amount of other pulps.

Besides the end use of the product, the production processes and the materials used are similar between Copying and Graphic papers and Newsprints. These similarities are reflected under the current criteria sets for both product groups. The main difference stems from the percentage of recycled fibre used, and the differences in the production process (newsprints are mainly manufactured by the means of mechanical treatment whereas copying and graphic papers stems mainly from chemical or semi-chemical pulping technologies).

2.1.2 ISO/TC 6 definitions

ISO/TC 6 Paper, board and pulps that sets standardization in the field of paper, board and pulps and cellulosic nanomaterials (CNM), including terminology, sampling procedures, test methods, product and quality specifications, and the establishment and maintenance of appropriate calibration systems. The total number of published ISO standards (including updates) related to the TC 6 and its SCs is 183[1].

One of these is "*ISO 4046: Paper, board, pulps and related terms*". These generally coincide well with the definitions established by CEPI. For the sake of brevity, they are not reproduced in this report.

2.1.3 ISO 12625 definitions for tissue paper

In addition to the definition of some 66 specific terms relating specifically to tissue paper, ISO 12625:2011 sets out the following general principles which should be followed when using the term "tissue":

The term "tissue" describes products and base papers made from lightweight, dry or wet creped and some "non-creped" papers.

Tissue products can be made of one or several plies, each ply being of one or several layers, prepared as sheets or rolls, folded or unfolded, embossed or unembossed, with or without lamination, printed or not printed and possibly finished by post-treatment, e.g. lotion application.

Products of such a kind derive from a single-ply, semi-finished, wet-laid tissue-base paper that is predominantly composed of natural fibres. The origin of fibres may be virgin or recycled, or a mixture of both. A typical grammage of single-ply tissue-base papers ranges from 10 g/m2 to 50 g/m2.

The properties of the tissue-base paper give to its resulting products the typical high capacity of tensile energy absorption together with a good textile-like flexibility, surface softness,

[1] http://www.iso.org/iso/home/store/catalogue_tc/catalogue_tc_browse.htm?commid=45674

comparatively low bulk density and high ability to absorb liquids. Disposable tissue products are commonly used for hygienic and industrial purposes.

Nonwovens are not classified as tissue, even if one subgroup of the nonwovens is manufactured in a wet-laid manner according to a process similar to the tissue making process.

Specific terms apply to tissue products depending on their intended end-use, for example "away-from-home products", "toilet paper", "kitchen towel" or "hand towel", to name a few.

2.1.4 EN 643 definitions of recovered paper grades

Paper can originate from virgin or recycled fibre. EN 643 establishes a common list of almost 100 standard grades for paper and board for recycling at the European level.

Paper and board for recycling are defined as

"natural fibre-based paper and board suitable for recycling; consisting of paper and board in any shape or product made predominantly from paper and board, which may include other constituents that cannot be removed by dry sorting, such as coatings, laminates, spiral bindings, etc."

EN 643 makes use of the "European Recovered Paper Identification System" (RPID) to improve the traceability of the paper mill's supply and consequently the safety and security of paper production processes and products. The standard also establishes the tolerance level for unwanted materials (maximum of 1.5% for the majority of grades), and list prohibited materials which presence should be directly notified to the supplier and the load should be returned. The concept of classification of recycled paper in reference to its origin (e.g. newsprints, wrapping) and grades help categorize waste paper for recycling, facilitate its trade, and organise collection, sorting, and re-processing.

2.2 Scope and definition of EU Ecolabel product groups

In this section the existing scopes and definitions for each of the three EU Ecolabel product groups under revision are presented and compared with (i) feedback from the scoping questionnaire sent out to stakeholders and (ii) scopes and definitions for similar product groups under other ecolabel schemes.

2.2.1 Existing EU Ecolabel definitions

Current EU Ecolabel scope and definitions of the three product groups under revision are based on the final used/destination of the product.

EU Ecolabel Tissue paper (as per Commission Decision 2009/568/EC):

"shall comprise sheets or rolls of tissue paper fit for use for personal hygiene, absorption of liquids and/or cleaning of soiled surfaces. The tissue product consists of creped or embossed paper in one or several plies. The fibre content of the product shall be at least 90 %. Wet wipes and sanitary products; tissue products laminated with other materials than tissue and paper, and products as referred to in Directive 76/768/EEC are excluded from the scope".

EU Ecolabel Newsprint paper (as per Commission Decision 2012/448/EU):

"shall comprise paper made from pulp and used for printing newspapers and other printed products. The product group 'Newsprint paper' shall not include copying and graphic paper, thermally sensitive paper, photographic and carbonless paper, packaging and wrapping paper as well as fragranced paper.

For the purpose of this Decision, the following definitions shall apply:

(1) 'newsprint paper' means paper mainly used for printing newspapers and made from pulp and/or recovered paper the weight of which ranges between 40 and 65 g/m2;

(2) 'recovered fibres' means fibres diverted from the waste stream during a manufacturing process or generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product which can no longer be used for their intended purpose.

EU Ecolabel Copying and Graphic Paper (as per Commission Decision 2011/332/EU):

"shall comprise sheets or reels of not converted, unprinted blank paper and not converted boards up to basis weight of 400 g/m2. It shall not include newsprint paper, thermally sensitive paper, photographic and carbonless paper, packaging and wrapping paper as well as fragranced paper.

For the purpose of this Decision, the following definition shall apply:

'recycled fibres' means fibres diverted from the waste stream during a manufacturing process or generated by households or by commercial, industrial and institutional facilities in their role as end-users of the product, which can no longer be used for their intended purpose. Excluded is reutilisation of materials generated in a process and capable of being reclaimed within the same process that generated it (mill broke — own produced or purchased).

2.2.2 Feedback from scoping questionnaire.

Over 400 potentially interested stakeholders were directly informed about the initial scoping questionnaire for the revision of EU Ecolabel criteria for paper products. The survey period ran for 5 weeks between December 2015 and January 2016.

A total of 56 responses were received, with 75% being from industry stakeholders. Around 54% of respondents were actual EU Ecolabel license holders with a further 9% actually in the process of applying for a license or thinking of doing so. Their opinions about the adequacy of the existing scopes are illustrated in Figure1.

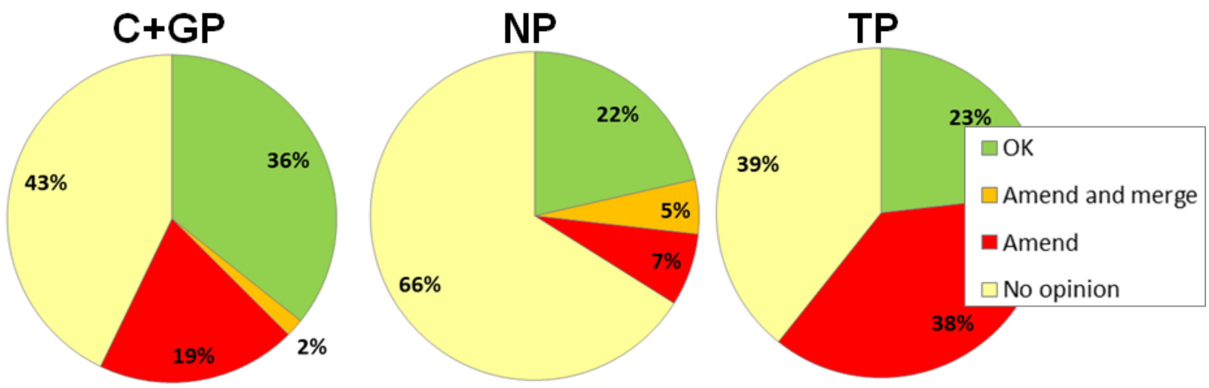

Figure 1. Stakeholder feedback about adequacy of existing scopes and definitions for C+GP (Copying and Graphic Paper), NP (newsprint Paper) and TP (Tissue Paper).

From Figure 1 it is clear that all three scopes and definitions have points to discuss at the 1st AHWG meeting. However, the tissue paper appears to be a bigger concern than the other two product groups. Specific opinions wanted the scope for tissue paper to be extended to disposable tablecloths and other applications. With Copying and Graphic paper, it was requested to remove the (artificial) upper limit of grammage.

2.2.3 Other ecolabel scopes for similar product groups

The International Organization for Standardisation (ISO) has identified three broad types of voluntary labels, with Eco-labelling fitting under the Type I designation:

Type I: voluntary, multiple-criteria based, third party program that awards a license that authorises the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle considerations. ISO14024 lists the guiding principles for Type 1 Ecolabels;

Type II: self-declared environmental claim, i.e. environmental claim that is made, without independent third-party certification, by manufacturers, importers, distributors, retailers or anyone else likely to benefit from such a claim, in line with ISO 14021;

Type III: voluntary programs that provide quantified environmental data of a product, under pre-set categories of parameters set by a qualified third party and based on life cycle assessment, and verified by that or another qualified third party in line with ISO 14025.

The different label types have been identified by the ISO as sharing a common goal:"...*through communication of verifiable and accurate information that is not misleading on environmental aspects of products and services, to encourage the demand for and supply of those products and services that cause less stress on the environment, thereby stimulating the potential for market-driven continuous environmental improvement*."

There are a number of Type I ecolabels that address paper products under analysis, such as the Nordic Swan, Milieukeur, Blue Angel, Good Green Buy, Czech Ecolabel, Hungarian Ecolabel, Austrian Umweltzeichen and others.

The scopes and definitions that have been identified as closely related to the EU Ecolabel paper product groups under revision are as follows:

Nordic Ecolabel (Iceland, Norway, Finland, Sweden, and Denmark)[2] Tissue Paper:

Cellulose-based tissue paper made from virgin and/or recovered fibres e.g. toilet paper, kitchen towels, paper towels and paper handkerchiefs. Wet wipes may be labelled in accordance with the criteria for cosmetic products, which specify that the paper material must fulfil the Nordic Ecolabel or EU Ecolabel requirements on tissue paper.

Excluded: Tissue paper products containing cleaning agents designed for the cleaning of surfaces (e.g. floor cleaning agents. Products that contain viscose or that are laminated with non-cellulose based material (several of these products are covered by the Nordic Ecolabel criteria for hygiene products).

Blue Angel[3] RAL UZ 5 (Germany): Sanitary Paper (July 2014):

"These Basic Criteria apply to sanitary paper products, e.g. paper towels, toilet paper, paper cleaning cloths, handkerchiefs, facial tissues, napkins, kitchen papers and cover papers (e.g. paper couch covers). Sanitary paper products made of recycled paper (List of German Standard Grades and their Qualities in accordance with DIN EN 643) e.g. paper towels, toilet paper, paper cleaning cloths, handkerchiefs, facial tissues, napkins, kitchen papers and cover papers (e.g. paper couch covers). The paper fibres, crepe toilet and towel paper must be made from 100 % recovered waste paper of specified grades. All other sanitary paper products must be made from a minimum of 65% waste paper. The products should not exceed a maximum whiteness level of 80 % (to DIN ISO 2470)"

Green Seal (GS)[4] (United States)-1 Sanitary Paper (July, 2013):

"This standard establishes environmental, health, and social requirements for sanitary paper products including paper towels, general-purpose wipes, paper napkins, bathroom tissue, facial tissue, toilet seat covers, placemats, tray liners, table coverings, and other sanitary paper products. The standard covers products for

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[2] http://www.nordic-ecolabel.org/
[3] https://www.blauer-engel.de/en/our-label-environment
[4] http://www.greenseal.org/AboutGreenSeal.aspx

institutional as well as retail markets. This standard does not include nonwoven sanitary products, general-purpose disposable and flushable wipes containing cleaning agents or fragrances, disposable diapers, or sanitary napkins and tampons. See Appendix 1 for an example list of products included in the standard."

Green Seal (GS) (United States)-15 Newsprint (July, 2013):

"This standard establishes environmental requirements for all newsprint and printed products manufactured from newsprint (Paper having a surface density between 40 g/m2 and 57 g/m2, generally used in the publication of newspapers, and made primarily from mechanical wood pulps combined with some chemical wood pulp), including newspapers and miscellaneous published material made from newsprint such as inserts, flyers, etc."

Nordic Ecolabel (Iceland, Norway, Finland, Sweden, and Denmark) Graphic and Printing Paper:

Wood-based and wood-free unconverted copying and printing paper that is made from chemical and/or mechanical pulp and/or recycled fibre for writing, printing and copying. The following boards made from chemical and/or mechanical pulp and/or recycled fibre can also be Nordic Ecolabelled.-Cardboard: Solid bleach board (SBB), solid bleached sulphate (SBS) and solid unbleached board (SUB), folding boxboard (FBB) and white lined chipboard (WLC). Only paper with a distinct trade name can be ecolabelled. Paper with a trade name that may appear on both ecolabelled and non-ecolabelled paper is not eligible for Nordic Ecolabelling. These criteria do not apply to tissue paper, greaseproof paper, coffee filters, cardboard (other than the aforementioned), kraft paper or sack paper.

Blue Angel RAL UZ 72 (Germany): Printing and publication papers (April 2011):

Writing papers for office and home use computer paper, laser printers, inkjet printers, digital printing and offset printing, publication paper, newsprints magazines or catalogues. Special conditions are made for aging resistance paper.

The scope includes: graphic paper, and expiring on Dec. 31 2015: finished products made from recovered paper, e.g. for the product lines of exercise books, writing pads, drawing books, calendars, envelopes, mailing bags, manuals, invoice papers, posters, photo envelopes, masking papers (e.g. for painting and varnishing work) as well as print and press products (e.g. telephone books).

Richtline UZ 02 (Austria): Graphic Paper

Writing papers for office and home use computer paper, laser printers, inkjet printers, digital printing and offset printing, publication paper, newsprints magazines or catalogues. Special conditions are made for aging resistance paper. Newsprint, (SC), (ULWC; LWC, MWC, HWC) included. The paper fibres of the products must be made from 100 % recovered post-consumer paper. At least 50% waste paper of ordinary, medium and kraft waste paper grades as well as of the special grades Publication papers SC, ULWC, LWC; MWC, HWC: 100% waste paper of ordinary, medium and kraft waste paper grades as well as of the special grades

2.2.4. Concluding remarks on scope and definition

The Commission Statement suggested merging of newsprints and graphic and copying papers under one product group. The preliminary analysis conducted by JRC-IPTS shows that from technical point of view merging of these two product group is feasible. This approach would harmonize the definition of copying and graphic paper with that used by CEPI. Extending the scope and definition of copying and graphic paper to include newsprint paper could potentially help increase uptake as it would harmonise the definition and scope of the EU Ecolabel with that of other ecolabels.

Extending the scope of copying and graphic paper was also discussed favourably by the industry during previous criteria revision. It was suggested that by extending the scope and definition of copying and graphic paper to include newsprint, the applicant could be provided with the opportunity to put the Ecolabel label on the product near a phrase such as 'Printed on Ecolabel paper', which could help spread awareness to consumers.

Copying and graphic paper differ from newsprint paper in the pulping processes used. Newsprints are mainly manufactured through mechanical treatment whereas copying and graphic paper stem from chemical or semi-chemical pulping treatments. As such, the energy consumption used in pulping and papermaking is different for each product group. Furthermore, the additives applied in paper production for preparing the surface are different between the two paper products, as are the fibre qualities and the composition of the pulp mixtures required to meet these qualities.

Unlike the current EU Ecolabel definition, the ISO 12625 standard includes table napkins and mats and other such products in the scope. In terms of the other Ecolabel standards, the US Green Seal also includes tablecloths, mats and other such products in the scope for tissue products. However these products, if printed, must meet specified concentration limits, and if they're fragranced, are excluded from the scope. Sanitary napkins and diapers are also excluded from the scope.

Furthermore, Blue Angel and the Austrian ecolabel also include napkins in their scope for tissue paper, but make no specific reference to tablecloths or mats. No specific reference is made to printed or fragranced products or diapers either. Nordic Swan makes no specific mention of napkins, tablecloths, mats or diapers. It however prohibits the use of fragrances but allows for printed products by referring to EN 646 and prohibiting bleeding according to the testing method outlined.

We propose to align product group scope and definition with ISO 12625 and expand the scope for tissue paper to include non-coated tablecloths, mats, non-sanitary napkins and other such products.

2.3 Legal framework

2.3.1 EU Ecolabel Regulation

The most directly relevant European Regulation is Regulation (EC) No 66/2010 on the EU Ecolabel. The Regulation shapes the way that criteria are examined and defines the processes and principles by which they should be developed. Some of the key points to bear in mind are that:

- Criteria shall cover the most significant environmental impacts, in particular, the impact on climate change, the impact on nature and biodiversity, energy and resource consumption, generation of waste, emissions to all environmental media, pollution through physical effects and use, and release of hazardous substances;
- It shall encourage reduction of hazardous substance use by: 1) substitution of hazardous substances by safer substances, 2) use of alternative materials, design or technologies which eliminate the need for hazardous substances, wherever technically feasible;
- The net environmental balance between the environmental benefits and burdens shall be covered, including health and safety aspects, at the various life stages of the products;
- To enhance synergies, criteria established for other environmental labels shall be considered, particularly labels that are officially recognised (nationally or regionally) and EN ISO 14024 type I environmental labels where they exist for that product group;

2.3.2 Chemical-based Regulations

The impacts of REACH **Regulation (EC) No 1907/2006** are almost ubiquitous and the **CLP Regulation (EC) No 1272/2008** is required to be addressed to one degree or another with all chemical substances and mixtures placed on the market. However, with EU Ecolabel criteria, these Regulations carry an even greater relevance due to Article 6(6), which make specific requirements for the non-presence of substances with certain hazard statements in the final product. Article 6(7) then makes an allowance for derogation under certain circumstances although this shall not apply to any Substances of Very High Concern if they would be present at quantities >0.1%.

In paper processing, the use of fungicides and slimicides is commonplace and this means that the **Biocidal Products Regulation (EC) No 528/2012** will have an influence on what chemicals can and cannot be placed on the market. While this is not a direct influence on any potential EU Ecolabel applicants (they can only buy products on the market) care must be taken due to the transitory nature of this Regulation, as certain biocidal products are being gradually phased out.

2.3.3 Industrial Emissions Directive

Directive 2010/75/EU on industrial emissions is the main EU instrument regulating pollutant emissions from industrial installations and has a strong influence on the European pulp and paper industry and is anticipated to have a strong role to play with the revised EU Ecolabel criteria.

The IED was adopted on 24 November 2010. It is based on a Commission proposal recasting 7 previously existing directives following an extensive review of the policy (EC, 2016). The IED entered into force on 6 January 2011 and had to be transposed by Member States by 7 January 2013.

The IED is based on several pillars, in particular (1) an integrated approach, (2) use of best available techniques, (3) flexibility, (4) inspections and (5) public participation.

The IED aims to achieve a high level of protection of human health and the environment taken as a whole by reducing harmful industrial emissions across the EU, in particular through better application of Best Available Techniques (BAT). Around 50,000 installations undertaking the industrial activities listed in Annex I of the IED are required to operate in accordance with a permit (granted by the authorities in the Member States). This permit should contain conditions set in accordance with the principles and provisions of the IED. The integrated approach means that the permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure.

The permit conditions including emission limit values must be based on the Best Available Techniques (BAT). In order to define BAT and the BAT-associated environmental performance at EU level, the Commission organizes an exchange of information with experts from Member States, industry and environmental organizations. This process results in BAT Reference Documents (BREFs); the BAT conclusions contained are adopted by the Commission as Implementing Decisions. The IED requires that these BAT conclusions are the reference for setting permit conditions.

According to paragraph 6.1 of the Annex I (Categories of activities referred to in Article 10) of the IED Directive: Industrial plants for the production of:

(a) pulp from timber or other fibrous materials;

(b) paper and board with a production capacity exceeding 20 tonnes per day,

are subject to the IED Directive rules and, in particular, they have to refer to the BREF, the Reference Document on Best Available Techniques (BAT), in order to reduce the environmental impacts associated to their productive processes.

In 2014, the best available techniques (BAT) conclusions, for the production of pulp, paper and board were established under IED Directive by means of Commission Implementing Decision 2014/687/EU.

The BREF document covers processes involved in the production of pulp and paper in integrated pulp and paper mills as well as non-integrated pulp mills (market pulp) and non-integrated paper-mills using market pulp.

2.3.4 Renewable Energy Directive 2009/28/EC

The Directive establishes an overall policy for the production and promotion of energy from renewable sources in the EU. It requires the EU to fulfil at least 20% of its total energy needs with renewables by 2020 – to be achieved through the attainment of individual national targets. All EU countries must also ensure that at least 10% of their transport fuels come from renewable sources by 2020. The Directive specifies national renewable energy targets for each country, taking into account its starting point and overall potential for renewables. These targets range from a low of 10% in Malta to a high of 49% in Sweden[5].

2.3.5 Air Quality framework Directive

Council Directive 96/62/EC on ambient air quality assessment and management describes the basic principles as to how air quality should be assessed and managed in the Member States. It lists the pollutants for which air quality standards and objectives will be developed and specified in legislation. A substantial body of Community legislation adopted in relation to ambient air quality are summarised below and links the relevant documents provided.

- The Directive 2008/50/EC on ambient air quality and cleaner air for Europe;
- The Directive 1999/30/EC relating to limit values for sulphur dioxide, nitrogen dioxide and oxides of nitrogen, particulate matter and lead in ambient air.
- The Directive 2000/69/EC relating to limit values for benzene and carbon monoxide in ambient air.
- The Directive 2002/3/EC relating to ozone in ambient air.
- The Directive 2004/107/EC relating to arsenic, cadmium, mercury, nickel and polycyclic aromatic hydrocarbons in ambient air.
- The Council Decision 97/101/EC establishing a reciprocal exchange of information and data from networks and individual stations measuring ambient air pollution within the Member States. This "EoI Decision" describes the procedures for the dissemination of air quality monitoring data by the Member States to the Commission and to the public.
- The Commission Decision 2004/461/EC laying down a questionnaire for annual reporting on ambient air quality assessment under Council Directives 96/62/EC and 1999/30/EC and under Directives 2000/69/EC and 2002/3/EC of the European Parliament and of the Council.

2.3.6 Timber Regulation

Regulation (EU) 995/2010 lays down the obligations of operators who place timber and timber products on the market:

1) It prohibits the placing on the EU market for the first time of illegally harvested timber and products derived from such timber;

2) It requires EU traders who place timber products on the EU market for the first time to exercise 'due diligence'. The core of the 'due diligence' notion is that operators undertake a risk management exercise so as to minimize the risk of placing illegally harvested timber, or timber products containing illegally harvested timber, on the EU market.

[5] https://ec.europa.eu/energy/en/topics/renewable-energy/renewable-energy-directive

3) Once on the market, the timber and timber products may be sold on and/or transformed before they reach the final consumer. To facilitate the traceability of timber products economic operators in this part of the supply chain (referred to as traders in the regulation) have an obligation to keep records of their suppliers and customers.

This Regulation covers a wide range of timber products listed in its Annex including solid wood products, flooring, plywood, pulp and paper. The application of the Regulation started in March 2013. The Regulation applies to both imported and domestically produced timber and timber products. Timber and timber products covered by valid FLEGT or CITES licenses are considered to comply with the requirements of the Regulation:

2.4 Policy framework

A number of different EU policies have a direct or indirect influence on the pulp and paper industry and those with the most relevant influences are briefly summarized in this section.

2.4.1 Climate change strategy and targets

The EU has set itself targets for reducing its greenhouse gas emissions progressively up to the year 2050. The 2020 package is a set of binding legislation to ensure the EU meets its goals and sets three key targets:

- 20% cut in greenhouse gas emissions (from 1990 levels)
- 20% of EU energy from renewables
- 20% improvement in energy efficiency

The targets were set by EU leaders in 2007 and enacted in legislation in 2009. They are also headline targets of the Europe 2020 strategy for smart, sustainable and inclusive growth.

Further key targets for the year 2030 have already been stated as follows:

- At least 40% cuts in greenhouse gas emissions (from 1990 levels)
- At least 27% share for renewable energy
- At least 27% improvement in energy efficiency

The framework was adopted by EU leaders in October 2014 and will build on the 2020 climate and energy package. It is also in line with the longer term perspective set out in the Roadmap for moving to a competitive low carbon economy in 2050, the Energy Roadmap 2050 and the Transport White Paper. These targets are defined to put the EU on the way to achieve the transformation towards a low-carbon economy as detailed in the 2050 low-carbon roadmap.

2.4.2 The EU Emissions Trading System (EU ETS)

The EU emissions trading system (EU ETS) is the European Union's policy to combat climate change and cost-effectively reduce industrial greenhouse gas emissions. It is the first - and still by far the biggest - international system for trading greenhouse gas emission allowances that covers more than 11,000 power stations and industrial plants in 31 countries, as well as airlines and, of particular relevance to this report, the pulp and paper industry. The European Union Emission Trading System (EU-ETS) establishes quotas for CO_2 emissions and allows trading emission abatements and surpluses. The cap is then reduced over time so that total emissions fall. In 2020, emissions from sectors covered by the EU ETS will be 21% lower than in 2005. By 2030, the Commission proposes, they would be 43% lower. Altogether the EU ETS covers around 45% of total greenhouse gas emissions from the 28 EU countries[6].

By putting a price on carbon and thereby giving a financial value to each tonne of emissions saved, the EU ETS has placed climate change on the agenda of company boards and their financial departments across Europe.

2.4.3 Third Energy Package

The third Energy Package is a legislative package for an internal gas and electricity market in the European Union. Its purpose is to further open up the gas and electricity markets in the European Union. The package was proposed by the European Commission in September 2007, and adopted by the European Parliament and the Council of the European Union in July 2009. It entered into force on 3 September 2009.

The Third Energy Package consists of two Directives and three Regulations:

- Directive 2009/72/EC concerning common rules for the internal market in electricity;
- Directive 2009/73/EC concerning common rules for the internal market in natural gas;
- Regulation (EC) No 714/2009 on conditions for access to the network for cross-border exchanges in electricity and repealing Regulation (EC) No 1228/2003;
- Regulation (EC) No 715/2009 on conditions for access to the natural gas transmission networks and repealing Regulation (EC) No 1775/2005;
- Regulation (EC) No 713/2009 of the European Parliament and of the Council of 13 July 2009 establishing an Agency for the Cooperation of Energy Regulators.

2.4.4 Circular Economy Package

The Circular Economy Package includes revised legislative proposals on waste to stimulate Europe's transition towards a circular economy. The Circular Economy Package consists of an EU Action Plan for the Circular Economy[7] that establishes a concrete and ambitious programme of action, with measures covering the whole cycle: from production and consumption to waste management and the market for secondary raw materials. The proposed actions will contribute to "closing the loop" of product lifecycles through greater recycling and re-use, and bring benefits for both the environment and the economy.

The revised legislative proposals on waste set clear targets for reduction of waste and establish an ambitious and credible long-term path for waste management and recycling. Key elements of the revised waste proposal include:

- A common EU target for recycling 65% of municipal waste by 2030;
- A common EU target for recycling 75% of packaging waste by 2030;

[6] http://ec.europa.eu/clima/policies/ets/index_en.htm

[7] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Closing the loop - An EU action plan for the Circular Economy COM/2015/0614 final

- A binding target to reduce landfill to a maximum of 10% of all waste by 2030;
- A ban on landfilling of separately collected waste;
- Promotion of economic instruments to discourage landfilling;
- Simplified and improved definitions and harmonised calculation methods for recycling rates throughout the EU;
- Concrete measures to promote re-use and stimulate industrial symbiosis - turning one industry's by-product into another industry's raw material;
- Economic incentives for producers to put greener products on the market and support recovery and recycling schemes (eg for packaging, batteries, electric and electronic equipments, vehicles).

2.4.5 Guidelines on State aid for environmental protection and energy 2014-2020

The Guidelines provide criteria for the assessment of the compatibility of capacity mechanisms with State aid rules[8]. The guidelines on public support for environmental protection and energy address feed- in tariffs and many other aids. The Commission had identified several environmental and energy measures for which state aid under certain conditions may be compatible with the internal market under Article 107(3)(c) TFEU. The new guidelines both support Member states in reaching their 2020 climate targets and address the market distortions that may result from subsidies granted to renewable energy sources. The guidelines are designed to foster a gradual move to market-based support for renewable energy. Preferential feed-in tariffs will gradually be replaced by feed-in premiums, which expose renewable energy sources to market signals. There is also a special regime for small installations[9].

2.4.6 Community framework for the taxation of energy products and electricity

Council Directive 2003/96/EC establishes general arrangements for the taxation of energy products and electricity. The EU system sets the minimum rates of taxation applicable to energy products when used as motor or heating fuels and to electricity. It therefore aims to improve the functioning of the internal market by reducing distortions in competition between mineral oils and other energy products. In line with the EU's objectives and the Kyoto Protocol, it encourages more efficient use of energy so as to reduce dependence on imported energy products and limit greenhouse gas emissions. Also in the interests of protecting the environment, it authorises EU countries to grant tax advantages to businesses that take specific measures to reduce Energy products and electricity are only taxed when they are used as motor or heating fuel, and not when they are used as raw materials or for the purposes of chemical reduction or in electrolytic and metallurgical processes.

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[8] Communication from the Commission — Guidelines on State aid for environmental protection and energy 2014-2020 OJ C 200, 28.6.2014, p. 1–55

[9] Mäntysaari, P. 2015. EU Electricity Trade Law: The Legal Tools of Electricity Producers in the Internal Electricity Market. Springer, 614 pp.

2.4.7 Biomass Action Plan

In 2014, the European Commission published a report on the sustainability of solid and gaseous biomass for heat and electricity generation. The report includes information on current and planned EU actions to maximise the benefits of using biomass while avoiding negative impacts on the environment.

The European Commission has issued non-binding recommendations on sustainability criteria for biomass. These recommendations are meant to apply to energy installations of at least 1MW thermal heat or electrical power. They:

- Forbid the use of biomass from land converted from forest, and other high carbon stock areas, as well as highly biodiverse areas.
- Ensure that biofuels emit at least 35% less greenhouse gases over their lifecycle (cultivation, processing, transport, etc.) when compared to fossil fuels. For new installations this amount rises to 50% in 2017 and 60% in 2018.
- Favour national biofuels support schemes for highly efficient installations.
- Encourage the monitoring of the origin of all biomass consumed in the EU to ensure their sustainability.

2.4.8 Forest related policies

Key European cross-cutting policies that address forestry and support the implementation of sustainable forest management include:

- Forest Action plan 2007-2011;
- Rural Development Policy;
- Plant Health and Reproductive Materials Strategy;
- Biodiversity and Bioeconomy Strategies.

The 1998 EU Forestry Strategy[10] established a framework for forest-related actions that support sustainable forest management and are based on cooperative, beneficial links between EU and Member State policies and initiatives. The Forest Action Plan 2007-2011 was an important instrument for implementing the strategy and addressed four objectives: competitiveness, environment, quality of life and coordination and communication.

The EU strategy for forests and the forest-based sector promotes a coherent, holistic view of forest management, covers the multiple benefits of forests, integrates internal and external forest-policy issues, and addresses the whole forest value-chain[11]. All EU Member States have signed up to and are bound by FOREST EUROPE commitments to manage their forests sustainably, according to their national forest policies and legislation.

2.4.9 Market-based Sustainable Forest management initiatives

Sustainable forest management (SFM) uses very broad social, economic and environmental goals. A range of forestry institutions now practice various forms of

[10] Council Resolution of 15 December 1998 on a forestry strategy for the EU COM(2006) 302

[11] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new EU Forest Strategy: for forests and the forest-based sector. COM(2013) 659 final

sustainable forest management and a broad range of methods and tools are available that have been tested over time and space. In 2006 the World Bank Global Forest Alliance published together with the World Wildlife Fund for nature (WWF) the Forest Certification Assessment Guide (FCAG) wherein the criteria for SFM are specified.

SFM does not in itself establish the link between the forestry and the final product. Chain of Custody (CoC) certification is a mechanism that allows establishing the verification system of the material flow along the supply chain. It tracks back the certified products from forest to shelf, providing the link between production and consumption. The Chain-of-Custody (CoC) certification attests that all of the wood used in the product originates from responsibly-managed forests.

Two main schemes now dominate the market for ensuring that wood in final products can be assured to be from sustainably managed forests, FSC and PEFC.

Chain-of-Custody (COC) certification attests that all of the wood used to make the certified paper comes from responsibly-managed forests. The wood is tracked from the forest, through the pulping process, to the paper mill, then to the merchant and printer. Example of FSC chain of custody certification scheme can be seen on Figure 2.

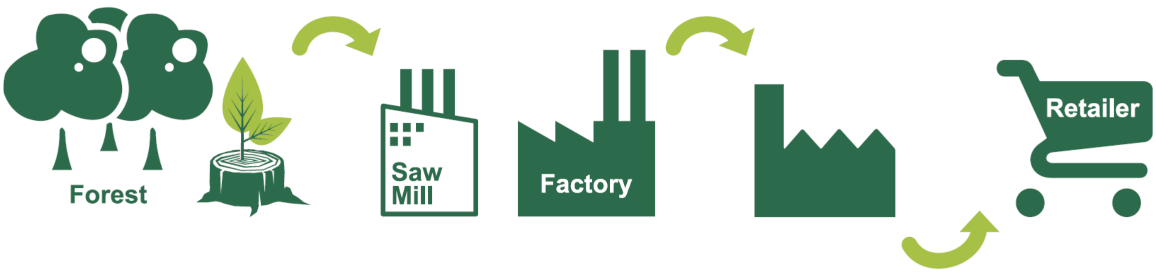

Figure 2. Illustration of supply chain which Chain of Custody (CoC) certification covers[12]

FSC[13] and PEFC[14] are by far the two dominant international forest certification schemes that set requirements for the sustainable management of forestry and require third party verification of the chain of custody for timber products. As suggested by the Central Point of Expertise on Timber (CPET) FSC and PEFC certification schemes provide a high level of assurance in their verification of the chain of custody.[15]

There are three methods allowed for tracing the origins of forest-based products, tailored to the situation and needs of certified companies.

- The percentage system – this mechanism allows mixing certified and non-certified raw material during the production or trading process. The non-certified material has to be either from controlled sources/wood or reclaimed material. The resulting percentage on the output side reflects the average of the inputs. ;
- The transfer system – output claims are based on the lowest type of input claim. If the input is 100% certified, the output can be claimed as 100% certified. If the input contains also 70% certified materials, ALL output can be claimed as 70% output only. This is the system that can be used for the FSC 100% label only;

[12] https://ic.fsc.org

[13] See: https://us.fsc.org/en-us/certification

[14] See: http://www.pefc.org/certification-services/overview

[15] CPET, UK Government timber procurement policy – definition of legal and sustainable for timber procurement. April 2010

- The credit system - the company can mix different inputs and it can allocate “mix credit” claims to a certain part of the outputs. As the inputs always have to be at least from controlled wood/sources, the parts that cannot be claimed as “mix” can be claimed as “controlled”

Approximately 9% of the world's forest is certified by FSC and/or PEFC, with rates being much higher in Europe.

3. Market analysis

This chapter is broadly split into two parts (i) the industry market structure and dynamics and (ii) analysis of statistics regarding the relative market penetration of EU Ecolabel paper products.

In general, publically available data has often been aggregated. Therefore the robustness of primary data used could not be verified within the project framework. It must therefore be stated that this section should be treated as rough estimation of the market trends.

3.1 Methodology

The analysis takes into consideration available statistical information, being supported by additional references and it analyses the EU-28 market with regards to the globally observed sector trends.

Data are mainly extracted from FAOSTAT and from the information published by the Confederation of European Pulps and Paper Industry (CEPI). The data that specifically refers to the European market analysis are supported by official EU production statistics such as PRODCOM and COMEXT that consider distinct categories of the paper product groups and use different statistical nomenclatures, i.e., NACE and CN, respectively.

Where possible, relevant market reports are used to complement the official statistics in order to help fill gaps in data, split aggregated data and to interpret results.

This NACE division includes the manufacture of pulp, paper and converted paper products. The manufacture of these products is grouped together because they constitute a series of vertically connected processes. More than one activity is often carried out in a single unit. There are essentially three activities:

(i) pulp manufacture, which involves separating the cellulose fibres from the wood or the dissolution and de-inking of fibres in used paper;

(ii) paper making involves releasing pulp onto a moving wire mesh so as to form a continuous sheet, which is then progressively dried and may be treated with various chemicals until a large continuous sheet is formed;

(iii). Converted paper products may be printed (e.g. wallpaper, gift wrap etc.), as long as the storage of information is not the main purpose (i.e. become graphic paper).

The production of pulp, paper and paperboard in bulk is included in NACE group 17.1, while the remaining classes include the production of further-processed paper and paper products represented by group 17.2., as follows (Table 3).:

Table 3. Detailed Structure of NACE Rev. 2 Division 17 (Manufacture of paper and paper products)

Group	Class	Description	ISIC v.4
17.1		***Manufacture of pulp, paper and paperboard***	
	17.11	*Manufacture of pulp*: -manufacture of bleached, semi-bleached or unbleached paper pulp by mechanical, chemical (dissolving or nondissolving) or semi-chemical processes -manufacture of cotton-linters pulp -removal of ink and manufacture of pulp from waste paper	1701*
	17.12	*Manufacture of paper and paperboard:* This class includes: -manufacture of paper and paperboard intended for further industrial processing -further processing of paper and paperboard:	1701*

Group	Class	Description	ISIC v.4
		• coating, covering and impregnation of paper and paperboard • manufacture of crêped or crinkled paper • manufacture of laminates and foils, if laminated with paper or paperboard -manufacture of handmade paper -manufacture of newsprint and other printing or writing paper -manufacture of cellulose wadding and webs of cellulose fibres -manufacture of carbon paper or stencil paper in rolls or large sheets This class excludes: -manufacture of corrugated paper and paperboard, see 17.21 -manufacture of further-processed articles of paper, paperboard or pulp, see 17.22, 17.23, 17.24, 17.29 -manufacture of coated or impregnated paper, where the coating or impregnant is the main ingredient, see class in which the manufacture of the coating or impregnant is classified - manufacture of abrasive paper, see 23.91	
17.2		***Manufacture of articles of paper and paperboard***	
	17.21	*Manufacture of corrugated paper and paperboard and of containers of paper and paperboard*: This class includes: -manufacture of corrugated paper and paperboard -manufacture of containers of corrugated paper or paperboard -manufacture of folding paperboard containers -manufacture of containers of solid board -manufacture of other containers of paper and paperboard -manufacture of sacks and bags of paper -manufacture of office box files and similar articles This class excludes: -manufacture of envelopes, see 17.23 -manufacture of moulded or pressed articles of paper pulp (e.g. boxes for packing eggs, moulded pulp paper plates), see 17.29	1702
	17.22	*Manufacture of household and sanitary goods and of toilet requisites:* This class includes: -manufacture of household and personal hygiene paper and cellulose wadding products: • cleansing tissues • handkerchiefs, towels, serviettes • toilet paper • sanitary towels and tampons, napkins and napkin liners for babies • cups, dishes and trays -manufacture of textile wadding and articles of wadding: sanitary towels, tampons etc. This class excludes: - manufacture of cellulose wadding, see 17.12	1709*
	17.23	*Manufacture of paper stationery* This class includes: -manufacture of printing and writing paper ready for use -manufacture of computer printout paper ready for use -manufacture of self-copy paper ready for use -manufacture of duplicator stencils and carbon paper ready for use -manufacture of gummed or adhesive paper ready for use -manufacture of envelopes and letter-cards -manufacture of educational and commercial stationery (notebooks, binders, registers, accounting books, business forms etc.), when the printed information is not the main characteristic -manufacture of boxes, pouches, wallets and writing compendiums containing an assortment of paper Stationery This class excludes: - printing on paper products, see 18.1	1709*
	17.24	*Manufacture of wallpaper*	1709*

Group	Class	Description	ISIC v.4
		This class includes: -manufacture of wallpaper and similar wall coverings, including vinyl-coated and textile wallpaper This class excludes: -manufacture of paper or paperboard in bulk, see 17.12 -manufacture of plastic wall paper, see 22.29	
	17.29	*Manufacture of other articles of paper and paperboard* This class includes: -manufacture of labels - manufacture of filter paper and paperboard -manufacture of paper and paperboard bobbins, spools, cops etc. -manufacture of egg trays and other moulded pulp packaging products etc. -manufacture of paper novelties -manufacture of paper or paperboard cards for use on Jacquard machines This class excludes: -manufacture of playing cards, see 32.40 -manufacture of games and toys of paper or paperboard, see 32.40	1709*

*only partially reproduced

3.2 Industry structure

Pulp and paper mills generated $563.6 billion in revenue during 2013. Over the past 5 years, revenue from the global pulp and paper industry is expected to increase at an average annual rate of 0.4%[16] (Bajpaj, 2015). Positive growth in tissue and packaging grades continued to offset the drops in global graphic paper production.

The volume of the global pulp and paper industry has contracted slightly over the past five years (-0.4%), primarily due to the transition to digital media and paperless communication across most developed economies such as North America and Europe. However, manufacturing booms in many emerging markets have partially offset the decline by driving increased demand for paper used in packaging material[17]. The industry is dominated by International Paper and Kimberly-Clark from the United States, Stora Enso and UPM-Kymmene from Finland, and Oji Paper and Nippon Paper Group from Japan. It is estimated that the top 20 companies generate some 40 percent of the total global paper and paperboard production.

The pulp supply consists of market pulp producers and of companies using the bulk of their pulp output in their own integrated paper production and selling only the remaining part on the open market. In Europe 31% of paper mills have a capacity of more than 100,000 tonnes a year while 24% have a capacity of less than 10,000 tonnes, the smaller ones being mainly situated in Italy, Germany, Spain and France. Most of the mills with a production capacity of more than 300,000 tonnes are in Sweden, Finland and Germany. Italy, Germany and France have the largest number of mills in Europe.

The pulp and paper industry structure confederated in CEPI (European Confederation of Pulp and paper Industry) countries is shown in Table 4. CEPI represents approximately 505 pulp, paper and board producing companies across Europe that represent 93.0% of

[16] Bajpai, P. 2015. Pulp and paper Sector. Microbiological issues in papermaking. Elsevier Inc.
[17] World. Global Paper & Pulp Mills: Market Research Report 2015: http://www.ibisworld.com

the European pulp and paper industry[18]. CEPI members have a combined turnover of 75 billon EUR and add 15 billon EUR to the EU GDP.

Table 4. Pulp and paper industry structure in CEPI countries[19]

	1992	2000	2005	2010	2013	2014
Industry Structure						
Number of Companies	1 032	929	831	674	636	628
Number of Mills	1 570	1 309	1 224	992	941	920
Pulp	296	233	218	172	163	159
Paper & Board	1 274	1 076	1 006	820	778	761
Number of Paper Machines	2 182	1 858	1 725	1 393	1 307	1 283
Employment	411 113	279 987	246 785	194 894	183 690	181 111
Turnover2 (Million Euros)	n.a.	79 388	74 537	76 226	75 337	74 500
Investments2 (Million Euros)	n.a.	5 637	5 318	2 728	3 425	3 500
Added Value2 (Million Euros)	n.a.	24 494	18 154	16 560	16 500	16 000
Total Pulp3 (000 Tonnes)						
Production Capacity	39 584	43 842	47 247	44 189	41 480	40 960
Operating Rate	85.40%	91.20%	88.10%	87.60%	89.80%	89.20%
Production	33 807	39 962	41 602	38 695	37 263	36 545
CEPI Internal Deliveries	n.a.	39 224	40 150	37 045	36 690	35 716
Consumption*	37 815	46 377	47 492	43 849	41 198	41 051
Market Pulp ('000 Tonnes)						
Production	9 314	11 423	13 142	12 706	13 352	13 164
Exports to Outside CEPI	n.a.	1 332	2 071	2 567	3 785	3 239
Imports from Outside CEPI	n.a.	7 924	7 961	7 721	7 721	7 745
Consumption	n.a.	18 015	19 032	17 860	17 288	17 670
Exports/Production	n.a.	11.70%	15.80%	20.20%	28.30%	24.60%
Imports/Consumption	n.a.	44.00%	41.80%	43.20%	44.70%	43.80%
Paper & Board ('000 Tonnes)						
Production Capacity	73 280	97 658	109 801	103 714	101 181	101 026
Operating Rate	88.80%	93.00%	89.50%	91.70%	90.20%	90.10%
Production	65 052	90 823	98 259	95 065	91 268	91 067
CEPI Internal Deliveries	n.a.	78 796	84 661	80 263	76 343	76 470
Exports to Outside CEPI	n.a.	13 887	17 793	19 164	19 649	19 164
Imports from Outside CEPI	n.a.	6 383	5 903	5 783	4 800	5 177
Consumption*	60 102	82 065	86 369	81 684	76 419	77 080
Exports/Production	n.a.	15.30%	18.10%	20.20%	21.50%	21.00%
Imports/Consumption	n.a.	7.80%	6.80%	7.10%	6.30%	6.70%

[18] Members of CEPI in 2014: The National Associations of the 18 following countries are CEPI members: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, The Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, United Kingdom.
[19] Key Statistics 2014. European Pulps and Paper Industry

3.3 Pulp production and consumption

Roundwood is by far the dominant wood raw material type used by the pulp and paper, wood product and bio-energy. Roundwood is defined by FAO as:

"All roundwood felled or otherwise harvested and removed. It comprises all wood obtained from removals, i.e. the quantities removed from forests and from trees outside the forest, including wood recovered from natural, felling and logging losses during the period, calendar year or forest year. It includes all wood removed with or without bark, including wood removed in its round form, or split, roughly squared or in other form (e.g. branches, roots, stumps and burls (where these are harvested) and wood that is roughly shaped or pointed. It is an aggregate comprising wood fuel, including wood for charcoal and industrial roundwood (wood in the rough). It is reported in cubic metres solid volume underbark (i.e. excluding bark)."

Although roundwood can be shipped with or without bark, it is likely that pulp mills will receive roundwood with over bark because after debarking, they can use the bark to help meet their plant CHP needs.

The total apparent consumption of industrial roundwood in the UNECE region continued its upward trend in 2014, reaching 1.06 billion m3, up by 2% compared with 2013 and 6% higher than in 2010. The use of softwood[20] industrial roundwood increased to 788.3 m3 (up by 2.1% over 2013 and 4.4% over 2010) and hardwood industrial roundwood increased to 275.5 million m3 in 2014 (up by 1.9% over 2013 and 10.7% over 2010)[21].

In Europe, total log consumption (including industrial roundwood and woodfuel) was almost 147 million m3 of wood chips and roundwood[22] (mainly hardwood logs [23]), up 2.4% from 2013. Most of the wood used in Europe is supplied by from within Europe. In CEPI countries in 2014, 8.5 % wood (mainly pine and spruce) was supplied from domestic sources. The main importer of wood to Europe was Russia (5.7%).[24,25]

There are several initiatives across the EU to support, implement and assess sustainable forest management. Criteria and indicators have been developed by Forest Europe for the pan-European region to report on the implementation of sustainable forest management by countries.

64.6% of wood, chips and sawmilling by-products delivered to European mills are forest management certified by independent forest certification schemes and can be counted in the companies' chain of custody. (2010: 61.6%) Because of the regulation on timber legality and potential biomass sustainability requirements, it is likely that this figure will increase further[26]. 68.1% of market pulp is actually sold with chain of custody certificate enabling further labelling (2010: 60.9%). 32.3% of total paper tissue and board is sold with a chain of custody certificate enabling further labelling. (2010: 25.6%). 45.9% of 100% paper for recycling based paper, tissue and board is sold with chain of custody enabling further labelling. (2008: 0.1%). The product certification requires interconnection between different actors of the supply chain: from raw material supply, through pulp and paper manufacturing to final product certification.

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[20] *Hardwood* - Non-Coniferous: the wood from non-coniferous (broadleaved) trees: birch, eucalyptus, aspen, beech, hornbeam, ash, maple, acacia, quercus-cerris, oak, alder, poplar, willow, chestnut. The wood of these trees is composed of short fibres. *Softwood* – Coniferous: pine, spruce, Fir, Hemlock, Larch, Cedar. The wood of these trees is composed of long fibres.

[21] UNECE. Forest Products Annual Market Review 2014-2015

[22] CEPI Preliminary Statistics 2015. Confederation of European Paper Industries. Available at: www.cepi.org

[23] UNECE/FAO 2015

[24] CEPI Preliminary Statistics 2015. Confederation of European Paper Industries. Available at: www.cepi.org

[25] EUROSTAT

[26] CEPI Sustainability Report 2013.

The Sustainable Forest Initiative (SFI) program is one of the largest in the world, with a standard based on principles and measures that promote responsible environmental behaviour and sound forest management.

The total surface of certified forests in the CEPI countries reached 86 million ha (taking into consideration the UNECE assumptions on forest surfaces that are certified by both FSC and PEFC). This accounts for nearly 53% of the total forest area in the CEPI member countries. Comparably, 92.2% of forests managed by European pulp and paper companies are certified. Nearly 18,000 Chain of Custody (CoC) certificates were granted in CEPI member countries by both certification systems, more than a 50% increase since 2010. Sales of CoC products have also increased. For instance, sales for paper, tissue and board are now 25% of total sales[27].

Europe plays an important role in the global pulp and paper industry, it is the second largest producer and the third largest consumer of paper and board, North America being the leader, and Asia being very close to Europe. Its role in pulp production is significant – the annual production of wood pulp in Europe is about 41.8 million tonnes/year, the amount produced representing about 22 % of the world's total pulp production of 192.4 million tonnes[28,29]. Finland and Sweden are major producers of softwood and hardwood pulps, followed by Portugal, Germany and Spain. More than 50 % of the sulphate pulp and sulphite pulp manufactured in Europe is used in integrated pulp and paper mills. Market pulp is mainly produced by mills in Finland, Sweden, France, Portugal, Spain, Austria, Germany, and Poland; bleached kraft is the dominating grade for the market pulp.

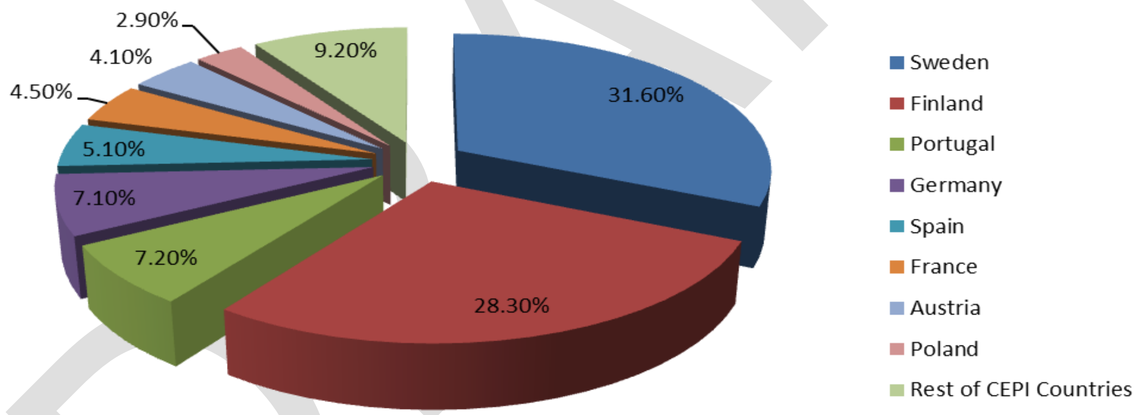

Figure 3. CEPI Total Pulp production in CEPI countries in 2014[30]

From the global perspective, according to FAO statistics approx. 78% of the pulp is produced by means of chemical methods, 16%- mechanical, and 5% semi-chemical pulping technologies[31]. In CEPI countries, in 2014 when compared to the previous year total pulp production falls by 4.3% and market pulp output decreases by around 3.7% with total output of approximately 36 million tonnes. Output of mechanical pulp has

[27] CEPI Sustainability Report 2013.
[28] Eurostat
[29] CEPI Sustainability Report 2013.
[30] CEPI. Key Statistics 2014. European Pulp and Paper Industry
[31] FAOSTAT Database, Food and Agriculture Organization of the United Nations available at http://faostat.org

decreased by around 6.0% whilst production of chemical pulp decreased by around 3.5% when compared to 2013. The main grades of wood pulp for papermaking in 2013 across Europe were sulphate pulp (66% of total pulp production), followed by mechanical and semi-chemical pulp (28% of total pulp production) and sulphite pulp (5 % of total pulp production). Table 5 shows the total production and consumption of the major pulp grades manufactured in Europe (data for 2013).

Table 5. Total production and consumption in 2014 for the major types of pulps manufactured in Europe (CEPI area)

Types of pulp	Total production ('000 Tonnes)	Share	Total consumption ('000 Tonnes)	Share (%)
Mechanical & semi-chemical pulp	10 360	28,4%	10 186	24,8%
Sulphite	1 683	4,6%	1 428	3,5%
Sulphate	24 568	66,4%	29 076	70,8%
Total chemical pulp	26 264	71,9%	30 504	74,3%
Total wood pulp for papermaking	36 373	99,5%	40 690	99,1%
Other pulp	172	0.5%	361	0,9%
Total pulp	36 545	100%	41 051	199%

3.4 Paper and board production and consumption

According to FAO statistical data, the world paper and paperboard production increased from 371 in 2009 to almost 397.6 million tons of paper in 2013. According to RISI Report (2014) the global paper and paperboard production advanced 0.8% to reach a new record level of 403 million tonnes in 2013[32,33]. Major producing countries include China, the United States and Japan. These three countries account for half the world's total production. Leading exporting and importing countries include the United States and Germany[34].

The increase in production in Asia-Pacific region by 13% (from 2009 to 2013) represented the main stimulation of the market growth stating that productions in other regions did not vary considerably within considered period of time. China accounted for 25% of world demand and 26% of global production of total paper and board in 2013. In terms of pulp production, the United States remained the top producing country in the world with 49.4 million tonnes in 2013, followed by Canada producing 17.3 million tonnes, with China a close third at 17.1 million tonnes[35]. Between 2000 and 2010, Chinese paper and paperboard consumption grew by 143%, this was outstripped by a 182% increase in Chinese production.

The share of international trade in paper and paperboard markets relative to global production has increased slightly in the last decade. Globally, the share of exports to production was on average 27% in the 1990s and increased to 30% on average in the 2000s. Regionally, North America and Western Europe are the only regions that have been, and are projected to be, net exporters of paper products,[36] with net exports of 12

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[32] RISI. 2014. Annual Review of Global Pulp & Paper Statistics

[33] The differences in production quantity reported by FAO and RISI might come from the reporting sources, nevertheless both sources cites the similar numbers

[34] ®Statista 2016, available at: http://www.statista.com/topics/1701/paper-industry/

[35] RISI. 2014. Annual Review of Global Pulp & Paper Statistics

[36] Hetemäki, L., Hänninen, R. & Moiseyev, A. 2013. Markets and Market Forces for Pulp and Paper Products, pp. 99-128, in Hansen, E., Panwar, R. & Vlosky, R. & (eds.). The Global Forest Sector: Changes, Practices, and Prospects. CRC Press, Taylor and Francis Group, USA. 462 p.,

million tonnes and 8 million tonnes respectively in 2013. Asia-Pacific, Latin America and Caribbean and Africa are all net importers, with net imports of 8 million tonnes, 6 million tonnes and 4 million tonnes in 2013, respectively[37]. Figure 4. represents the global production distribution in 2013.

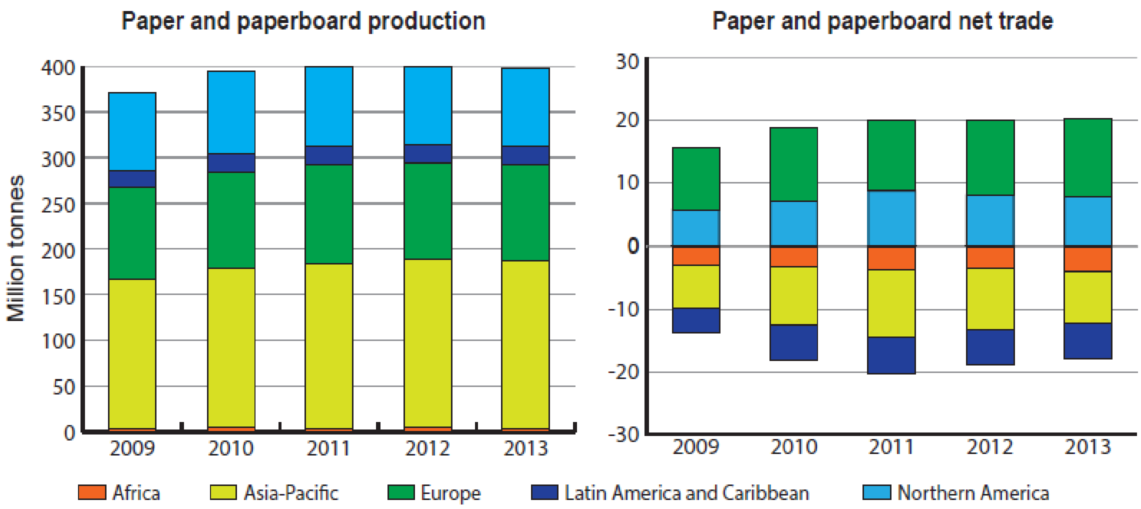

Figure 4: Regional paper and paper board production and net trade

The consumption of paper and board is strongly related to standards of living and the economic situation of the user populations and, in the long term, there is a strong correlation between the increase in the consumption of these products and the growth in the gross national product (GNP). On average about 57 kilos of paper is consumed per capita in the world. Urbanisation is associated with the increase in demand for hygienic products such as tissue paper which consumption is expected to grow at an annual rate of 2.4 % over the next 5 years[38]. The development of new communication technologies affected the consumption of newsprint paper mainly in the United State and Western Europe. Paper and paperboard consumption continues to grow in Asia, especially in China. Estimates suggest that global paper consumption in 2025 will amount to 500 million tonnes, which means growth of about 1.6% a year. Asia's share of global consumption is already 44%. Europe and North America account for almost a third of consumption. Demand in Eastern Europe is also growing faster than in traditional markets[39]. The overall consumption of paper and board in CEPI countries[40] in 2014 increased by between 0.5% and 1.0% when compared to 2013, based on the latest data available[41]. Weak printing and publishing activities continue to have an impact on the overall production of graphic grades, which fell by 3%. Production of uncoated woodfree grades is estimated to have increased by 1.2% compared with 2013 whilst output of uncoated mechanical grades fell by 3.5%.

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[37] FAO, Forest Products Statistics 2013. Global Forest Products Facts and Figures

[38] Bajpai, P. 2015. Green Chemistry and Suistainability in Pulp and paper Industry. Springer International Publishing AG Switzerland

[39] http://www.forestindustries.fi/industry/paper_cardboard_converted/paper_pulp/Global-paper-consumption-is-growing-1287.html

[40] CEPI countries: Austria, Belgium, Czech Republic, Finland, France, Germany, Hungary, Italy, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, United Kingdom

[41] Confederation of European Paper Industries (CEPI) Preliminary Statistics 2014

While China appears to be consuming most of its paper production, this statistic masks that as much as a quarter is exported as packaging for manufactured goods and in finished products that use paper (e.g., in instruction manuals)[42]. Most analysts anticipate a continuing shift in trade patterns due to faster-growing demand in emerging markets, therefore the highest long-term demand growth for paper is expected in packaging (wrapping paper, containers and cartons) and tissue[43].

Table 6. Production and apparent consumption of paper and paperboard in Europe, 2010, 2013 and 2014 (thousand tonnes)[44]

	Production				Apparent consumption			
	2010	*2013*	*2014*	*Change (2013/2014)*	*2010*	*2013*	*2014*	*Change (2013/2014)*
Graphic papers	44,49	39,783	38,953	-2.1	38,461	33,222	33,335	0.3
Newsprint	9,49	8,323	7,813	-6.1	9,49	8,022	7,721	-3.7
Uncoated mechanical	7,737	6,477	6,233	-3.8	6,261	5,068	4,934	-2.7
Uncoated woodfree	9,274	9,406	9,393	-0.1	9,623	8,665	8,623	-0.5
Coated papers	17,988	15,577	15,514	-0.4	13,088	11,467	12,057	5.2
Sanitary and household papers	7,098	7,411	7,59	2.4	7,46	7,232	7,447	3.0
Packaging materials	45,717	47,472	47,963	1.0	44,139	44,106	44,923	1.9
Case materials	26,718	27,864	28,058	0.7	26,923	28,081	28,163	0.3
Cartonboard	9,786	10,324	10,571	2.4	9,003	7,718	8,227	6.6
Wrapping papers	5,152	5,28	5,327	0.9	4,585	4,512	4,756	5.4
Other papers, mainly packaging	4,061	4,004	4,007	0.1	3,628	3,795	3,778	-0.5
Other paper and board	4,572	4,113	4,19	1.9	4,695	4,241	4,231	-0.2
Total paper and paperboard	101,875	98,779	98,695	-0.1	94,755	88,802	89,936	1.3

Different paper grades have different end-uses, prices and demand patterns. On the producer side, there is tendency to focus on few specific paper markets. In Europe, mainly due to increase of demand for cartonboard and coated papers, the total apparent consumption of paper and paperboard rose by 1.3% (Table 6. in 2014). Graphic paper consumption increased by 0.3% but the production dropped by 2.1%, led by a rise of 5.2% in the consumption of coated papers; the increase was despite consumption dropping by 2.7% for uncoated mechanical papers and by 3.7% for newsprint. A continuing decrease in graphic paper consumption is expected as a result of the growing pace of digitalisation and changing lifestyles. However, this is counterbalanced by growth in packaging and hygiene papers, mainly due to demographic trends in Europe. The consumption of packaging materials increased by 1.7%, led by growth of 6.6 % in cartonboard and a 5.4% rise in wrapping papers due to increasing online shopping, while the consumption of sanitary and household papers grew by 3.0%.

The various types of paper produced globally in 2013 are set in table 7. In terms of the quantity produced or consumed, packaging and board products are the largest paper

[42] Zhao, H. 2012. Outlook for Global Recovered Paper – March 2012. RISI

[43] WWF Living Forests rReport: Chapter 4: Forest and Wood Products. 2012

[44] Forest Products Annual Market Review 2014-2015, UNECE/FAO 2015

product sector, followed by writing and printing paper. As shown on Figure 5 the % of production of different types of paper in CEPI countries reflects the global situation [45].

In CEPI countries, the share of packaging grades accounted for 47.6% (45.9% in 2013) of the total paper and board production, with graphic grades taking 40.5% (41.9% in 2013). Hygienic paper manufacturers are estimated to have seen a small fall in output of around 0.3% when compared with 2013 and accounted for 7.6% of total production. Output of all other grades of paper and board – mainly for industrial and special purposes - increased by 3.6% (4.3% of total production).

Figure 6 shows the distribution of paper and paperboard production amongst the five main paper grades. Wrapping and packaging paper accounted for over half of all production in 2013 (216 million tonnes, or 54% of the total), followed by printing and writing paper (105 million tonnes or 27% of the total), household and sanitary paper (8%), newsprint (7%) and other paper and paperboard. The two main trends in the different products are the gradual decline in newsprint production (a fall of 10%, from 32 million tonnes in 2009 to 29 million tonnes in 2013) and the 13% increase in wrapping and packaging paper over the period (from 191 million tonnes to 216 million tonnes). Household and sanitary paper production also increased over the period (an increase of 12%, from 28 million tonnes to 31 million tonnes).

Table 7. Various type paper global production in Million Metric tonnes in 2013[46]

Paper & Board Category	Production	
	Million tonnes	%
Newsprint	29.0	7
Writing & Printing Papers	105.0	27
Household & Sanitary Paper	31.0	8
Wrapping & Packaging paper and board	216.0	54
Paper and paper board	16.0	4
Total	397.0	100

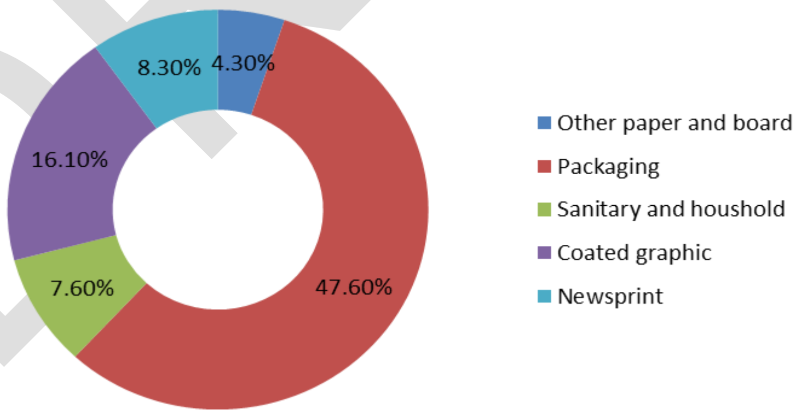

Figure 5. Production of paper and board by grade in CEPI countries in 2014[47]

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[45] CEPI. Key Statistics 2014. European Pulp and Paper Industry
[46] FAOSTAT Database, Food and Agriculture Organization of the United Nations available at http://faostat.org
[47] CEPI Preliminary Statistics 2014. Confederation of European Paper Industries

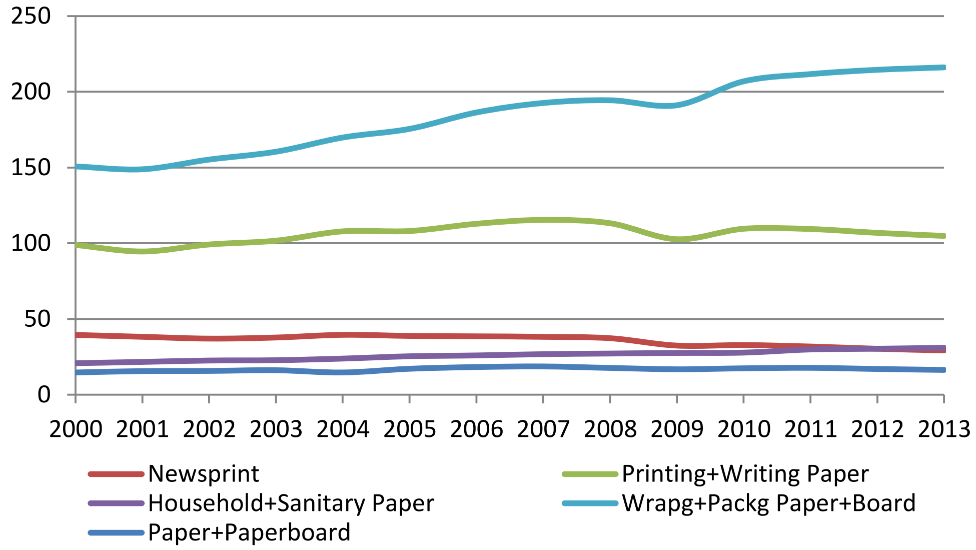

Figure 6. World production of different paper products within the period of time 2000-2013 (million tonnes)

3.5 Recycled fibre market

In the early 1970s governments in the developed world began to promote additional paper recycling, and over the period 1970–2010 recycled paper collection worldwide increased from about 31 million tons to over 210 million tons[48]. Recycled fibre (RCF) makes up roughly half of total furnish compared with about one-third 15 years ago. At the global level, the recovery rate of RFC accounts to 54% over the period 2009-2013. In the three main regions that consume paper and paperboard (and use recovered paper), the recovery rates are high and remained stable over the period 2009-13. Northern America and Europe now have the highest recovery rate (both 62% in 2013), followed the Asia-Pacific region (51%). It is estimated that in 2014 the utilisation of paper for recycling by CEPI members was unchanged when compared to 2013 at 47.5 million tonnes[49].

[48] FAOSTAT Database, Food and Agriculture Organization of the United Nations available at http://faostat.org/site/626/default.aspx#ancor (2013)

[49] CEPI. Preliminary Statistics 2014

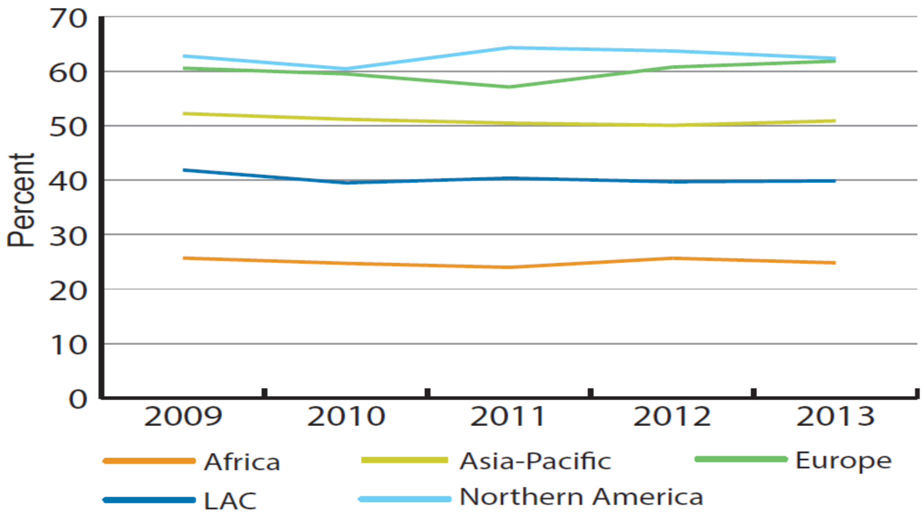

Figure 7. Recycled Paper recovery rates[50]

The previously mentioned drop in demand for newsprint paper is affecting supplies of RCF for containerboard producers. Both cartonboard and tissue producers use large amounts of old newspapers (ONP) as furnish. In China, for instance, they account for two-thirds of ONP consumption, while newsprint producers use the remaining third. Therefore, lower output of ONP is stimulating carton-board and tissue producers to compete for the same sources of recycled fibres as containerboard manufacturers, namely mixed grades and high grades[51]. All in all, it is estimated that the demand for recycled paper will exceed supply by 1.5 million tonnes (1.65 tons) of recycled pulp per year by 2018. The paper industry is investing in paper packaging plants in the developing world to satisfy growing demand in these regions[52].

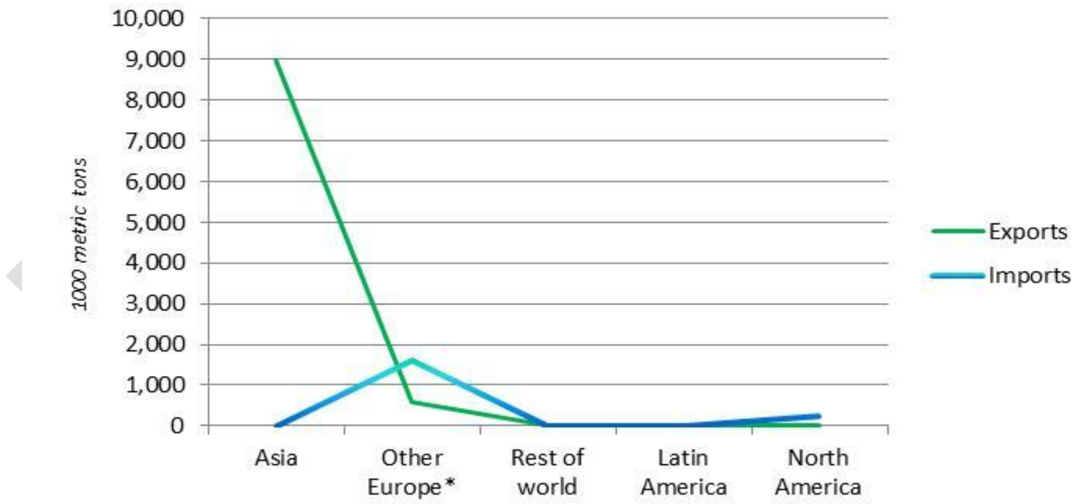

Figure 8. CEPI Imports and exports of paper for recycling in 2014, by region (in 1,000 metric tons)

[50] FAOSTAT Database, Food and Agriculture Organization of the United Nations available at http://faostat.org/site/626/default.aspx#ancor

[51] Tighter recycled fibre markets: Softwood strikes back! Report April 2013. McKinsey. Available at: http://www.mckinsey.com/industries/paper-and-forest-products/our-insights/tighter-recycled-fibre-markets#0

[52] Mohan, A.M. Recycled paper packaging market to grow to $139B by 2018. Packaging World, June 20, 2014, Available at: http://www.packworld.com/sustainability/recycling/recycled-paper-packaging-market-grow-139b-2018

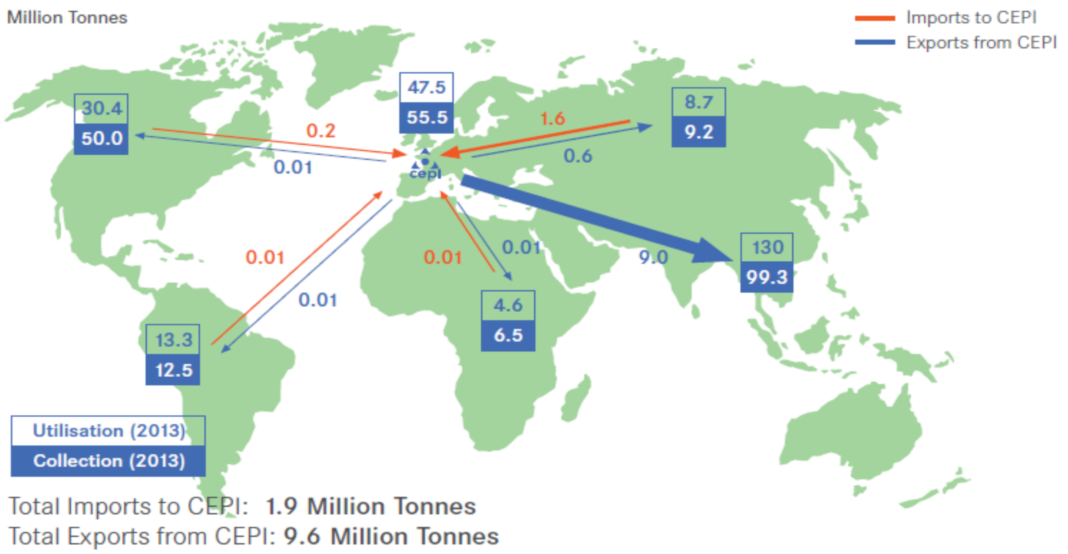

Figure 9. CEPI Trade flows of paper for recycling in 2014

The global RCF trade suggests recovery rates may be nearing their practical limits in many markets already[53]. According to Mansikkasalo et al. (2014)[54], the barriers to increased paper recycling can broadly be classified into supply-side and demand-side barriers. Supply-side barriers cause a shortage of secondary material because it has not been removed from the waste stream in large enough quantities or cannot be separated and prepared for reuse cost-effectively. The demand-side barriers include factors such as the relative cost of input materials and the costs of transportation.

Significant amounts of RCF now flow from developed to emerging markets and return in the form of product packaging. It has been estimated that by 2020, China will need to import 40 million to 50 million tonnes annually, approximately half of the packaging grades produced in China will leave the country again as transport or consumer packaging for finished goods, to be recovered in other markets (so called "hidden" trade in wrapping and packaging paper). This implies that China's true recovery rate (that is, RCF supply adjusted for the estimated volumes leaving the market as packaging) is already fairly high and not much different from the recovery rates in developed markets. [55]

The magnitude of paper and board recycling strongly relies on the infrastructure of the segregation, recovery, recycling system. Therefore the possible increase of the global supply of recovered fibre depends critically on raising both the quality and quantity of paper recovered in emerging markets. However, there are signs in some markets that lower quality recycled fibre is beginning to result in lower yields low yields will in turn push up demand for recycled fibre as well as increase the cost, because producers will need to use more lower-quality RCF to make the same amount of paper or board of any given quality. Following European Recovered Paper Council (ERPC), with the increasing

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[53] Tighter recycled fibre markets: Softwood strikes back! Report April 2013. McKinsey. Available at: http://www.mckinsey.com/industries/paper-and-forest-products/our-insights/tighter-recycled-fibre-markets#0

[54] Mansikkasaloa, A. , Lundmarkb,R, Patrik Söderholmb,P 2014. Market behavior and policy in the recycled paper industry: A critical survey of price elasticity research. Review. Forest Policy and Economics 38, pp. 17

[55] Tighter recycled fibre markets: Softwood strikes back! Report April 2013. McKinsey. Available at: http://www.mckinsey.com/industries/paper-and-forest-products/our-insights/tighter-recycled-fibre-markets#0

recycling rate the fibre yield from recycling is bound to decline, producing continuously more reject[56].

Europe has the highest recovery and utilisation rate of fibres in the world (71.7 % in 2013)[57,58]. The recycling rate has increased significantly from levels around 40% in 1990 and 62% in 2005, but has started levelling up since the last five years. It is estimated that the utilisation of paper for recycling by CEPI members was unchanged when compared to 2013 at 47.5 million tonnes. Analysing statistical data, it can be observed that some Member States are reaching the saturation level of the paper recycling potential.

In most Member States, collectors and reprocessors are private companies, operating under permits. There are on the one hand "waste management" companies, some of them multinational, which collect large volume of waste paper as well as other wastes. In addition, within the EU many small size specialized companies participate in the collection, transport, recovery and recycling of waste paper, each normally having a niche of waste paper grade specialisation, some having equipment, some being essentially merchants. Although usually public organizations are not active in waste paper export and trading, mostly carried out by private sector operators, in some countries some public bodies and even paper mills export waste paper that cannot find national outlets, be it because of low domestic demand or for commercial reasons[59].

Although recycling is both economically and ecologically sound, recovered paper cannot be efficiently used in all paper grades, nor can it be used indefinitely because of shortening up fibre length, and decrease in its quality and usability. Fibre shortens up every time it is used and at some point, usually after 4-6 cycles, it is too short to be used in papermaking. To ensure product quality a certain amount of virgin pulp input will always be needed. The typical role of recycled fibre in the resource mix of paper making is such that it substitutes for mechanical pulp in newsprint and in some board grades[60].

In terms of grades, waste paper can be classified as follows[61,62]:

- Mixed grades: Approximately 19% of the collected waste paper;
- Corrugated and Kraft grades: Approximately 47 % of collected waste paper;
- Newspapers and Magazines: Approximately 23,6% of collected waste paper;
- High grades. Approximately 10% of the collected waste paper.

It is interesting to notice the low percentage of waste paper which is classified as 'high grade'. High grades have a high level of homogeneity and quality and stem from separate collection in e.g. businesses and industry. The sources of this material are fewer compared to mixed sources, and high grades are normally kept separated from other fractions, and require little sorting.

[56] European Recovered Paper Council (ERPC). Paper Recyclin. Monitoring Report 2011

[57] http://www.cepi.org/node/18574

[58] The difference in recovery rate between those reported by CEPI and UNECE/FAO might stem from the difference in reporting systems.UNECE/FAO data refers to European geographical region.

[59] Villanieva A. and Eder, P. 2011. End-of-waste criteria fro waste paper: Technical proposal. JRC-IPTS Report

[60] JRC 2006. Development of a Model of the World Pulp and Paper Industry. Technical Report Series. EUR 22544 EN

[61] CEPI. Key Statistics 2014. European Pulp and Paper Industry

[62] Precise classification rules of recovered paper are specified under EN 643

Table 8. Recovered Paper Utilisation by Sector in CEPI Countries in 2014

Paper Sector '000 Tonnes	Recovered Paper Grades A Mixed Grades	B Corrugated and Kraft	C Newspapers & Magazines	D High Grades	E Total Use of Recovered Paper	F Usage by Sector * %	G Total Paper Production	E:G Utilisation Rate ** %
Newsprint	25	0	7 163	55	7 244	15,2	7 594	95,4
Other Graphic Papers	154	18	2 766	706	3 643	7,7	29 328	12,4
Total Graphic	**179**	**18**	**9 929**	**761**	**10 887**	**22,9**	**36 922**	**29,5**
Case Materials	4 829	16.309	265	835	24 480	51,5	26 204	93,4
Carton Boards	1 725	533	157	855	3 270	6,9	8 546	38,3
Wrappings, Other Pack.	1 858	1 932	150	473	4 413	9,3	8 501	51,9
Total Packaging Papers	**8 412**	**21 017**	**572**	**2 163**	**32 163**	**67,6**	**43 251**	**74,4**
Household & Sanitary	**298**	**103**	**582**	**1 916**	**2 899**	**6,1**	**7 001**	**41,4**
Others	**255**	**1 049**	**126**	**166**	**1 597**	**3,4**	**3 892**	**41,0**
Total	**9 144**	**22 187**	**11 208**	**5 006**	**47 546**	**100,0**	**91 067**	**52,2**
Share of Total	**19,2%**	**46,7%**	**23,6%**	**10,5%**	**100,0%**			
**Usage by sector: total use of recovered paper in a sector as % of the total recovered paper used by the industry*								
*** Utilisation rate: use of recovered paper in a sector as % of total paper production in that sector*								

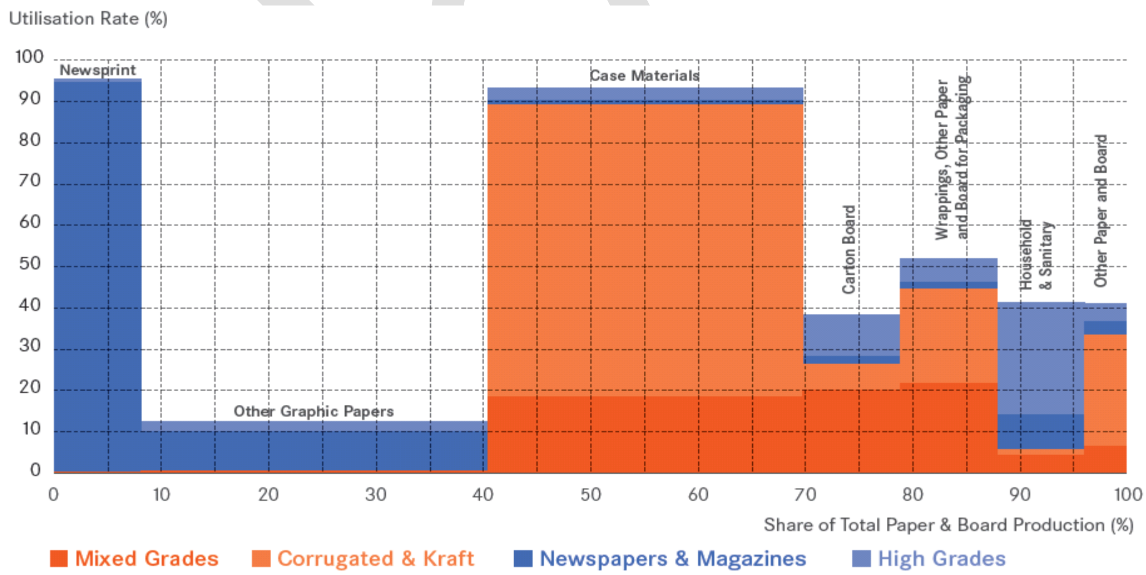

Figure 10. CEPI Utilisation of Paper for Recycling by Sector in 2014

In Figure 10. it is noticeable that to make recycled printing and writing paper, it is not possible to use mixed grades, but only some de-inking grades and higher grades, complemented with virgin fibre. On average, paper for printing applications other than newspapers requires high quality fibres, therefore it has a lower content of recycled fibres when compared to other types of paper. The packaging sector is the biggest consumer of waste paper - almost two thirds of waste paper is used to produce case materials, folding boxboard, wrappings and other packaging materials. The figure illustrates two clearly split recycling cycles – not closed loop but nearly – one for recycling of printed products in newsprint (mostly mechanical fibre, requiring de-inking), and one for recycling of "brown" fibre for card (mostly chemical fibre, non-bleached). These two cycles comprise the bulk of the recycling flows. It is also evident that clean, bleached chemical fibre waste paper (high grades) can be used for all papermaking purposes[63].

3.6 Market penetration of the EU Ecolabel

There are currently (as of the September 2015 reporting period) 2 031 licences issued for awarding 44 711 EU Ecolabel products and services in 35 product categories. As can be observed in Table 9, EU Ecolabel tissue paper and copying and graphic paper products represent a considerable share of that number. In general paper product groups under revision represent 9,5 % of EU Ecolabel uptake in terms of number of licenses, and 21% in terms of number of products. EU Ecolabel Tissue Paper product group share is 6,6 and 13,3%, respectively.

Table 9. EU Ecolabel uptake for Tissue paper, Copying and graphic paper, and Newsprint paper product groups

Product Group	Number of Licences	Number of Products	Awarding Competent Bodies
Tissue Paper	135	5 959	Austria (1), Belgium (1), Bulgaria (2), Czech Republic (2), Denmark (1), Finland (1), France (13), Germany(40), Italy (36), Lithuania (1), the Netherlands (3), Poland (2), Portugal (2), Slovakia (2), Slovenia (1), Spain (14), Sweden (6) and United Kingdom (7)
Copying and Graphic Paper	60	3 921	Austria (6), Finland (5), France (8), Germany(20), Italy (1), the Netherlands (2), Norway (2), Poland (2), Portugal (1), Slovenia (1), Spain (4), Sweden (7) and United Kingdom (1)
Newsprint Paper	5	32	Austria (1), Finland (2), France (1) and Spain (1)
TOTAL	**192**	**9 546**	**20 Countries**

Figure 11. shows the evolution of EU Ecolabel licenced paper products under revision compared with other products/services since the harmonised September 2014 reporting period[64].

[63] Villanieva A. and Eder, P. 2011. End-of-waste criteria fro waste paper: Technical proposal. JRC-IPTS Report
[64] http://ec.europa.eu/environment/ecolabel/facts-and-figures.html

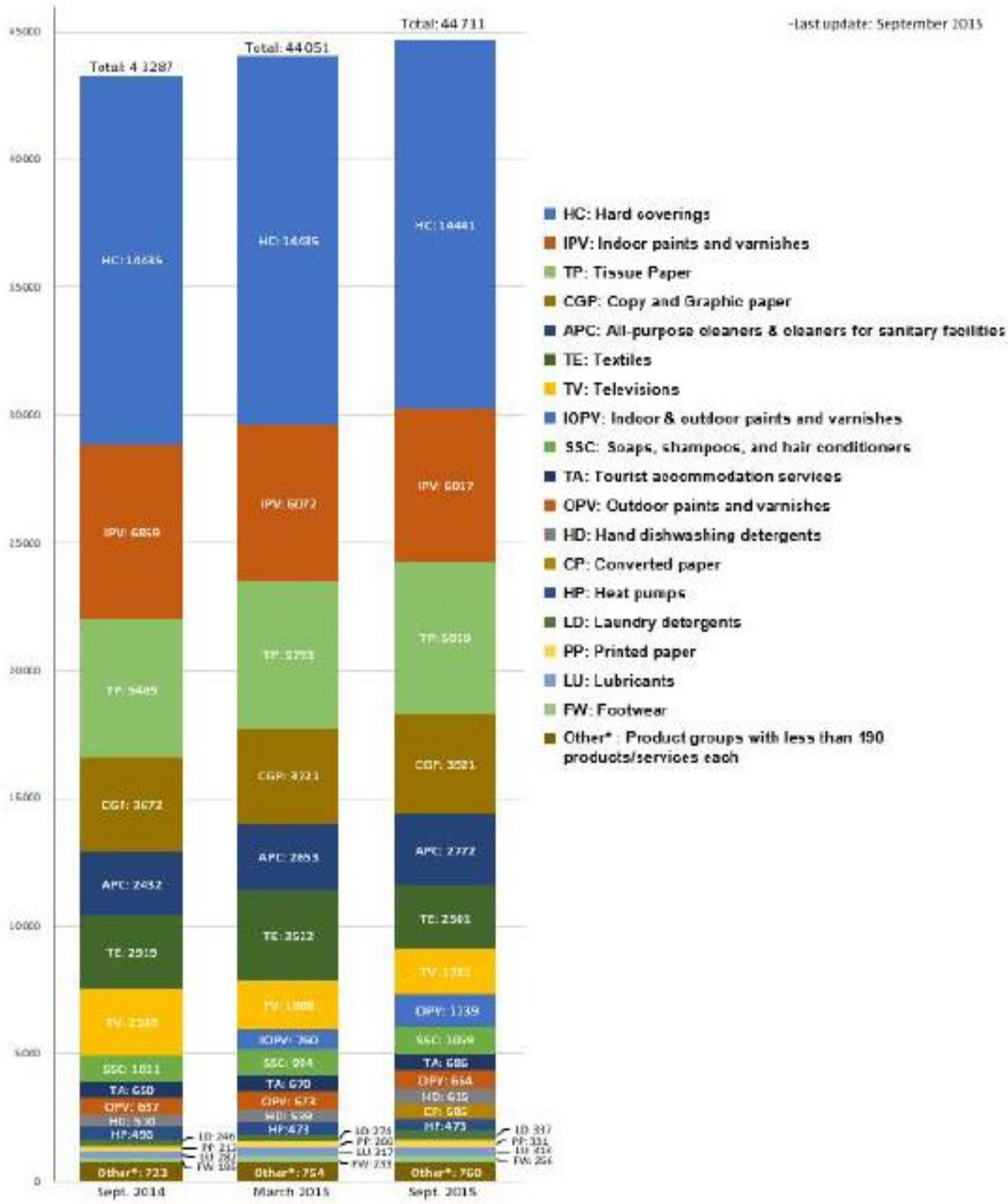

Figure 11. **Total EU Ecolabel products and services per product group**

The data in Figure 11 show that tissue paper is the 3rd most successful of all EU Ecolabel product groups in terms of number of products on the market and that Copying and Graphic paper is 4th on the list. Newsprint paper only amounted to a total of 32 products under 5 licenses.

Thus it is vital to maximise the opportunity of the many active stakeholders and license-holders that are interested in this revision process but to also set the level of ambition in an appropriate manner so that the number of licences will not decrease in the long term.

4. Life cycle analysis evidence for paper products

EU Ecolabel criteria should be based on scientific evidence and focus on the most significant environmental impacts during the whole life cycle of the product. The aim of Task 3 in this report is to identify the environmental "hot-spots" in the life-cycle of copying and graphic paper, newsprint paper and tissue paper products – thus setting a robust basis for subsequent EU Ecolabel criteria. A general diagram of the life cycle of paper products is included below.

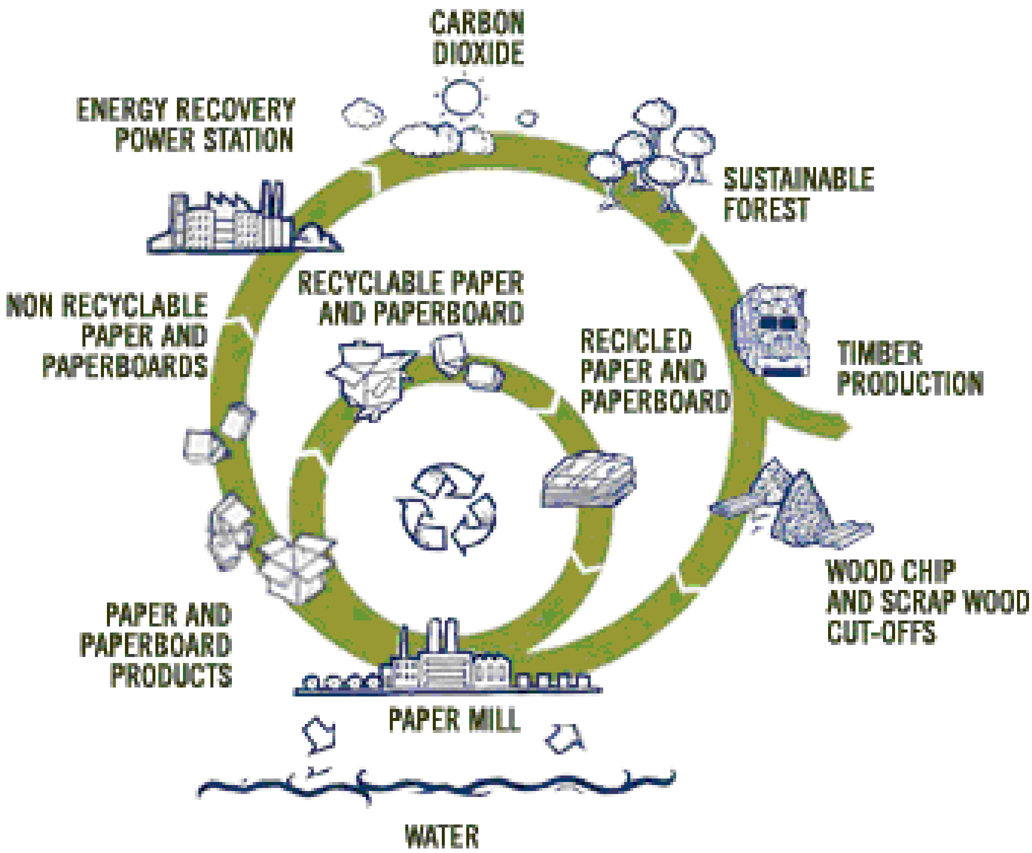

Figure 12. General life cycle of paper products[65].

From the general diagram it is already clear that most of the environmental impacts of paper products will be associated with material sourcing, pulping and papermaking processes. The existing EU GPP criteria for copying and graphic paper[66] state the following key environmental impacts:

- Forest destruction and potential loss of biodiversity.
- Emissions to air and water during pulp and paper production.
- Energy and water consumption during production.
- Chemical consumption during production.
- Waste generation during production such as rejects and sludge.

[65] See: http://www.burgo.com/en/environment/policies/us-and-the-environment (accessed Nov. 2015).
[66] http://ec.europa.eu/environment/gpp/pdf/toolkit/paper_GPP_product_sheet.pdf

For the current revision of EU Ecolabel and EU GPP criteria, a review of new and existing life cycle assessment (LCA) studies for paper products has been carried out. The aim of this reassessment is to confirm the main environmental issues and LCA hot-spots associated with relevant paper products and where environmental improvements can be made. The approach taken is as follows:

i) A preliminary review to identify potentially relevant life-cycle assessment (LCA) studies, Product Category Rules (PCRs) and Environmental Product Declarations (EPDs) to determine what the key impact categories are.

ii) Existing PCRs are analysed in more detail and hot-spots and other key environmental issues identified.

iii) Existing Environmental Product Declarations (EPDs) for relevant paper products are reviewed and summarised.

iv) Screening criteria are developed and applied to all identified LCA studies and scoring criteria are applied to studies that pass the screening step.

v) The highest scoring LCA studies are reviewed in more detail.

vi) Conclusions are drawn and hot spots justified.

The relationship between PCRs, LCAs, EPDs and the existing ISO framework of standards can broadly be illustrated as follows:

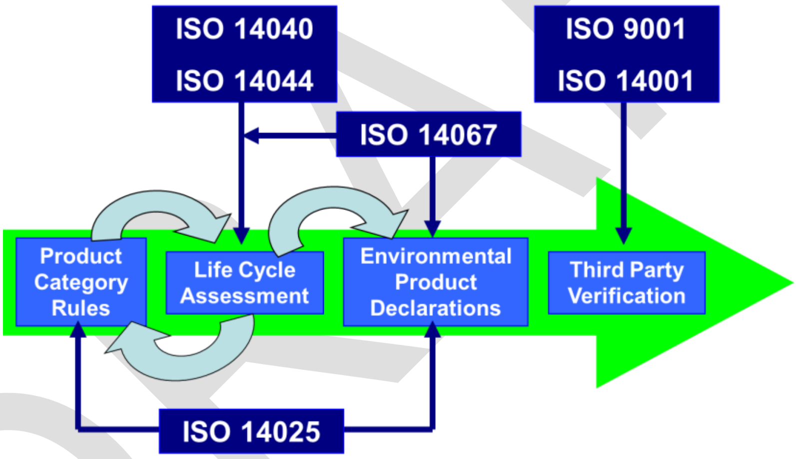

Figure 13. Links between PCRs, LCAs, EPDs and third party verification as key steps towards lower environmental impact products.

The analysis of the environmental impacts for any product group would have begun with LCAs, as per the ISO 14040 series of standards. However, in order to help LCAs be more comparable with each other within a particular product group, it became necessary to define PCRs as common rules in line with the ISO 14025 approach. Once established, PCRs would then form the basis for any new LCA study.

Specific data from an LCA may be presented in a simplified format as an EPD, again following the approach set out by ISO 14025 and respecting any relevant PCRs, so that declarations made available to consumers are truly comparable within a certain product group. The ISO 14067 standard relates to the carbon footprint (CF) of products and can also be used as a basis for EPDs. However, it should be noted that the CF of a product is only one impact category associated with LCA data and, as with EPDs, will only give a partial picture of all the environmental impacts associated with a product.

4.1 Preliminary review of LCA-related literature

For this report, a preliminary review of LCA-related literature has identified the following documents of potential relevance:

- 3 sets of PCRs
- 61 academic publications relating to the LCA of paper products during the period 2002-2015 (see Supplementary LCA document for full list).
- 49 EPDs published under the International EPD database and around 90 EPDs published under the Paper Profile initiative.

4.1.1 Key impact categories identified in PCRs

The PCRs are of particular value to this report because they are developed by discussion among experts and tend to focus on the most relevant impact categories that can be reliably reported. The three sets of relevant PCRs identified are:

- International EPD system PCRs for (i) Tissue Paper (UN CPC 321) and (ii) Processed Paper and Paperboard (UN CPC 3214)
- Paper Profile PCRs
- Pilot Environmental Footprint Category Rules (PEFCRs) for intermediate paper products.

Particular emphasis will be placed on the findings thus far in the ongoing development of PEFCRs due to the fact that this focuses on intermediate paper products that are common to all three Product Groups and due to the fact that the rules are set for actual LCA studies instead of EPD reporting. A comparison of the impact categories addressed in each of the PCRs is summarised in Table below.

Table 10. Key impact categories addressed in paper product PCRs (and indicators)

Impact Category	International EPD System		Paper Profile	PEFCR Intermediate Paper Products (draft v 0.1.4)
	Tissue Paper	Paper and Paperboard		
Climate Change	kgCO_2eq.	kgCO_2eq.	kgCO_2 /t	kgCO_2eq.
Ozone Depletion				kg CFC-11eq.
Ecotoxicity			AOX (kg/t)	CTUe*
Human Toxicity				CTUh*
Particulate Matter / Respiratory inorganics				kg PM2.5eq.
Ionising radiation				kg U235eq. (to air)
Photochemical Ozone formation	kg C_2H_4eq.	kg C_2H_4eq.		Kg NMVOC eq.**
Acidification	kg SO_2eq.	Kg SO_2eq.	kg SO_2 / t kg NO_x / t	mol H+ eq.
Eutrophication	kg PO_4eq.	Kg PO_4eq.	Total N (kg/t) Total P (kg/t)	mol N eq. kg P eq. kg N eq.
Resource Depletion				Kg Sb eq. m3 water related to water scarcity
Land Use				Kg (deficit)

A colour code has been introduced to provide an indication of how well the indicator fits into an LCA approach as it is proposed to be used in each set of PCRs. The colour coding for the PEFCR is specifically based on Annex II from Recommendation 2013/179/EU. The colour code ranges from highly recommended (green) to poorly recommended (red). The reason for the Paper Profile indicators being coloured in red is simply related to the fact that the way in which they are reported does not fit directly with common LCA calculation methodologies. Nonetheless, the information is useful and particularly relevant with regards to EU Ecolabel criteria verification and to BAT emission data reporting in regarding emissions to air and water.

From Table 10, it is clear that the most important impact categories addressed in PCRs for Paper Products are:

- Climate change
- Photochemical Ozone Formation
- Acidification
- Eutrophication

These four impact categories are addressed in all EPDs published under the International EPD system for Paper Products. However, it is worth noting that the PEFCRs make it clear that **all** impact categories for Paper Products **should** be assessed due to the fact that the PEFCRs are designed for intermediate products (i.e. prior to conversion).

4.1.2 Key impact categories identified in LCA studies

From the 63 LCA studies identified in the academic literature, only 37 actually assessed at least one of the main impact categories listed in the ILCD Handbook (ref). The frequency with which impact categories were assessed is illustrated in Figure 14.

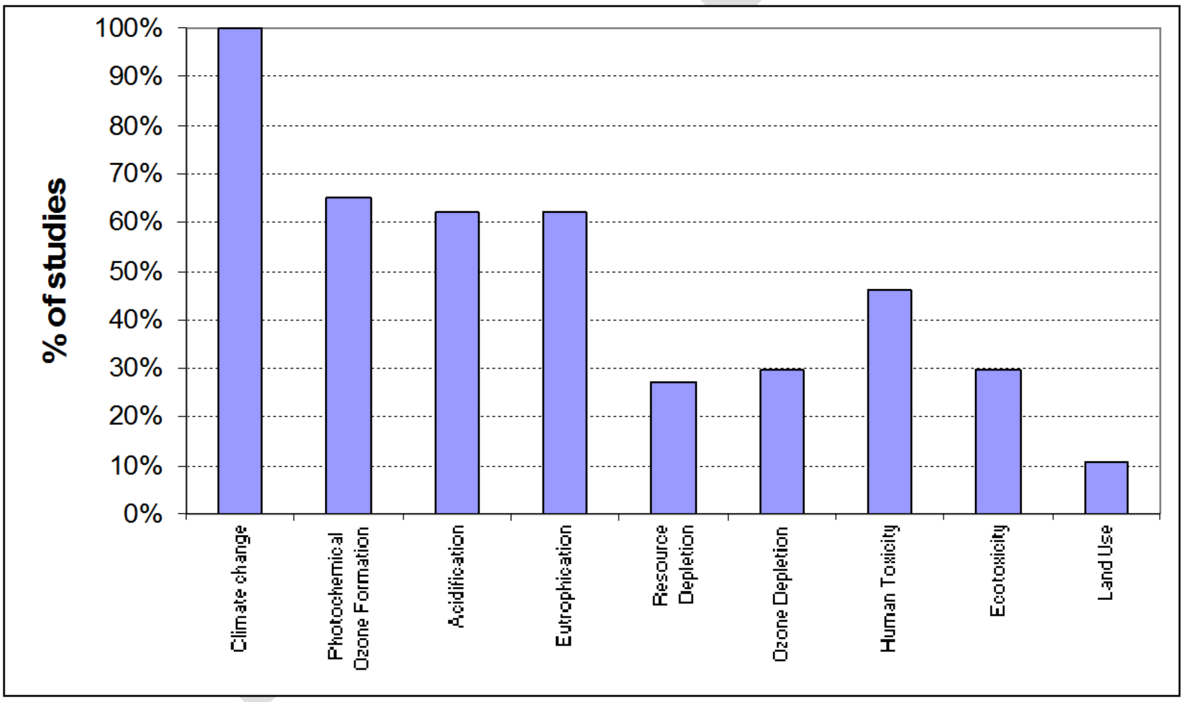

Figure 14. Frequency with which impact categories were assessed in screened LCA studies

It is clear that climate change is the dominant impact category of concern with paper products – appearing in every single screened LCA study. The next most significant impact categories were Photochemical Ozone Formation, Acidification and Eutrophication – each assessed in slightly more than 60% of screened studies. Other impact categories only appeared in 30% or less of screened LCA studies except for human toxicity at around 45%. However, it should be considered that human toxicity was an aggregated score of human toxicity impacts, ionizing radiation and particulate matter.

4.2 Product Category Rules (PCRs) for paper products

It is important to review existing PCRs because they have generally been developed by widespread expert consultation and will often suitably address the main issues of concern from an LCA perspective whilst trying to avoid the most problematic or controversial areas. This section presents an overview of the following PCRs:

- PCRs from the International EPD system (Environdec).
- PCRs under development for the "intermediate paper products" PEF study.

Table 11. Comparison of International EPD PCRs (for tissue paper) and the PEFCRs (for intermediate paper products).

Area	International EPD System PCRs for Tissue products (CPC sub-class 32131)	PEFCR for Intermediate Paper Products for making Tissue Paper or Graphics Paper
Definition	The cellulose fibres may be virgin fibres or recycled fibres, i.e. fibres derived from recovered paper. The product groups covered by this PCR include: • Products that consist of at least 90% fibres, the fibres being virgin or recycled, cellulose based natural fibres. • Parent reels, sheets or rolls of tissue paper fit for use for personal hygiene, wiping, cleaning and absorption. The tissue product normally consists of creped or embossed paper in one or several plies. When present, the core in a rolled product is included. Laminated tissue products and wet wipes are excluded from the product group.	Graphic papers include the following grades (defined earlier) • Newsprint • Uncoated Mechanical • Uncoated woodfree • Coated papers (i.e. coated mechanical/coated groundwood and coated woodfree). • Recovered paper Tissue papers include the following grades (also defined earlier • Paper for toilet tissue • Paper for towels (WS*) • Paper for napkins (WS*) • Paper for hankies (WS*) *WS = wet strength.
Product classification system	Uses the UN CPC system: 32: Pulp, paper and paper products, printed matter and related articles 321: Pulp, paper and paperboard 32121: Newsprint 32131: Toilet or facial tissue stock, towel or napkin stock and similar paper. 32143: Paper and paperboard coated with kaolin or with other inorganic substances	Uses the NACE/CPA system: C17 – Manufacture of paper and paper products C17.12 – Paper and Paperboard and all sub categories therein except: • C17.12.12 Handmade paper and paperboard. • C17.12.43 Filter paper and paperboard; felt paper • C17.12.44 Cigarette paper • C17.12.77 Paper, paperboard, cellulose wadding and webs of cellulose fibres, coated, impregnated, covered, surface covered or printed, in rolls or sheets.
Specification of company/ product	**Mandatory:** Manufacturing company, site and country, trade name (if relevant) and species/variety (if relevant) **Voluntary:** ISO 14001, EMAS certificate of manufacturing site, Environmental policy, Type I & II environmental labels	**Not necessarily required for carrying out an LCA, data confidentiality may be an issue.**
Functional unit:	• 1 tonne (1000 kg) of tissue (including packaging) or • 1 m^2 of tissue or • The amount of tissue required to absorb 1g of water (DIN 54540) or • Amount of tissue used for a specific function (e.g. hand drying).	1 tonne (1000kg) of saleable (graphics, packaging or tissue) paper grade at the paper mill´s gate. The mill´s gate is at the end of reel winding process of the pigment/mineral coated or uncoated paper reel. If rewinding and reel packaging are part of the intermediate product they shall be included. Additional units that may be used: • 1 m^2 of product or • (for tissue) the amount of tissue required to absorb 1g of water as per EN ISO 12625-8 or similar.

Content declaration	All relevant materials and substances shall be declared to account for a minimum of 99 % of the gross weight of the product including: • The type of pulp • The type of recovered paper (e.g. according to EN 643) • Bleaching agents The following functional chemicals shall be declared if they amount to more than 2% of the weight of the final product: • Wet strength agents • Dry strength agents • Dyes • Fixing agents • Fluorescent whitening agent • Glue (laminating glue, pick-up glue & tail seal glue) • Softeners, de-bonders & absorbency aids • Lotions, perfumes & detergents	**Inputs and outputs of unit processes are included in LCA analysis but substances in the intermediate product are not explicitly stated**
Data quality, units and quantities*	Electricity should specify the national or supplier-specific energy mix. Units for electricity: kWh or MWh Units for fuels: MJ (GJ)	
System boundaries	**Upstream:** Energy wares, chemicals, packaging, forestry & waste paper **Core:** Transports, pulp production, tissue production, converting **Downstream:** Distribution, use, End-of-Life waste management **Time:** Site-specific data to be averaged over 12 months. New site-specific data must be verified during at least 40 days. All other data must be less than 5 years old.	**Upstream:** Energy wares, wood from forest, water, paper for recycling & other materials. **Core:** Pulp production, paper and paperboard production. Downstream: Conversion, Distribution, Use, End-of-Life including collection of paper for recycling, energy recovery or disposal.
Upstream unit processes to include	• Forestry, from first thinning to final felling and transport to pulp mill • Production processes of the energy wares used in forestry and in manufacturing. • Production of functional and other chemicals used in the core processes. • Production of other raw materials • Production of primary and secondary packaging (including cores, if applicable) • The manufacturing of primary and secondary packaging	• Collection and sorting of recovered paper. • Transport of sorted paper • Seedling production, soil preparation, planting, pre-commercial thinning, fertilization, felling and transport • Production of off-site woodchips and of sawmill residues. • Other materials: production of functional chemicals, process chemicals, minerals and capital goods (with linear depreciation) • Water • Production of energy wares (fuels, electricity and heat) • Transport to pulp/paper mill
Core unit processes to include	• Transports of raw materials • Recycling process of purchased recycled paper and the transport from the recycling process to where the material is used. • Waste treatment of waste generated during manufacturing; • Pulp production (in the case of virgin fibres) • De-inking process (in the case of recycled fibres) and the transport from the recycling process to where the de-inked pulp is used. (An additional process with virgin fibre production shall be added for compensating for actual fibre loss in the de-inking process. The paper quality determines which type of fibres to be compensated). • Tissue production	• Pulp production from virgin fibres and associated processes (e.g. debarking, chipping, cooking/groundwood pulping, refining, delignification, washing, bleaching, drying) • Pulp production from recovered fibres and associated processes (e.g. repulping, mechanical removal of impurities, deinking, bleaching, drying) • Paper and paperboard production (e.g. stock preparation, refining and a paper and board machine), additional processes (e.g. coating, sizing, drying and calendaring), finishing processes (e.g. reeling and reel winding). • Supporting activities (e.g. water and solid waste treatment, electricity and steam generation, chemical recovery) • Transportation (of pulp to paper and paperboard facility if not integrated and of

	• Transport of parent reels (if applicable) • Converting of products • Wastewater treatment • Transports to warehouse for finished products	waste generated by the mill).
Downstream unit processes to include	• Transport of the product to customer. For regional markets, an average distance of 1000 km may be used. Guidance for sea transport given[67] • Disposal of products • Waste management of transport packaging waste (based on scenarios)	• Excluded from the scope because rules relate only to intermediate paper products.
Allocation rules	Avoid allocation as far as possible by splitting processes into sub-processes for which separate data can be collected. However, the system boundary should not be expanded simply to avoid allocation.	Allocation is permitted for tall oil, turpentine, bark and other co-products with a known dry mass. The PEF recycling formula is to be used for paper made with recycled fibres.
Additional information to report	**Use of resources:** • Non-renewable materials (mass); Renewable materials (mass) • Non-renewable energy (MJ); Renewable energy (MJ) • Recovered energy flows, such as thermal (MJ) • Total water used (mass) • Water used in core processes (mass) **Impact category indicators:** • GHG - GreenHouse Gas emissions (CO_2eq) • AP - Emission of Acidifying gases (SO_2eq) • POCP – Ozone Creation Potential (C_2H_4eq) • EP – Eutrophication Potential (PO_4^{3-}eq) **Waste production:** • Hazardous waste, in kg (as defined by regional directives) • Non-hazardous waste, in kg	**Use of resources:** • Total energy consumption and how this is split between renewable and non-renewable energy. • % of fibres sourced from sustainably managed forests and/or monitored forests. **Impact category indicators:** • GHG - GreenHouse Gas emissions (CO_2eq) • Acidification (mol H+eq) • Eutrophication (terrestrial mol N eq; freshwater kg P eq; marine kg N eq) • ODP – Ozone Depletion Potential (kg CFC-11eq) • ET – Ecotoxicity (CTUe) • HT – Human Toxicty, cancer and non-cancer (CTUh) • PM/RI – Particulate Matter / Respiratory Inorganics (kg PM2.5) • IR – Ionising Radiation (human health effects – kg U235eq to air) • POF – Photochemical Ozone Formation (kg NMVOC eq) • Resource Depletion (water – m3 H2O related to local scarcity; mineral/fossil – kg Sb eq) • Land Use (kg deficit)

*Reasonable multiples may be adopted for a better understanding

The PEFCR screening study aims to examine the impacts associated with single representative paper products to act as a sort of benchmark meanwhile EPD PCRs are set up to be applied to individual products.

Although the PCRs set out in the International EPD and the PEF documents have certain aspects in common, it is worth noting what the most important differences between the two sets of rules are that:

- The international EPD scope and boundary includes downstream processes while the PEFCR does not.
- The PEFCR includes 11 impact categories while the International EPD rules include only 4.

[67] See: www.sea-distances.org (accessed Oct. 2015).

- The units used for indicators for common impact categories are different for acidification, eutrophication and photochemical ozone formation.
- Conversion is defined as a core process with the International EPD rules and is included in the scope whereas it is defined as a downstream process in the PEFCR and therefore excluded from the scope.

While the first and fourth differences listed above can be explained by the fact that one system applies to final products and the other applies to intermediate products, it is best to summarise findings from the PEFCR screening study with data reported in International EPD systems EPDs separately.

4.2.1 Main findings from the PEFCR screening study for intermediate paper products

One of the principal aims of the PEF studies is to improve the comparability of LCAs regarding a certain product group even if this comes at the cost of reducing the flexibility that exists in the ISO 14040/44 framework. A key component of any PEF project is the screening study, which sets out agreed system boundaries, defines a representative product, states which impact categories/indicators should be assessed and identifies the main LCA hot-spots in the product life cycle at various levels (i.e. life cycle stage level, process level, elementary flow level).

The findings reported here relate to the latest draft of the PEFCR screening study (v4.1) that was published in August 2015. Tissue paper and graphic paper are explicitly included within the scope of the study.

4.2.1.1 System boundary definition for intermediate paper products

The system boundaries are defined as shown below.

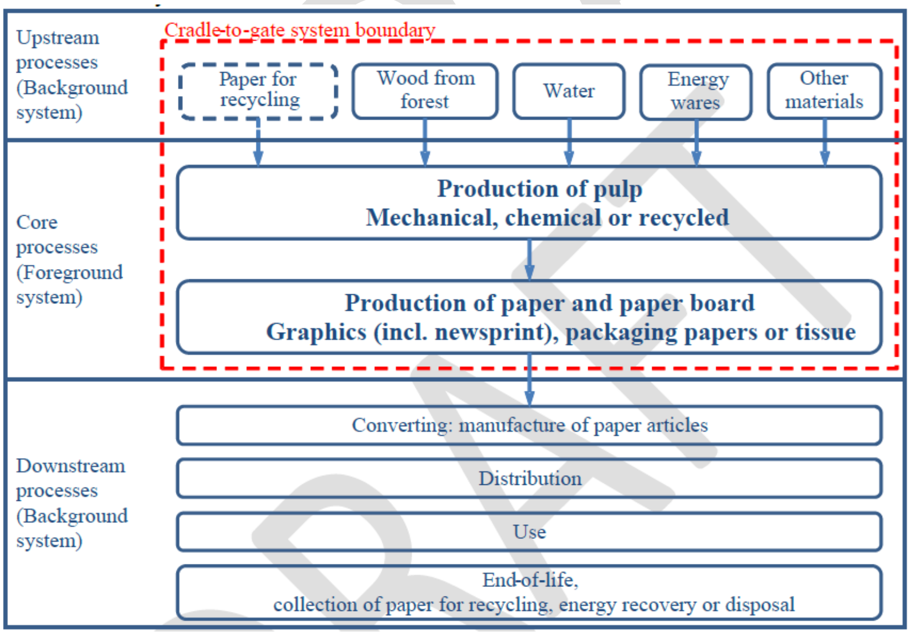

Figure 15. System boundaries defined for the PEF study for intermediate paper products.

Copying and Graphic Paper, Newsprint Paper and Tissue Paper share the same main material flows although the use of different pulps can have significantly different impacts related to chemicals and additives used, the choice of papermaking technology and ancillary equipment such as wastewater treatment plants and recovery boilers can greatly influence energy efficiency and emissions.

4.2.1.2 Definition of representative graphic paper and tissue paper products

Based on information compiled by the Finnish Technical Research Centre (VTT) for the European Association of Graphic Paper Producers in 2012, a series of market reports and the BAT reference document for the production of pulp, paper and board, the following representative products were defined for Graphic Paper and for Tissue Paper, the latter being split into wet strength (WS) and no wet strength (no WS).

Table 12. BoM of EU representative intermediate paper products for Graphic Paper and Tissue Paper in the PEF screening report (data are weighted averages, expressed as kg/tonne net saleable product and add up to 1000kg of paper produced).

Input	Graphic	Input	Tissue (WS)	Tissue (no WS)
Water content	58.0	Water content	50.0	50.0
Pulp consumption				
Mechanical (SGW)	53.8	Kraft pulp softwood	673.0	704.3
Mechanical (TMP)	132.8	Deinked pulp	224.3	234.8
Int. kraft pulp	108.5			
Non-int. kraft pulp	195.7			
Deinked pulp	178.6			
Additives				
Fillers	253.0	Wet strength agent	41.7	0
Latex	4.59	Dry strength agent	6.0	6.0
Polyacrylates	0.53	Other organic chemicals	2.5	2.5
Sizing agents	0.76	Other inorganic chemicals	2.5	2.5
Starch, total	10.98			
Talc	1.98			
CMC	0.74			
Total	**1000**	**Total**	**1000**	**1000**
Biogenic carbon (as C)	340	Biogenic carbon (as C)	417	437
Biogenic carbon (as CO2)	1247	Biogenic carbon (as CO2)	1530	1601

From the data in Table 12, all three types of paper (graphic, tissue-WS and tissue-no WS) had similar quantities of deinked pulp. This stems from the average recycled fibre contents of 27% and 25% calculated for graphic paper and tissue paper respectively.

Additives are much more significant in graphic paper (27% by weight) than in WS tissue paper (5%) or no-WS tissue paper (1%) with fillers dominating in graphic paper (accounting for around 90% of all additives used).

4.2.1.3 Identification of key impact categories

The PEF screening study reports results for a total of 17 different impact categories which are summarised in Figure 16 below, splitting impact categories in terms of perceived quality and then in terms of magnitude of impact.

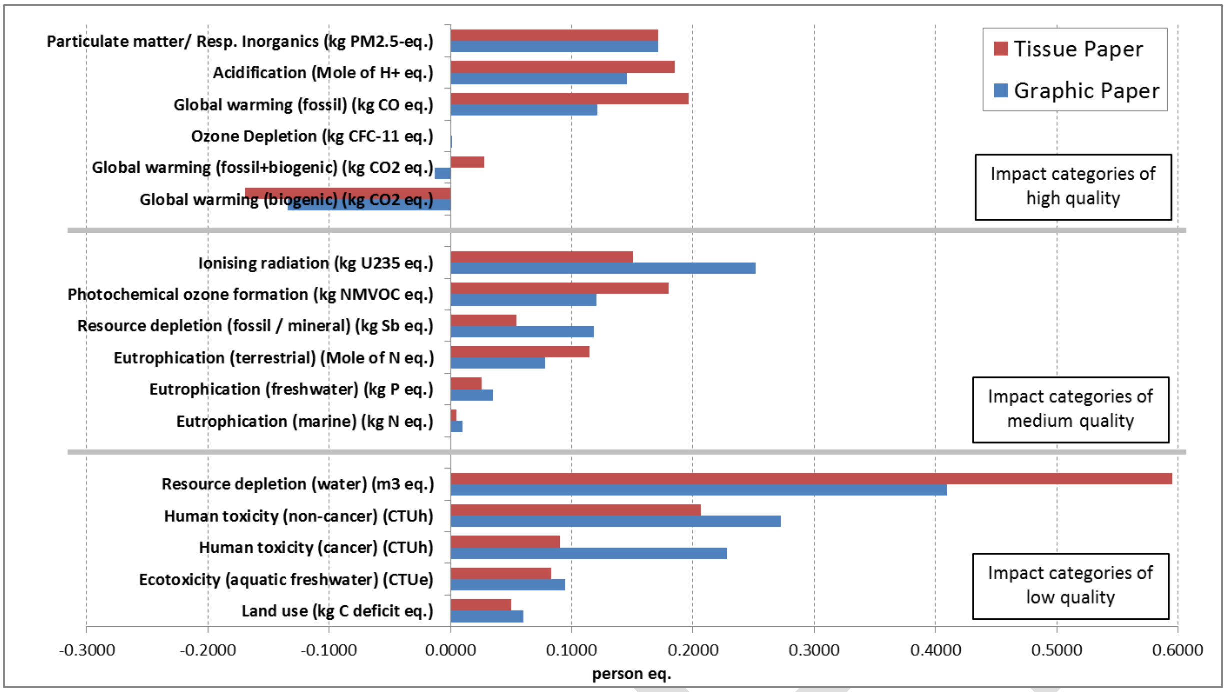

Figure 16. Identification of most relevant impact categories for representative products in the PEF screening study for both graphic paper and tissue paper.

Broadly speaking, the trends are similar for both graphic paper and tissue paper. In terms of overall normalised impact. It is clear that the most significant impact category is water resource depletion. However, this impact category is considered to be of low quality in the LCA community and there limitations of simple volumetric based indicators are clearly described and discussed by Berger and Finkbeiner (2012)[68].

Considering impact categories of high quality, all categories were of a similar degree of importance between tissue and graphic paper. Ozone depletion potential was negligible and the fossil global warming impacts are largely cancelled out by biogenic global warming impacts. Both acidification and particulate matter/respiratory organics were the dominant adverse environmental impacts associated with high quality indicators.

With impact categories of medium quality, ionising radiation and photochemical ozone formation were most important. Fossil and mineral resource depletion and terrestrial eutrophication were also significant, but to a lesser degree. Freshwater and marine eutrophication impacts were found to be much less important, arguably reflecting the substantial progress made in curbing emissions of N and P in final effluents from wastewater treatment plants.

Impact categories of low quality are dominated by water resource consumption although human toxicity (cancer and non-cancer) is also significant in terms of scale when compared to higher quality impact categories.

4.2.1.4 Hot spot identification: most relevant life cycle stages

The next step is to identify where the impacts are concentrated within the life cycle of intermediate paper products. Due to the intermediate nature of this product group, the use phase and End-of-Life (EoL) stages are not included although credits for avoided EoL

[68] Berger M. and Finkbeiner M., 2012. Methodological challenges in volumetric and impact-orientated water footprints. Journal of Industrial Ecology, 17(1) p.79-89.

impacts are defined where recycled fibres are incorporated into the product. The life cycle of the intermediate Graphic paper product is split into the following stages shown in Table 13. No data were included in the screening study for Tissue Paper based on the argument that general trends and tendencies were similar.

Table 13. Relative contributions of defined life cycle stages for Graphic Paper for each impact category

	Credit EoL saved	Raw material acquisition	Transport	Pulping	Papermaking	Overall contribution
Global warming (fossil) (kg CO2 eq.)	-1%	20%	4%	13%	63%	**83%**
Global warming (biogenic) (kg CO2 eq.)	13%	144%	**0%**	-47%	-10%	**97%**
Ozone Depletion (kg CFC-11 eq.)	0%	41%	3%	21%	36%	**97%**
Human toxicity (cancer) (CTUh)	0%	56%	2%	20%	22%	**98%**
Human toxicity (non-cancer) (CTUh)	-1%	39%	8%	22%	33%	**94%**
Acidification (Mole of H+ eq.)	-1%	18%	7%	27%	48%	**93%**
Particulate matter/ Resp. Inorganics (kg PM2.5-eq.)	-3%	17%	3%	28%	55%	**83%**
Ecotoxicity (aquatic freshwater) (CTUe)	0%	34%	1%	46%	19%	**80%**
Ionising radiation (kg U235 eq.)	0%	19%	0%	55%	26%	**81%**
Photochemical ozone formation (kg NMVOC eq.)	-2%	21%	13%	31%	37%	**89%**
Eutrophication (terrestrial) (Mole of N eq.)	-2%	18%	14%	34%	36%	**88%**
Eutrophication (freshwater) (kg P eq.)	-4%	19%	1%	52%	33%	**85%**
Eutrophication (marine) (kg N eq.)	-4%	67%	4%	21%	12%	**88%**
Land use (kg C deficit eq.)	0%	83%	1%	4%	13%	**83%**
Resource depletion (water) (m3 eq.)	0%	6%	0%	54%	40%	**94%**
Resource depletion (fossil / mineral) (kg Sb eq.)	0%	54%	2%	6%	38%	**92%**

The data in Table 13 show the EoL credit savings due to the incorporation of recycled content are generally insignificant for each of the impact categories considered - even when the representative product had a recycled fibre content of 25%. Transport was also relatively unimportant in all impact categories compared to other life cycle stages. The most relevant impacts related to transport were terrestrial eutrophication (14% of total) and photochemical ozone formation (13% of total).

As could reasonably be expected, the three dominant life cycle stages of paper products are: raw material acquisition, pulping and papermaking. Raw material acquisition was the dominant stage for global warming (biogenic), human toxicity and land use. This stage was also dominant for ozone depletion and marine eutrophication, but it should be noted that these were relatively insignificant impacts according to the normalised data. All other impact categories were dominated by the pulping and/or papermaking stages.

4.2.1.4 Hot spot identification: most relevant processes

A more detailed look at the hot-spots identified in the PEF screening study involves looking at were the largest contributions to each impact category occurred at the level of specific processes occurring within each life cycle stage.

From a quick glance at Table 14, it is clear that the main sources of most impacts are due to **energy use** in both pulping and papermaking stages and to **chemicals and additives** used in both the pulping and papermaking stages.

Focussing only on the normalised and weighted impact categories that were identified to be of most concern in Table 14, the dominant processes and associated elementary flows are as follows:

- **Water resource depletion:** 80% of total impact is due to water abstraction for the pulping (51%) and papermaking stages (29%).
- **Acidification:** Dominated by SO2 and NOx emissions (97.8%). Around 46% of acidification potential was due to energy required for papermaking but only 7% due to energy required for pulping. However, an additional 20% of acidification potential is related due to the pulping process itself.
- **Particulate Matter / Respiratory Inorganics:** Dominated by the emissions of dust <2.5μm and SO2 (74.1%). Around 50% of total impact was due to energy consumption for papermaking and 18% due to the pulping process.
- **Global warming:** 61% of fossil carbon is emitted due to energy required for the papermaking process.
- **Photochemical ozone formation:** Dominated by emissions of NOx to air (79.6%). Around 40% of total impacts were due to energy use (pulp 5%; paper 35%), 25% of total impacts due to the pulping process and 15% due to chemicals and additives (5% pulp; 10% paper).
- **Human toxicity (non-cancer):** Dominated by emissions of As(V) to freshwater, Hg(II) to air, Zn(II) to air and Zn(II) to agricultural soil (79.2%). Around 35% of this impact was related to chemicals and additives used in pulping (17%) and papermaking (18%) stages while a further 34% was related to energy required for the pulping (15%) and papermaking (19%) processes.
- **Human toxicity (cancer):** Dominated by emissions of Cr(VI) to freshwater and industrial soil (77.6%). Around 47% of this impact was related to chemicals and additives used in pulping (31%) and papermaking (16%) stages while a further 18% was related to energy required for the pulping process.
- **Ionising radiation:** Dominated by emissions of Rn^{222} and C^{14} (96.9%). Around 79% of this impact was related to energy use during the pulping (55%) and papermaking stages (24%).

Table 14. Relative contributions of defined processes for Graphic Paper for each impact category

	Transport	Wood from forest	Paper for recycling	Credit EoL saved	Pulp - waste	Pulp - energy	Paper - energy	Pulp – water withdrawal	Paper – water withdrawal	Pulp – chemicals and additives	Paper – chemicals and additives	Pulping - process	Paper - process	Paper mill infrastructure	Highlighted contribution
Global warming (fossil) (kg CO2 eq.)	4%	2%	1%	-1%	0%	7%	61%	0%	0%	9%	9%	6%	0%	2%	**85%**
Global warming (biogenic) (kg CO2 eq.)	0%	144%	**0%**	13%	-4%	12%	-10%	0%	0%	0%	1%	-55%	0%	0%	**97%**
Ozone Depletion (kg CFC-11 eq.)	3%	5%	5%	0%	0%	20%	32%	0%	0%	10%	21%	1%	0%	4%	**83%**
Human toxicity (cancer) (CTUh)	2%	6%	3%	0%	0%	18%	5%	0%	0%	31%	16%	2%	0%	18%	**83%**
Human toxicity (non-cancer) (CTUh)	7%	3%	2%	-1%	0%	15%	19%	0%	0%	17%	18%	6%	0%	13%	**82%**
Acidification (Mole of H+ eq.)	5%	2%	1%	-1%	0%	7%	46%	0%	0%	7%	11%	20%	0%	2%	**84%**
Particulate matter/ Resp. Inorganics (kg PM2.5-eq.)	2%	3%	1%	-3%	0%	9%	50%	0%	0%	6%	8%	18%	0%	5%	**85%**
Ecotoxicity (aquatic freshwater) (CTUe)	1%	2%	2%	0%	0%	17%	6%	0%	0%	11%	19%	28%	0%	13%	**88%**
Ionising radiation (kg U235 eq.)	0%	2%	1%	0%	0%	55%	24%	0%	0%	8%	8%	0%	0%	2%	**95%**
Photochemical ozone formation (kg NMVOC eq.)	10%	7%	3%	-2%	0%	5%	35%	0%	0%	5%	10%	25%	0%	2%	**80%**
Eutrophication (terrestrial) (Mole of N eq.)	11%	3%	3%	-2%	0%	5%	33%	0%	0%	5%	10%	28%	0%	2%	**82%**
Eutrophication (freshwater) (kg P eq.)	1%	1%	1%	-4%	2%	19%	4%	0%	0%	8%	9%	31%	18%	11%	**88%**
Eutrophication (marine) (kg N eq.)	4%	4%	0%	-4%	1%	11%	10%	0%	0%	12%	50%	9%	0%	2%	**83%**
Land use (kg C deficit eq.)	1%	76%	1%	0%	0%	3%	7%	0%	0%	1%	5%	1%	0%	5%	**83%**
Resource depletion (water) (m3 eq.)	0%	0%	0%	0%	0%	2%	11%	51%	29%	4%	2%	0%	0%	0%	**80%**
Resource depletion (fossil / mineral) (kg Sb eq.)	2%	8%	3%	0%	0%	3%	5%	0%	0%	19%	25%	3%	0%	33%	**85%**

Overall, the PEF screening study clearly demonstrates the importance of energy requirements and of chemicals and additives used on a series of different environmental impact categories. Consequently, EU Ecolabel criteria should continue to focus on these areas.

Other areas of importance that were flagged up are the sourcing of wood (impacts on climate change and land use) and water resource depletion (for the pulping and papermaking processes). This would justify the continued use of EU Ecolabel criteria relating to sustainable fibre sourcing and the investigation of potential criteria relating to water efficiency.

Perhaps surprisingly, the beneficial impact of using recycled fibres was not significant in any of the impact categories evaluated when the recycled content was around 25%.

4.3 Review of information in EPDs

This section is split into an analysis of the EPD information available via the International EPD system and the Paper profile initiative. While the aim is to carry out this analysis in the context of LCA-based considerations, it is acknowledged that this is not possible with the Paper Profile data due to the lack of guiding PCRs which link directly to well-established LCA standards. Nonetheless, a concise summary of the information is considered useful and may help understand issues related to data reporting that are also relevant to EU Ecolabel criteria verification.

4.3.1 International EPD system EPDs

The International EPD system follows the United Nations Central Product Classifications (UN CPCs). Each EPD must state which CPC code the product falls under. The three most relevant codes and hierarchy for tissue paper, newsprint paper and copying and graphic paper are illustrated below.

Section 3: Other transportable goods, except metal products, machinery and equipment

- **Division 32:** Pulp, paper and paper products; printed matter and related articles
  - **Group 321:** Pulp, paper and paperboard
    - **Class 3212:** Newsprint, handmade paper and other uncoated paper……
      - **Sub-class 32121: Newsprint**
    - **Class 3213:** Toilet tissue stock, uncoated kraftliner and other uncoated paper and paperboard….
      - **Sub-class 32131: Toilet or facial tissue stock, towel or napkin stock and similar paper**
    - **Class 3214: Paper and paperboard**

Of the 49 EPDs listed on the Environdec website to date (Nov. 2015), 32 fell under "Absorbent Hygiene Products (CPC 32193)", 12 under "Processed paper and paperboard (CPC 3214)" and 5 under "Beverage cartons (CPC 32153)". No EPDs have yet been published for "Tissue products".

Although the EPDs published under the "Processed Paper and Paperboard" were found to be mainly for cartonboard for packaging applications, a brief summary of reported data reveals how the 4 impact categories listed in the PCRs (climate change, acidification, ozone creation potential and eutrophication) (plus an extra impact category: photochemical oxidant formation) are split between upstream, core and downstream processes previously defined in Figure 15. While this is not directly relevant to the three Paper Product Groups being revised, the raw materials, pulping and papermaking processes have much in common between different paper products.

EPDs have been selected to highlight the influence of the following variables on the environmental impacts of paper products:

- Paper grammage and
- Recycled fibre content (0% or 95-100%)

A comparison is made of 13 papers in total. The first 10 are composed of 5 papers (each with 2 grammages and from the same manufacturer) made from 100% virgin fibres and the remaining 3 papers contain at least 95% recovered fibres. The 5 impact categories are analysed separately in the graphs below.

4.3.1.1 Global warming potential

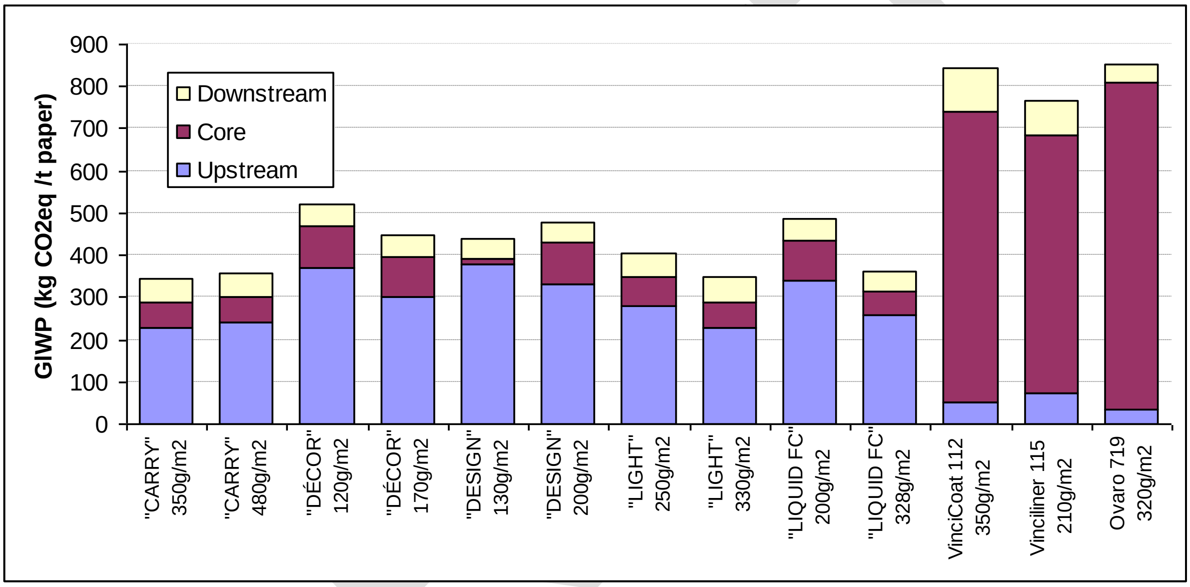

Figure 17. Split of GWP impacts across different life cycle stages for 13 different papers.

For the first 10 columns in Figure 17, it is clear that GWP is most significant in the upstream processes for paper made from virgin fibre. Closer inspection of the EPDs revealed that most upstream GWP was related to chemicals used and to a lesser extent, energy wares. No significant trend in GWP was noted when comparing the same paper products of different grammage except that upstream GWP seems to decrease slightly for the higher grammage paper.

With papers made from recovered fibre, the upstream impacts are greatly reduced but the impacts during core processes are greatly increased to such an extent that the total GWP approximately doubles when compared to virgin fibre based papers. This is in contrast to results from LCA studies reported in the literature. It may be due to the fact that the PCRs for Paper Profile focus on purchased electricity although inputs from energy wares are also included in the upstream subsystem of the boundary. Another possible reason could be that the assumed energy mix is highly emitting because DIP or TMP would use lots of high emission grid electricity whereas chemical pulp based on virgin fibres would produce excess electricity which could be claimed in an integrated mill set-up.

4.3.1.2 Acidification potential

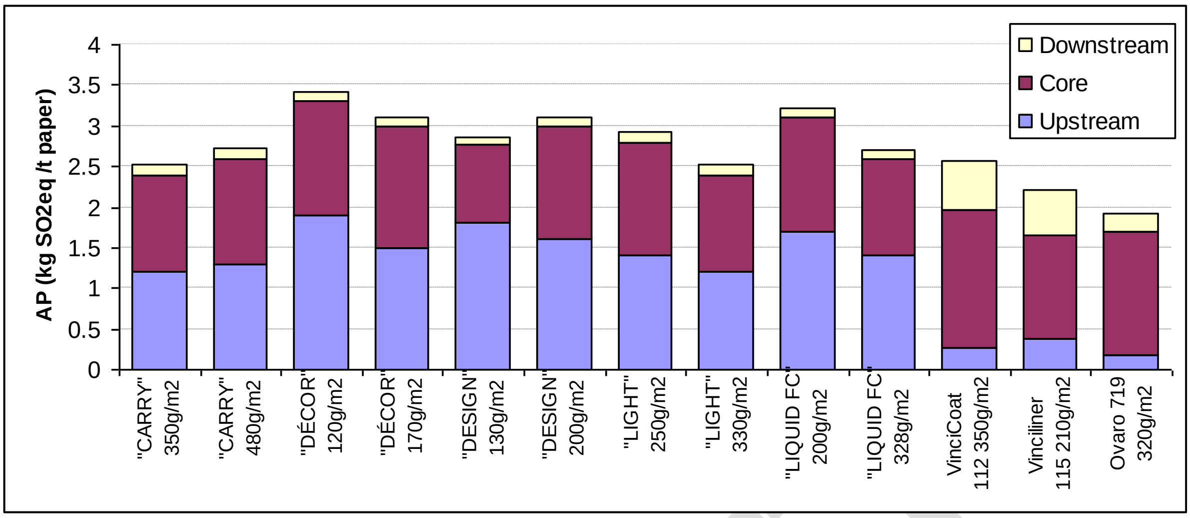

Figure 18 . Split of Acidification Potential (AP) impacts across different life cycle stages for 13 different papers.

Similar trends are noted with AP in Figure 18 as for GWP in Figure 17. No consistent trend is noted in equivalent virgin-fibre based papers of different grammage except that AP in upstream processes is generally lower. Upstream impacts relating to AP are much more significant for virgin-fibre based papers than recovered-fibre based papers. As stand-alone values, the impacts for AP are slightly higher in core processes for recovered-fibre based papers but are much more significant when considered as a % of total AP for each individual paper product. Downstream impacts were larger for papers containing recovered fibres.

4.3.1.3 Eutrophication potential

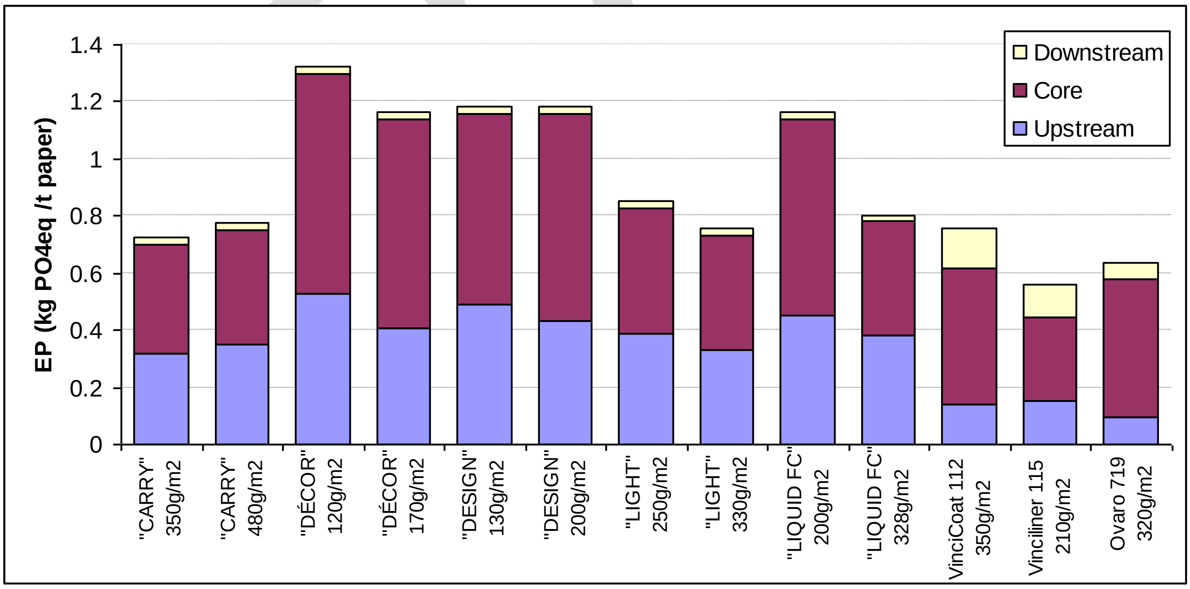

Figure 19. Split of Eutrophication Potential (EP) impacts across different life cycle stages for 13 different papers.

With regards to EP, Figure 19 shows that upstream impacts are much lower in papers made from recovered fibres and that total impacts were similar to or significantly lower than those for papers made from virgin fibres. There was significant variation between different virgin-fibre based papers but only one case of a clear difference in impacts being associated with a change in grammage.

4.3.1.4 Ozone Depletion Potential

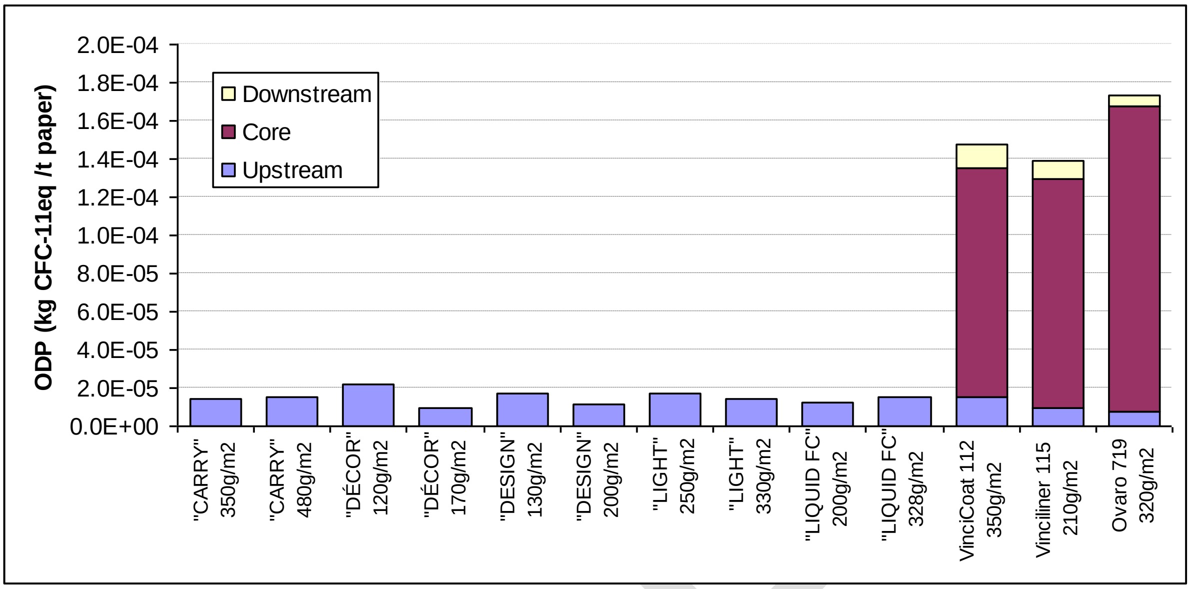

Figure 20. Split of Ozone Depletion Potential (ODP) impacts across different life cycle stages for 13 different papers.

A very clear distinction is noted between virgin-fibre and recovered-fibre based papers for ODP impacts, with much higher impacts (approximately x8) being associated with the latter. Impacts due to upstream processes are quite similar for all papers in the graph. However, the big difference is in impacts related to core processes, which are so small with virgin-fibre based papers as to be negligible but so significant with recycled-fibre based papers as to account for around 80-90% of total impact.

4.3.1.5 Photochemical Oxidant Formation

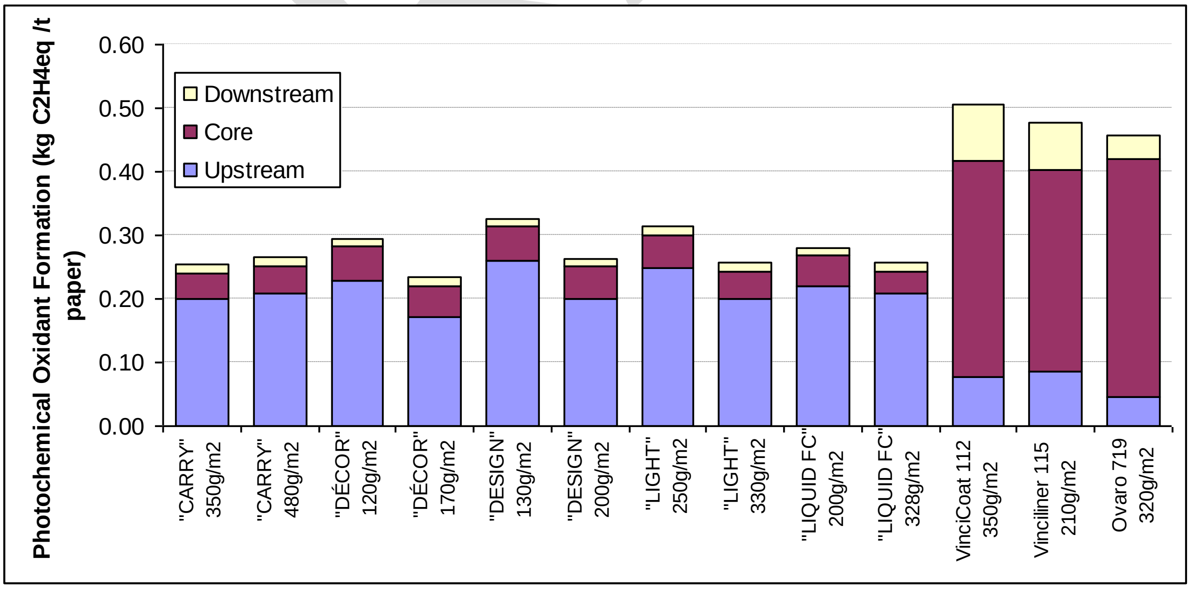

Figure 21. Split of Photochemical Oxidant Formation impacts across different life cycle stages for 13 different papers.

The trends for photochemical oxidant formation represent a combination of some of the trends observed for other impact categories. As for GWP, EP and AP, the upstream impacts are much higher for virgin-fibre based paper than recovered-fibre based paper.

As with GWP, upstream processes are the dominant source of impact for virgin-fibre based papers but core processes are the dominant source of impact for recovered-fibre based papers. As with ODP, total impacts are significantly higher for recovered-fibre based paper than virgin-fibre based paper.

4.3.2 Paper Profile EPD summaries

Paper Profile is a voluntary industry initiative that aims to enable paper buyers to make well informed product choices based on the certain environmental parameters of paper products. Rules are set to allow data to be collected, processed and presented in a uniform manner, resulting in a simple, reader-friendly 1 page EPD. A summary of the main PCRs is given below.

Table 15. A summary of the main points for Paper Profile PCRs.

Area	Rules
General requirements	Declaring organisation must be a member of Paper Profile. Declaration must be audited on an annual basis.
Scope	Applies to all paper products. Includes emissions from both pulp and paper production. Water consumption, wastewater treatment and waste discharge included. Packaging is excluded. Allocation only allowed if it is production line specific, linked by clear cause-effect relationships and that all lines add up to 100% of consumed resources/emissions.
Specification of company/product	**Mandatory:** Brand or product name, grammage (if relevant), production mill (and production line, if relevant), period during which data was gathered, date of issue of EPD, logo of verifying company (if relevant) and logo of the producer. **Voluntary:** Owner of brand name (if different to producer).
Functional unit:	1 tonne of final product
Wood / fibre sourcing	State the certified environmental management system in place for producer. State the management system used by producer to ensure traceability of wood (tracing at least to the country of origin and also for wood used in supplied pulp). State if only recovered paper is used. State if a certified Chain of Custody (CoC) system is in place. If so, then state the % which is CoC certified.
Data quality	Annual mean values based on one year should be used. Data for new or improved processes must be determined during at least 3 months. Emission data from external suppliers must be accompanied by a formal written statement signed by the supplier. However, if the supplier is ISO 14001 or EMAS certified, a formal statement shall not be necessary.
Emissions to water and air	**Water:** COD (ISO 6060 or eqvlt.), AOX (ISO 9592 or eqvlt.), N_{tot} (ISO 11905 or eqvlt) and P_{tot} (EN 1189 or eqvlt). **Air:** SO_2 (NS 4859 or eqvlt), NO_x (ISO-CD 10849 or eqvlt), CO_2 (fossil – based on emission factors).
Solid waste landfilled	Applies to solid waste (excluding fluids) landfilled onsite or in external sites. Includes both organic and inorganic material. Expressed as bone dry solids (BD) in kg / tonne paper product.
Purchased electricity	Includes electricity used in both pulp and paper sites. Expressed as kWh / tonne paper product. Surplus electricity from a non-integrated mill will **not** be discounted.
Pulp supplier data requirements	Data for at least 75 % of all pulp used during the reporting period is required. In cases where environmental data is missing for 5-25 % of pulp supplied, the calculation must be adjusted and normalised.
Product composition	The composition of the finished product shall be expressed as relative shares (wt. %, to nearest integer) of the following components • Chemical pulp. • Mechanical pulp. • Pulp from recovered fibre. • Other pulp (specify which). • Pigments and fillers. • Binders (e.g. starch, latex). • Moisture.

Although links to EPDs are not directly available on the Paper Profile website, a search of the main member company websites found 90 different EPDs for various paper products and 4 for pulp.

The Paper Profile system does not use any CPC or NACE coding system to group products, although a basic description of the paper type is provided on certificates which may indicate the product type (i.e. newsprint, uncoated mechanical etc. or proprietary names) and the paper machine used (i.e. PM2, PM8 etc.) in a given site.

A summary of 73 different certificates from 6 different companies (Heinzel Group, Holmen Paper, International Paper, Norske Skog Skogn, Papierfabrik Scheufelen and UPM) revealed the following results for ranges of paper composition (Table _) and for associated environmental parameters (Table 16).

Table 16. % compositions of 73 paper products listed under the Paper Profile initiative

	Mechanical pulp	Chemical pulp	Recycled fibres	Pigments and fillers	Binder	Moisture
Avg.	29.9	19.9	23.2	20.6	2.9	6.2
St. Dev.	28.5	26.1	32.7	14.8	2.0	1.7
Range	0 - 91	0 - 77.6	0 - 92	1 - 52	0 - 7	3.9 – 9.0

From Table 17, it is clear that the four most important components of the selected paper products are: mechanical pulp, chemical pulp, recovered fibres and pigments + fillers. On average, these components are of a similar degree of importance, but this masks the huge variation that exists between individual paper products where each of these components can drop to 0-1% or reach as high as 52-92%.

Table 17. Ranges of associated emissions to air and water and purchased electricity for 73 paper products listed under the Paper Profile initiative.

	Water emissions (kg/t paper)				Air emissions (kg/t paper)			kWh/t
	COD	AOX	N	P	SO_2	NOx	CO_2	Elec.*
Avg.	5.4	0.020	0.084	0.014	0.184	0.789	288.9	1194
St. Dev.	4.2	0.034	0.089	0.018	0.420	0.789	267.5	978
Range	0-21	0–0.140	0-0.450	0–0.115	0–1.900	0-2.740	1.9-914	60-3247

*purchased electricity

The Paper Profile emissions data is of particular interest because it is related to requirements set out in current EU Ecolabel criteria and should also be considered in light of the recently updated BREF document for the production of pulp, paper and board published in 2015.

The EU Ecolabel criteria for Newsprint Paper and for Copying & Graphic Paper set out criteria that no pulp bleached with chlorine compounds shall be used that was produced with AOX emissions exceeding **0.17 kg/ADT** (air-dried tonne) of pulp. It is clear that even the upper limit of Paper Profile products (**0.14 kg/ADT**) is well within this limit. However, a direct comparison cannot be made since the EU Ecolabel requirements refers to limits for each type of pulp used in a paper product whereas the Paper Profile calculation uses a weighted average of all pulps used in the paper. A truer comparison with the Paper Profile results can be made with the existing EU Ecolabel criteria for Tissue Paper, where the weighted average of AOX emissions was set at **0.12 kg/ADT** paper. Only 3 of the 73 Paper Profile products exceeded the 0.12 kg/ADT limit and only then by a small amount (i.e. two reported 0.13kg/ADT and one reported 0.14kg/ADT).

One common point to note is the wide variability in emissions for different Paper Profile products, for every parameter, the standard deviation in data is almost equal to or often greater than the average values. This reflects the great number of different paper product compositions and associated pulping processes and clearly makes a case for the need to relate any EU Ecolabel emissions criteria directly to BREF values at the level of individual pulps used rather than a single universal value for the pulp blend used.

4.4 Screening, scoring and summarising of LCA studies

A total of 61 LCA studies have initially been identified in the literature as being of potential relevance to the Copying and Graphic Paper, Newsprint Paper and Tissue Paper product groups. As part of the established JRC process for considering LCA based evidence as possible supporting rationale for existing or proposed EU Ecolabel criteria, these LCA studies have been screened according to certain minimum cut-off requirements. Studies meeting the minimum requirements are then scored according to a method which takes into account ILCD and PEF recommendations. Although all screened LCA studies may contribute certain useful information, greater emphasis will be given to the findings of those studies which score highest when considered LCA evidence in the context of rationale for existing or proposed EU Ecolabel criteria.

A full list of the identified LCA studies, describes the screening and scoring assessment rules that have been applied to them as well as the results and general findings that can be taken from this exercise.

Due to the long and repetitive nature of the text in this document, it was felt that it would be most appropriate to publish the LCA screening and scoring exercise as a separate supplementary document and not directly in the Preliminary Report itself.

The main findings of these studies, particularly the highest scoring ones, are also presented in a summarised format in the Preliminary Report.

The LCA studies have been broadly split into parts that cover different stages of the life cycle of paper products, namely: Forestry; Pulp & Paper Production and End of Life (EoL). The general findings of the studies summarised in this report are summarised below.

4.4.1. Forestry operations

Only one of the screened LCA studies was specific to the production of pulp wood although the general principles of environmentally responsible forestry operations can apply equally whether the wood is used for bioethanol production, for solid fuels or for pulp production.

The comprehensive review by Klein reveals some interesting trends in the LCA literature, specifically regarding the coverage of different impact categories and different stages in the wood production process, which are reproduced below:

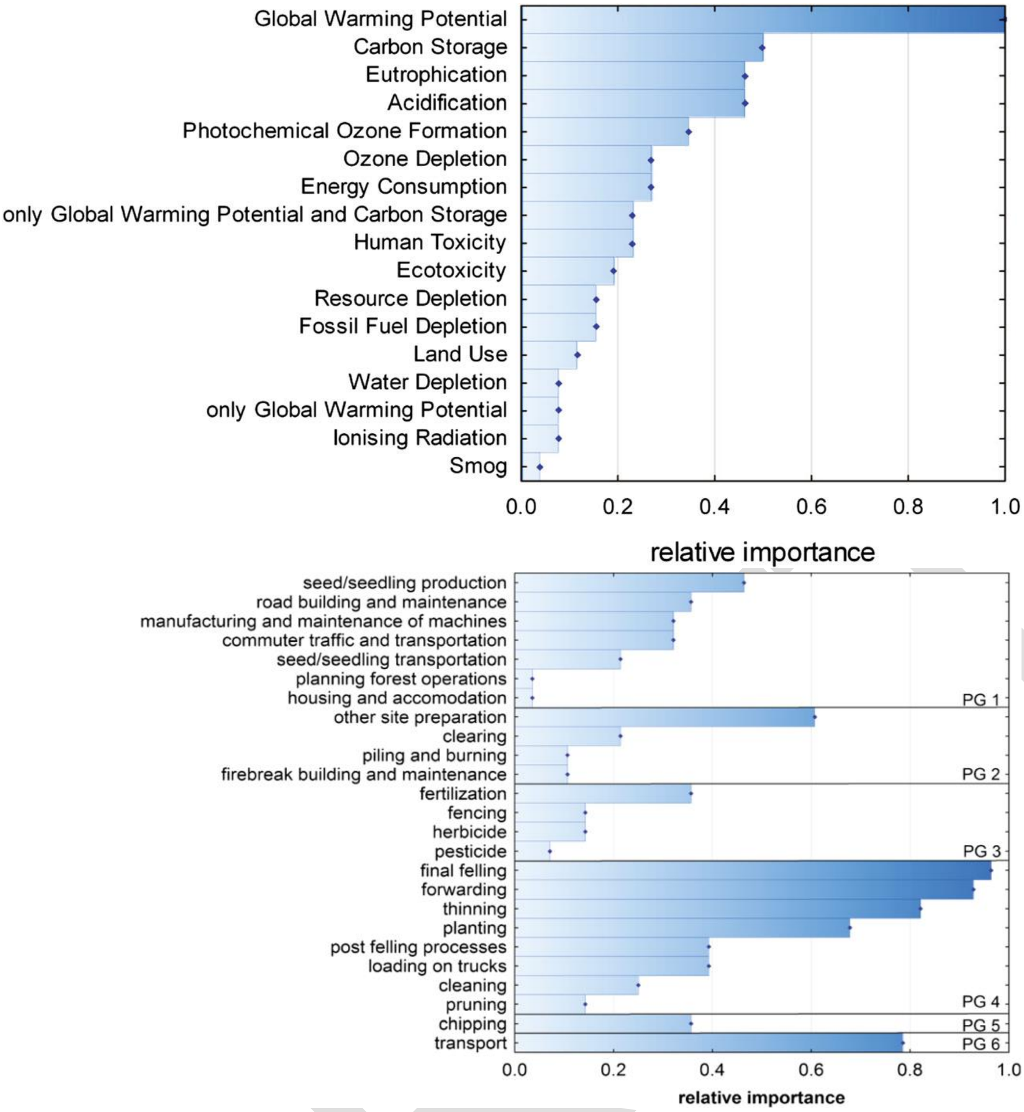

Figure 22. Illustration of (top) the most common impact categories and (bottom) most common production stages analysed in LCA assessment literature.

By far the most heavily studied impact category is GWP. A significant variation (by factors of 10-20) in GWP was found relating to forestry operations in different studies. However, putting this in some context, for every 1000kg of Carbon stored in wood products, Carbon emissions from forestry operations tended to range from 6 to 90kg. While studies for wood sourcing and for fibre sourcing from hemp and flax were included, the differences in functional units and the use of allocations for by-products from the hemp and flax processes make a direct comparison with wood impossible.

For the GWP impact category to be correctly understood, there is a need to better capture the effects of carbon stocks in forest soils and how different intensities of harvesting can affect the soil carbon stock over longer terms. There is a need for general guidance is needed for the LCA community. Only 3 of the 28 studies identified by Klein et al., (2015) made any attempt to investigate land use change. Carbon stocks are one of the key factors associated with Sustainable Forest Management (SFM) principles and could be used as a way to encourage more responsible harvesting techniques.

The PEF PCRs for intermediate paper products do recommend the use of Land Use as an impact category (using the Soil Organic Matter model based on Mila and Canals et al., 2007) and so more data on this would be of great value from LCA studies. One problem is the time required to accurately quantify land characteristics, which have to at least cover more than one rotation period (minimum 4 years) and ideally be longer. Lopes Silva et al., (2015) did attempt to quantify the impacts of forestry operations by the use of land characterisation factors.

Another major limitation of LCA evidence in relation to sourcing of pulp wood and or fibres was the lack any way to capture the impacts of forestry operations on biodiversity. This is a major issue when considering illegal logging and the conversion of primary forests to plantations. Independent and third party verified SFM schemes have become the main mechanism to ensure a minimum protection and preservation of biodiversity in forests and plantations.

The overall conclusions were quite consistent between studies and as follows:

- When included in the system boundary, secondary haulage was generally the most significant sources of environmental impacts.
- Logging was the next most significant stage and options for improvements are related to the use of hybrid forwarders, of more adequately sized engines and less intensive operations.
- Outcomes were sensitive to the fertiliser requirements. The growth of more robust species with lower nutrient requirements like Eucalyptus can offer advantages but the nutrient value of the existing soil is also an important factor for phosphorus and potassium fertiliser requirements.

These impacts were well correlated with the energy use requirements and fossil fuel combustion.

4.4.2 Pulp and papermaking

All studies that compared wood sourcing and forestry operations within a larger system boundary extending to pulp and/or paper mills found that overall *environmental impacts were much larger during the pulping and papermaking stage than forestry operations*. A typical example is reproduced in the Figure below.

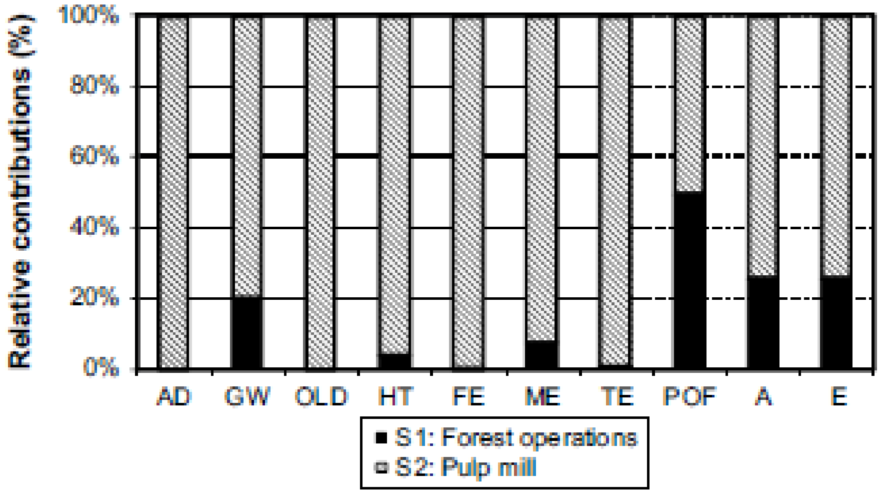

Figure 23. Relative significance of forestry operations and TCF pulp mill operations on different midpoint impact categories (Source: Gonzalez-Garcia et al., 2009)

However, in some certain cases forestry operations did show highly significant contributions to certain impacts (i.e. up to 50%) i.e.

- Photochemical oxidant formation / photochemical smog. Mainly due to unburned hydrocarbons emitted from inefficient 2-stroke chainsaws and incomplete combustion in other machinery used in harvesting operations.

- Eutrophication. Highly dependent on the fertiliser application rates, which in turn depend very much on soil nutrient status, the tree species planted and the harvesting intensity.

4.4.3 Influence of transport

When considered within the system boundary, *transport* was found to be a key source of impacts. Although most research looking at transport concentrated on GHG emissions, it is highly likely that other impact categories such as acidification (AP) would follow the same trends due to the reliance of most transport modes on fossil fuels. Two examples of the effect of different transport scenarios on different impacts are shown in Figure 24 below.

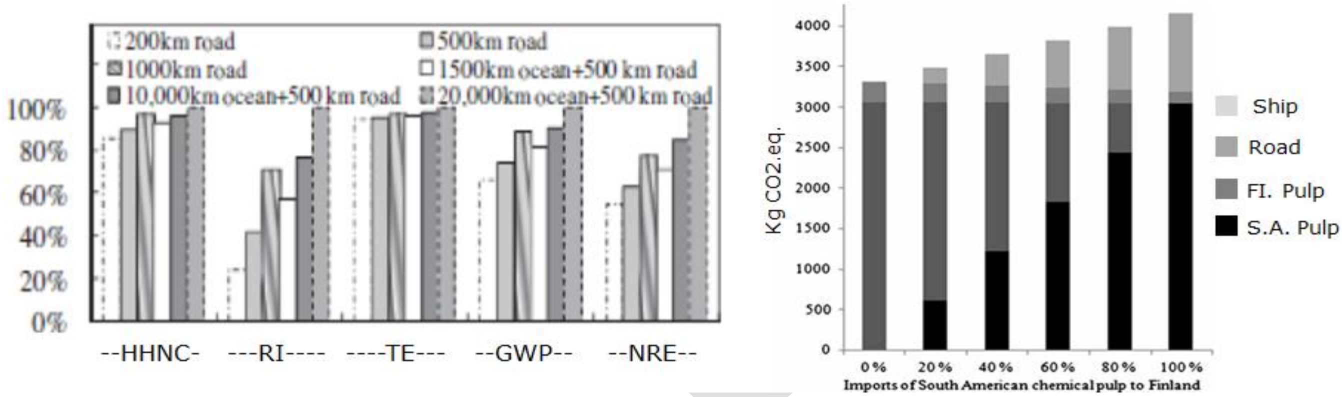

Figure 24. (Left) Effect of increased transport for recovered paper on 5 impact categories at a Chinese paper mill (from Hong and Li, 2012) and (right) the effect on GHG emissions by replacing different levels of Finnish pulp with imported South American pulp (from Judl et al., 2011).

Although the environmental impacts of recycled fibres are generally considered to be lower than those of virgin fibres, the transportation of recovered paper needs to be minimised to around the same level of that of virgin wood in order for this conclusion to be maintained (Hong and Li, 2012).

The import of cheaper virgin pulp produced in climate conditions in South America that are favourable for rapid growth may have slightly lower GHG emissions (i.e. 5%) than some European pulps although trans-oceanic transport impacts were too large (i.e. +27%) to be compensated for.

4.4.3. Hot spots in pulping and paper making processes

Most studies focused on chemical pulp (kraft) due to the existence of well-established inventory data for this process and the widespread use of the technique. Modern kraft plants will already have chemical recovery units, generate CHP from biomass waste (e.g. debarking and black liquor) and may have water recovery units too.

In general, the main hot-spots were:

- Chemical production for chemicals used during the digestion and bleaching stage (e.g. ClO2, H2O2, NaOH, O3, O2, DTPA etc.) → multiple impact categories.
- Air emissions from the recovery boiler or chemical recovery unit of the pulp mill → GWP and AP.
- Energy production for pulp mill and electricity production for the paper making stage → GWP, AP and partly EP.
- Wastewater effluent from the site WWTP (mainly COD, N and P) → EP.

If biodegradable wastes are sent to landfill, then CH4 emissions can be highly significant for GWP and POF (Lopes, 2003).

Despite much debate, there has been very little direct comparison from an LCA perspective of the two main bleaching processes for chemical pulp, namely TCF and ECF. Some trade-offs between the two processes that can be considered are:

- Brighter and stronger pulp typically produced by ECF.
- Higher AOX emissions and potential for dioxin formation with ECF (essentially zero for TCF).
- Different potentials for problematic pitch formation from TCF and ECF (Gutierrez et al., 2001).
- The need for EDTA / DTPA chelants in TCF, which are not readily biodegradable and can pass through activated sludge treatment and into WWTP effluents in significant quantities. Once in the aquatic environment, these chelants could potentially mobilise heavy metals from sediments.

Many of the trade-offs listed above are not well captured by LCA midpoint or endpoint indicators or impact categories and models relating to ecotoxicity and human toxicity are not yet widely used or recommended. Even still, LCA should still be capable of capturing the impacts of the different chemical requirements and energy for processing and consider emissions of AOX and EDTA in effluents. In the absence of clear and unequivocal LCA evidence from several studies claiming one technology to be superior to another, it is proposed not make any specific restriction on ECF bleaching except through the existing AOX emission criterion.

4.4.4. Improvement potential

Improvements in the actual production of chemicals are outside of the control of the paper industry and improvements here can only be made by improving process control to optimise chemical usage and recovery within the process.

While a shift from a wood species that has a lower lignin content and/or is easier to delignify, thus requiring less bleaching chemicals, may seem like an obvious improvement, this was not so clear from an LCA perspective due to the fact that this also reduced waste wood and black liquor and consequently the potential to generate biomass-based CHP and reduce reliance on grid electricity or, as is this case in most modern plants, produce surplus electricity and claim benefits caused by avoided production of grid electricity elsewhere (if focussing on pulp mill alone) or reduce electricity requirements altogether (if in an integrated mill situation).

Several authors have demonstrated that the scale of improvement possible is *very sensitive to the choice of energy mix for grid electricity* (Ghose and Chinga-Carrasco, 2013; Leon et al., 2015).

The main large scale improvement options for pulping and papermaking stages are as follows:

- Shift from fuel oil or coal to natural gas in pulp mill CHP units (lower CO2, SO2 and NOx emissions plus lower transport requirements to get fuel onsite).
- Shift from black-liquor / bark combustion-based recovery boilers to gasification to produce additional electricity via combined cycle turbines (with possibility to reduce NOx emissions, convert H2S gas to S solid).
- Substitution of fossil fuels (coal, oil or gas) for biomass in secondary boilers.
- Displacing fibres in paper with mineral fillers such as kaolin (particularly useful for reducing drying energy in the paper making stage).
- Reducing paper grammage by optimising the quantity of coating chemicals used.

4.4.5 Concluding remarks about LCA study

From the 63 papers reviewed, it became clear that the environmental impacts of the pulp and paper industry have been well studied. Considering the references contained within the reviewed papers, there are hundreds of LCA-related publications that investigate impacts from one angle or another.

To avoid excessive workload for relatively little return, no further detailed reviews of LCA studies are proposed unless specific publications that would have a clear relation to potential EU Ecolabel criteria are flagged p by stakeholders – who are indeed encouraged to bring to our attention any such studies, especially for Tissue Paper production.

From the studies reviewed so far:

- No clear and unequivocal evidence was found to support one bleaching technology over another (i.e. ECF, ECF-light or TCF).
- While there are clear environmental benefits associated with recovered paper, these must be considered in the context of transport scenarios on a case by case basis.
- With forestry, the continued uncertainty over how to deal with biogenic carbon, land use, land use change and biodiversity needs to be clarified although hnow PCRs are in place to deal with biogenic carbon at least.
- The fuel source used onsite for pulp mills and the energy sources used to generate on-site or purchased electricity dominate the impacts of pulp and paper production.
- Grid electricity has a ubiquitous influence on both site emissions, especially for mechanical pulp and paper making stages but also on the impacts associated with chemical production.

5. Technical analysis

This Chapter provides general information on the pulp and paper production techniques. The technological differences between product groups are also addressed.

It also addresses key pulp and paper industry best practices compiled from literature reviews and stakeholders communication. They are also coupled by the information contained in Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board.

5.1 Pulp and papermaking

Pulp for papermaking may originate from virgin wood and non-wood pulp by chemical, semi-chemical or mechanical means, or may originate from secondary material (re-pulping). Paper is produced by conversion (pulping) of cellulose raw material into paper sheets or boards. Thus the main objective of pulping process is the physical or chemical fibre liberation and its subsequent dispersion in water to form paper sheet of desired properties. During pulping process, bonding within the raw material structure are systematically ruptured by physical or chemical means. The production process relies on three main steps: pulping, bleaching, and paper making (see Table 18).

Table 18. Main steps involved in the manufacturing of pulp and paper (the list is only used as a sample having in mind that a complete set of operations that take place during pulp and paper manufacturing may vary)

Operation	Processes
Raw material preparation	Debarking
	Chipping and conveying
Pulping	Mechanical
	Semi-chemical
	Chemical
Chemicals recovery	Evaporation
	Recovery Boiler
	Recausticizing
	Calcining
Bleaching	With or without removal of lignin
Stock preparation and papermaking	Preparation of stock
	Dewatering
	Pressing and drying
	Finishing

The overall papermaking process starts with raw material preparation so that it meets the mill's feed specifications for species, cleanliness and dimensions. Wood is converted into chips or logs suitable for pulping in a series of steps which may include debarking, sawing, chipping and screening (Figure 25). Each of these operations is highly complex and integrates different processes.

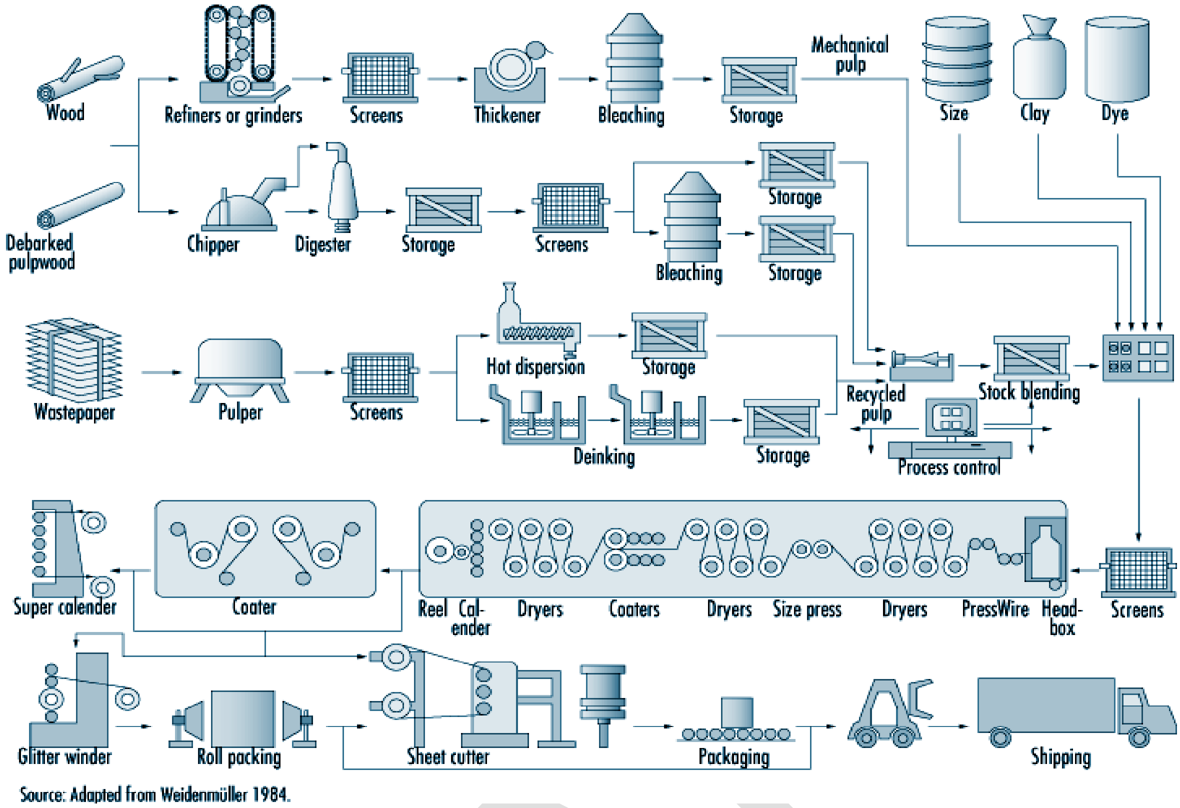

Figure 25. Schematic illustration of process flow in pulp and paper manufacturing operations[69]

A paper and paperboard mill may purchase pulp or manufacture its own pulp in house; in the latter case, such mills are referred to as integrated mills. Market pulp is sold as intermediate raw material and then used as input, together with other raw materials and additives, in paper mills, which produce paper for final use.

To a certain extent, the type of wood used for pulping bleaching may influence the yield, the applied processes and techniques, the process efficiency and the emission levels. Eucalyptus wood due its specific chemistry might generate higher phosphorous emission, or ECF hardwood pulp bleaching requires fewer chemicals than softwood, which usually means that the number of bleaching stages can be shorter.

5.1.1 Pulping

Fibre separation can be accomplished mechanically, thermally, chemically or by combination of these treatments. The main challenge related to pulp from recovered paper is de-inking and the removal of contaminants. The choice of method will influence the options for intended use and quality of the final product. Table 19 presents a summary of the pulp and resulting paper characteristics according to the pulping method applied.

[69] http://www.ilocis.org/documents/chpt72e.htm

Table 19. Summary of different pulping processes together with a typical final product destination

Pulping process	Fibre separation mechanism	Yield	Pulp properties	Typical products
Mechanical	Mechanical energy	High (85-95%) lignin preserved	Short, weak, unstable, high opacity fibres, good print quality	Newsprint, writing paper, magazines, books, container board
Chemical	Chemicals and heat	Lower (45-50% for bleachable/bleached pulp. 70% for brown paper)	Long, strong, stable fibres	Kraft: bags, wrapping, linerboard, newsprint, graphic, writing paper, Sulfite: fine paper, tissue, glassing, newsprint
Semi chemical	Combination of chemical and mechanical treatments	Intermediate (55-85%)	"Intermediate" pulp properties	Corrugated board, food packaging, newsprints, magazines
Recycled	Mechanical energy with some heat and chemicals	Depends on waste paper source. Up to 95% for waste packaging, and 60% for waste hygienic products	Mixture of fibre grades, properties depend on waste paper source	Newsprint, writing paper, tissue, packaging

Mechanical methods use physical action for fibre separation retaining lignin in the pulp, whereas chemical pulping is based on the dissolution of lignin (delignification) that interferes with hydrogen bonding of fibres.

Mechanical pulps are characterized by high yield, high bulk, high stiffness, and lower overall cost. This method is characterised higher energy requirement mainly for refining. Paper made of mechanical pulp has, in general, low strength since the lignin interferes with hydrogen bonding between fibres in the paper sheet. The lignin also causes the pulp to turn yellow with exposure to air and light (so called yellowing process). The fibre lengths is rather short thus producing paper of lower capacity of inter-fibre bonding (paper of lower mechanical properties). The use of this type of pulps is confined mainly to non-permanent papers like newsprint and catalogue paper.[70] There two principal mechanical pulps on the market: thermo-mechanical pulp (TMP) and groundwood pulp (GW).

There are several semi-chemical (or chemi-mechanical) processes available that employ various reagents: starting with the oldest called "cold soda," followed by acid sulphite, bisulphite, alkaline sulphite, sulphate, sulphur processes and finally the neutral sulphite semi-chemical (NSSC). The hybrid methods are generally conducted in two stages: a mild chemical treatment is followed by an intensive mechanical action to produce chemi-thermo-mechanical pulp (CTMP). The lignin structure and content is preserved, but extractives and small amounts of hemicellulose are lost. This is why the yield of the method is lower than mechanical treatment. The conventional thermos-mechanical pulp is treated with chemicals prior to refining and heating, to produce chemi-thermo-mechanical pulp (CTMP).

[70] Biermann, J.K. 1996. Pulping Fundamentals Handbook of Pulping and Papermaking (Second Edition), pp. 55-100

The overall objective of chemical pulping is to degrade and dissolve lignin while preserving carbohydrates. In practice, the methods for obtaining chemical pulp are able to remove much of the lignin, but also degrade a certain amount of hemicellulose and cellulose, so that the pulp yield is low when contrasting to mechanical process. The fibres obtained are more prone to bleaching process, being more resistance and of better quality, thus the process yield cellulose pulp of high quality. Chemical pulps are manufactured by cooking known as digesting. The raw materials are digested using the kraft (sulfate) and sulphite processes. Kraft processes produce a variety of pulps used mainly for packaging and high-strength papers and board. In this method, wood chips are cooked with caustic soda to produce brownstock, which is then washed with water to remove the cooking liquor for the recovery of chemicals and energy. This recovered cooking liquor is referred to as "black liquor"[71]. The Kraft process is the dominant production method of chemical pulping and accounted for approximately 75% of the global pulp production in 2012. Sweden is the largest producer of chemical wood pulp in Europe with a total of 8.1 million tonnes in 2012[72]. In the pulp and paper sector, the importance of black liquor gasification (BLG) to be burned in a combined cycle is assumed as a way to recovering process chemicals with an improvement in the energy production of the plant[73]. The recovery system can be applied both the sulphate and sulphite pulping process.

The white liquor used in the Kraft process is an aqueous solution mostly composed of sodium hydroxide (NaOH) and sodium sulphide (Na_2S). The liquid obtained after the pulping operation is known as black liquor that contains two fractions: organic (mixture of lignin, hemicellulose and other dissolved material from wood) and inorganic (residual cooking chemicals). In order to make kraft pulping economically feasible, the cooking chemicals are recovered through the chemical recovery process[74], that involves the concentration and combustion of the black liquor which removes the organic portion of the liquor, followed by recovery process by causticizing of the inorganic chemicals produced after the combustion of the liquor. The challenge of the chemical recovery process is to produce white liquor with proper concentrations of NaOH and Na_2S in order to produce cellulose pulp with desired characteristics. The concentration of the black liquor is typically done in a multiple effect evaporation system indicated as step 3 in Figure 26 to increase the dry solid (DS) concentration.[75] After conventional evaporation the typical DS content in the strong black liquor is about 65%. The DS content can be increased up to 80% by installing a superconcentrator[76]. The concentrators are steam heated evaporators designed to produce liquor suitable for firing without contact between the black liquor and the flue gas. Metso pioneered superconcentration and high dry solids firing in the mid-18s, reaching nowadays the concentration level of 80-85%.

The efficiency in converting the fuel value in kraft black liquor (13,000-15,000 kJ/kg) to steam is typically lower than fossil fuel combustion. The amount of steam produced is typically about 3,5 kg per kg of black liquor solids, but its exact quantity depends on the efficiency of recovery boiler. The high pressure stem is passed through a steam turbine

[71] Nicholas P Cheremisinoff, N.P. and Rosenfeld, P. Handbook of Pollution Prevention and Cleaner Production. Elsevier. 368 pp

[72] FAOSTAT: http://faostat.fao.org/

[73] De Freitas Ferreira, E.T. , Balestieri, A.P. 2015. Black liquor gasification combined cycle with CO2 capture Technical and economic analysis. Applied Thermal Engineering 75 , pp. 371-383

[74] Green, R.P., Hough, G., 1992. Chemical Recovery in the Alkaline Process, 3rd Edition, Tappi Press, Atlanta

[75] Moreira Saturnino, D. 2012. Modeling of Kraft Mill Chemical Balance. PhD. Graduate Department of Chemical Engineering and Applied Chemistry University of Toronto: https://tspace.library.utoronto.ca/bitstream/1807/32881/1/Saturnino_Daniel_M_201206_PhD_thesis.pdf

[76] Bajpai, P. 2015. Green Chemistry and Sustainability in Pulp and Paper Industry. Springer Internaitonal Publishing Ag Switzerland

to generate electricity. Depending on the quality of steam and the type of turbine kraft pulp mill can generate 25-35 MW of electricity by burning 1500t/day black liquor dry solids in the recovery boiler[77,78].

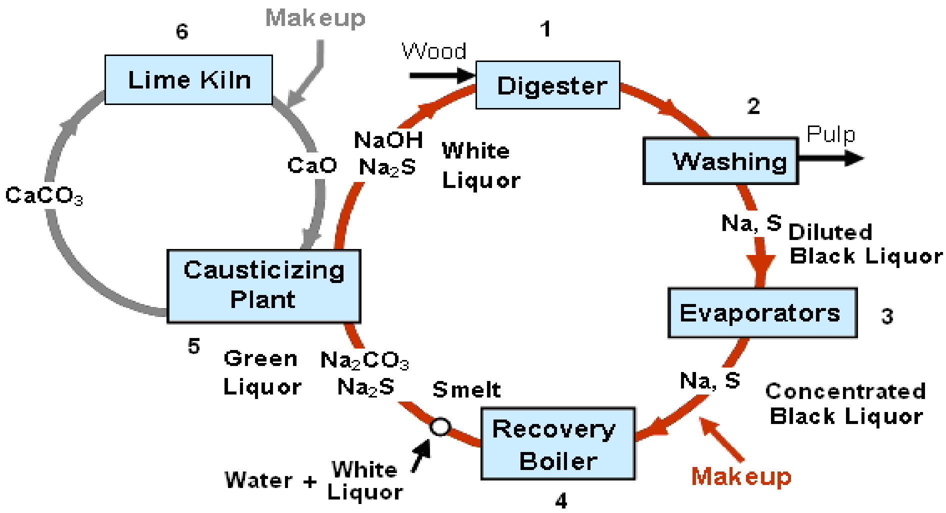

Figure 26. Schematic flow of the Kraft process and chemicals recovery[79]

Chemical recovery allows a mill to regenerate pulping chemicals at a rate of up to 98%[80], which significantly reduces the costs of purchased process chemicals. An added benefit is that chemical recovery allows a mill to generate a significant portion of its steam requirements by combusting the pulp residue contained in black liquor as part of the refining process. In chemical pulp mills black liquor is the main fuel, which is also regarded as biomass according to the EU ETS Directive[81]. Kraft pulp mills also use generated non-condensable gases as fuel[82].

Recycled paper processing is influenced by the nature of the final product, as follows:

- RCF for packaging paper and paperboards (Testliner and corrugated medium) – without deinking process
- RCF for newsprint and simple printing and writing papers
- RCF for higher grade graphic, printing and writing paper
- RCF for tissue and market deinked pulp (DIP).

The feedstock is put into a pulper together with hot water, white water or process water, and pulped with mechanical and hydraulic agitation resulting in their disintegration into fibres. For processes with deinking, such as newsprint, tissue, printing and copy paper,

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[77] Bajpai, P. 2011. Evironmentally Friendly Production of Pulp and Paper. John Wiley & Sons, 365 pp.

[78] Tran, H. 2007. Advances in kraft chemical recovery process. 3rd CEPI Internaitonal Colloqium on Eucalyptus Pulp, 4-7 March, Belo Horizontre, Brasil, 7 pp.

[79] Reeve, D.W., 2004. The Kraft Recovery Cycle, Kraft Recovery Short Course, p. 1.1-1.3, Tappi Press, Orlando FL

[80] United States Environmental Protection Agency (EPA) (2002). Profile of the Pulp and Paper Industry, 2nd Edition. Office of Enforcement and Compliance Assurance, Washington, D.C. Report: EPA/310- R-02-002

[81] http://ec.europa.eu/clima/policies/ets/documentation_en.htm

[82] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015.

magazines paper, market DIP, some chemicals such as NaOH are added as pulping additives. De-inking stage releases and removes the hydrophobic contaminants from the paper pulp. Most commonly used physical operations are: flotation or washing.

Wash deinking consists of a washing stage where dispersants are added to wash out the printing inks. When the pulp slurry is dewatered (thickened), the medium to fine particles are washed out. This process is most useful for removing particles smaller than about 30 µm, like water-based inks, fillers, coating particles, fines and micro adhesives. This process is more common when making deinked pulp for tissue. The processing equipment are belt filters, pressure belt filters, disk filters and static filters. Flotation deinking is the most common deinking process in Europe. Air blown into the pulp suspension where a collector is added, which because of its affinity both to the ink particles and air bubbles, causes air bubbles lifting the ink to the surface, forming a thick froth that can be removed. Flotation deinking is very effective in removing ink particles larger than about 10 µm. Subsequent washing and dewatering (thickening) in filters remove small particles (< 5 µm) from the pulp. A number of chemical operations can follow, e.g. chelants may be added to prepare for bleaching, where peroxides or hydrosulphites can be added to increase the brightness of the pulp[83].

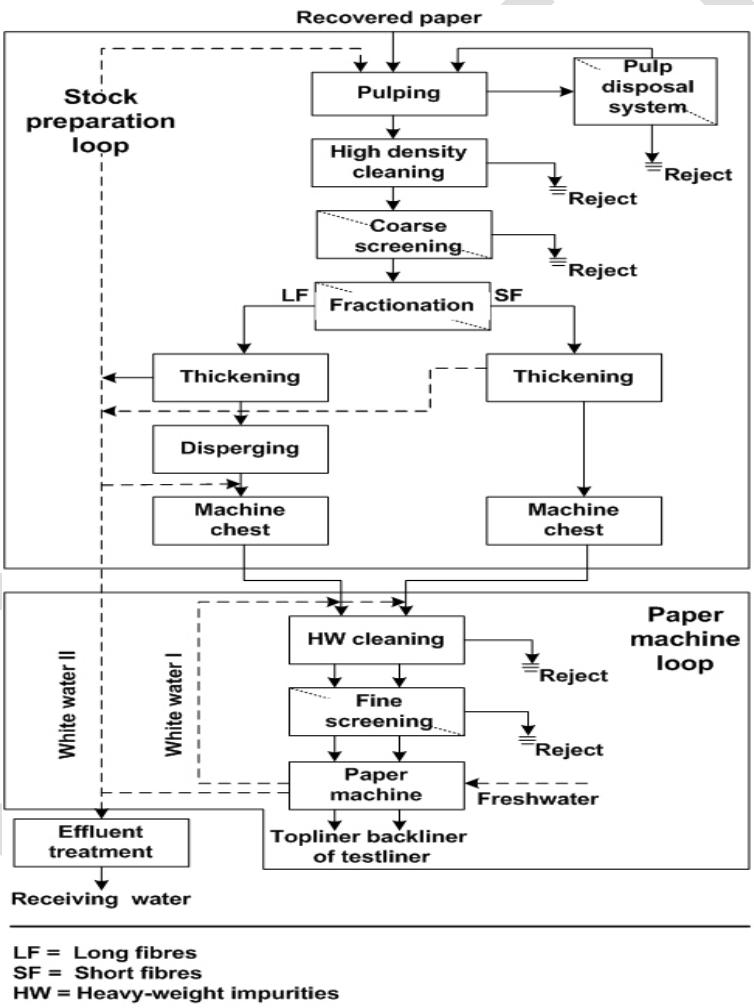

Figure 27. Flowsheet of an example stock preparation plant for processing paper for recycling for case-making material (two-ply Testliner)

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[83] Villanieva A. and Eder, P. 2011. End-of-waste criteria fro waste paper: Technical proposal. JRC-IPTS Report

RCF processing generates various types of rejects and sludge in varying quantities that are collected and have to be handled in the sludge and reject system.

5.1.2 Bleaching

Pulp bleaching is the chemical processing carried out to improve pulp optical properties. Pulp brightness_is a commonly used industry term for the numerical value of the reflectance factor of a paper or paperboard sample, with respect to blue light of specific spectral and geometric characteristics (directional reflectance at 457 nm, 44-nm wide). The parameter is reported as a percentage of how much light is reflected, so a higher number represents a brighter paper. Both TAPPI and the ISO have set industry standards for measuring brightness: TAPPI Standard T451 (directional measurement) and ISO Standard 2469 (diffuse measurement). The two standards are not interchangeable, mainly because of differing instrumentation and methodology (diffuse vs directional) used to take measurements[84].

Paper companies in Europe use the CIE whiteness scale (ISO Standard 11475) to describe a paper's optical properties[85]. Whiteness is the measurement of light reflectance across all wavelengths of light comprising the full visible spectrum (outdoor daylight) and therefore it is the one that best correlates with the visual perception of the paper. Papers that reflect a higher percentage of blue light tend to measure the highest, while those reflecting a higher percentage of yellow light tend to yield lower values. For a perfectly reflecting, non-fluorescent white material, the measurement is CIE 100 whiteness.

There is no correlation between a paper brightness and whiteness, because they are based on different measurement systems.

As to the product groups under revision, newsprint's brightness ranges from 55 to 75 ISO brightness.[86] Standard office papers is usually in the range of 82 to 90 ISO, but could be as bright as 104 ISO. The addition of optical brightening agents (OBAs) can increase the brightness to more than 100.) A brightness index of 90 ISO or above is commonly associated with high-quality papers. The function of an OBA is to reflect ultraviolet (UV) light from the light source as visible light in the blue spectral region giving measurements in excess of 100.

The degree of pulp brightness possible to achieve is to a large extent determined by the content of residual lignin. The type of fibre and pulp used for bleaching as well as the desired properties of end-products affect the type and intensity of a method used, e.g. bleaching with lignin removal is mainly applied when an end-product requires the brightness durability.

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[84] TAPPI uses directional brightness measurement of parallel beams of light that illuminate the paper surface at an angle of 45 degree. This measurement is popular mainly in the U.S. ISO brightness uses an integrating sphere to provide diffuse light and perpendicular observation geometry. The reflected light is viewed by a photocell positioned to view the sample in a perpendicular direction. ISO is popular mainly in Europe and South America

[85] IP. International Paper Transitions from Brightness to Whiteness Measurement. IP: Memphis, TN, Sept 19, 2005.

[86] Ducey, M. 2004. Matching newsprint qualities to press technology. The International Journal of Newspaper Technology.

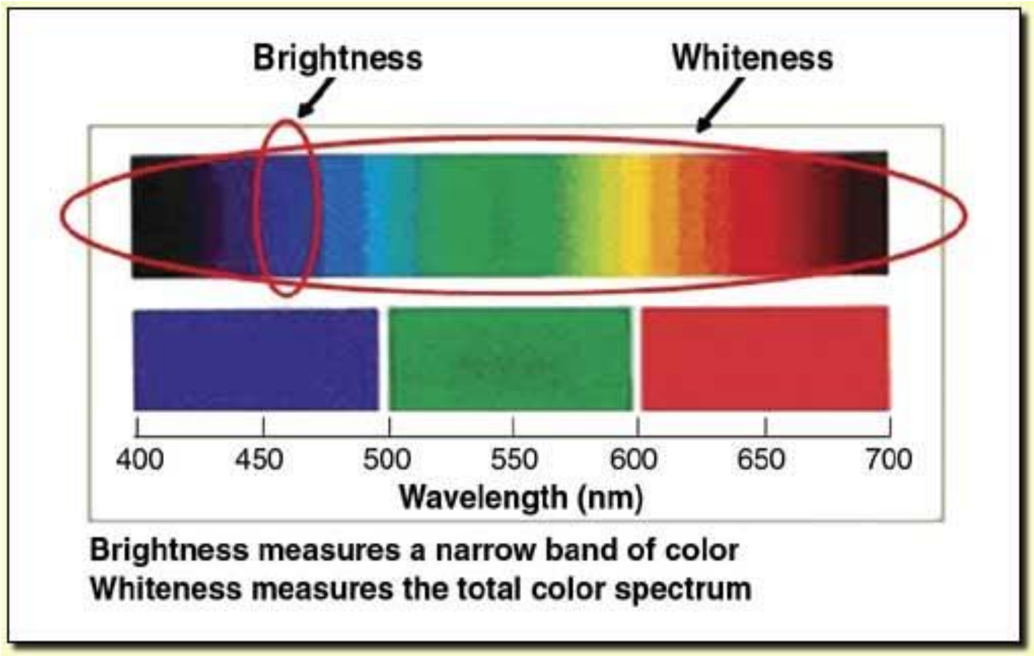

Figure 28. Differences between brightness and whiteness measurements to describe paper optical properties[87]

The bleaching techniques use for mechanical and chemical pulps are different in its concept. Chemical pulps are bleached with lignin removal whereas mechanical with its preserving. Mechanical pulp bleaching is often referred as brightening as the main objective is to remove the colour-causing groups known as chromophores (conjugated groups responsible for absorbing visible light). The most commonly used bleaching agent for mechanical pulp is alkaline hydrogen peroxide, followed by sodium dithionite. The brightness gained is temporary and paper suffers the effect of "yellowing" or brightness reversion through the exposure to air and light.

Chemical pulp bleaching aims at removal of residual lignin, thus the process is often called delignification. The process is usually in multistage being composed of four or more steps depending on the requirement towards the final product.

Table 20. Industrial bleaching stages[88]

Symbol	Stage	pH	Temp (°C)	Description
A	Acid wash			Acid wash to remove metal ions
B	Boron oxide			
C	Chlorination	2.0	20-25	Delignification, the organic chlorinated matter is produced as an effect of delignificaiton
D	Chlorine dioxide	3,5-4	60-80	Highly selective bleaching agent, used both for brightening and delignification. It oxidises lignin but does not add chlorine atoms on the lignin fragments.
E	Alkaline extraction	12.0	45-95	Used to remove solubilised colour components from partially bleached pulp.
F	Formadine sulphuric acid			

87 https://www.risiinfo.com/magazines/July/2006/PP/newspp20060904301.html

88 Paper on Web. 2009. Bleaching stages and sequences. Chemicals Used in Pulp and paper Manufacturing and Coating.: http:www.paperonweb.com

Symbol	Stage	pH	Temp (°C)	Description
H	Sodium hypochlorite	11.0-11.5	30-60	Formed by mixing in-situ elementary chlorine with alkali
M	Chlorine monoxide			
N	Nitrogen compounds			
O	Oxygen	>7.0	85-95	Pulp is treated in pressurised vessel. O stage removes lignin and modifies chromophore groups
P	Peroxide		65-80	Mainly used to brighten mechanical and recycled pulp.
Paa	Peracetic acid			
Q	Chelation			Used to control the brightness and reversion/damaging effect caused by iron salts and other metals
W				The pulp is washed to remove reactants from the previous stage
X	Xylanase			Boost the bleaching effect, typically used in TCF bleaching
Y	Sodium hydrosulfite	5,5	60-75	Reductive bleaching. Typically used for recycled pulp.
Z	Ozone	2,5	<65	Delignifying and brightening agent.

In the recent past, the appearance of new environmental regulations that have placed restrictions on emission levels from cellulose industry, coupled with rising environmental awareness in wider society, have promoted changes in the pulp bleaching techniques. Historically chemical pulp was bleached with the use of elementary chloride Cl_2 (C) or hypochloride (H) with extraction (E) in between, e.g. CEHEH. These sequences has been substituted by ECF bleaching e.g. DEDED; and more recently Totally Chlorine Free (TCF) pulp bleaching technologies e.g. OXZEPY (all symbols of chemicals used together with bleaching conditions are indicated in Table 20)

The distinguishing factor between the two processes is the use of chlorine dioxide in the ECF method. The TCF bleaching employs oxidative chemicals (such as oxygen, hydrogen peroxide, ozone), and more recently, still at limited industrial scale - biotechnological applications. TCF bleaching enables recovery of a larger part of dissolved organic material from bleaching, reducing the effluent load[89], and enabling total closure of recovery cycle[90]. Nevertheless, the TCF process carries a number of disadvantages in comparison to the ECF bleaching[91,92] such as among others. lower brightness, process selectivity, and possible yellowing .

The need to use sequential bleaching may affect the fibre strength, and simultaneously, raise the chemicals load in the process's effluents. Solutions such as pulp pre-treatment with oxygen deliginification, use of pressurized hydrogen peroxide, or enzymatic treatment might be used to improve process efficiency, decrease amount of chemicals used and subsequent pollution load. In ECF modern bleaching, pulp pre-treatment will result in the reduction of the charge of chlorine dioxide stage.

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[89] Shen, Y., Zhou, X., Lu, X., 2012. TCF Bleaching of Eucalyptus Urophylla xEucalyptus Grandis LH107 oxygen-delignified kraft pulp- partial Mg2+/Ca2+ substitution for chelants in chelation stage. Cell. Chem. and Technol. 46, pp 97-103.

[90] Bajpai, P., Environmentally Benign Approaches for Pulp Bleaching. Vol 1. New York. Elsevier Science 2005.

[91] Bajpai, P., Environmentally Benign Approaches for Pulp Bleaching. Vol 1. New York. Elsevier Science 2005.

[92] Loureiro, P.E.G., Evtuguin, D.V., Carvalho, M.G.V.S., 2011. The final bleaching of eucalypt kraft pulps with hydrogen peroxide: relationship with industrial ECF bleaching history and cellulose degradation. J. Chem. Tech. Biot. 86, 381-390.

ECF bleaching is currently the dominant method reaching in 2012 the chemical bleached pulp market share of 93.9%, contrasted with 4.7% for TCF bleached pulps (Figure 29)[93]. Studies of effluents from mills that use oxygen delignification and extended delignification to produce ECF (elemental chlorine free) and TCF pulps suggested that the environmental effects of these processes are low and similar.**[94]** Most European TCF pulp is produced in Sweden and Finland for sale in Germany.

However, there has been disagreement about the comparative environmental effects of ECF and TCF bleaching. Some researchers advocates no environmental differences between ECF and TCF method while others concludes that TCF effluents are the least toxic. The ECF process is regarded as being Best Available Technology with no significant difference between TCF and ECF**[95]**. US EPA's decision reflected**[96]** recognition that ECF accommodates water quality concerns and that to go further would impose capital cost requirements that would be financially debilitating to a large segment of the industry. Water quality improvements following ECF application have led to a widespread decline in the number of receiving streams downstream of paper mills that were characterized as impaired due to the presence of dioxins**[97]**. Following the findings of EIPPCB, ECF bleaching is capable of eliminating 2,3,7,8-TCDD and 2,3,7,8-TCDF to non-detectable levels. However, the complete elimination of dioxins in ECF bleached effluents is a question of kappa-number**[98]** and purity of ClO2.

For RCF usually brightening chemicals are used e.g. alkaline hydrogen peroxide (P), some chemicals such as NaOH might be introduced into the re-pulping process.

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[93] Bajpai, P. Green Chemistry and Sustainability in Pulp and Paper Industry. Springer International Publishing Switzerland 2015.

[94] Paper Task Force. 1995. "Environmental Comparison of Bleached Kraft Pulp Manufacturing Technologies." White paper no. 5. Joint publication of Duke University, Environmental Defense Fund, Johnson & Johnson, McDonald's, Prudential Insurance Company of America and Time Inc. https://web.archive.org/web/20061201152429/http://www1.environmentaldefense.org/documents/1626_WP5.pdf

[95] BREF 2015

[96] United States Environmental Protection Agency (USEPA). 2006. Final report: Pulp, paper, and paperboard detailed study. EPA-821-R-06-016. Washington, DC: United States Environmental Protection Agency, Engineering and Analysis Division, Office of Water.

http://water.epa.gov/lawsregs/lawsguidance/cwa/304m/upload/2006_12_27_guide_304m_2006_pulp-final.pdf

[97] ENVIRONMENTAL FOOTPRINT COMPARISON TOOL. A tool for understanding environmental decisions related to the pulp and paper industry. © 2013 National Council for Air and Stream Improvement.

[98]Reflects the residual content of lignin in pulp

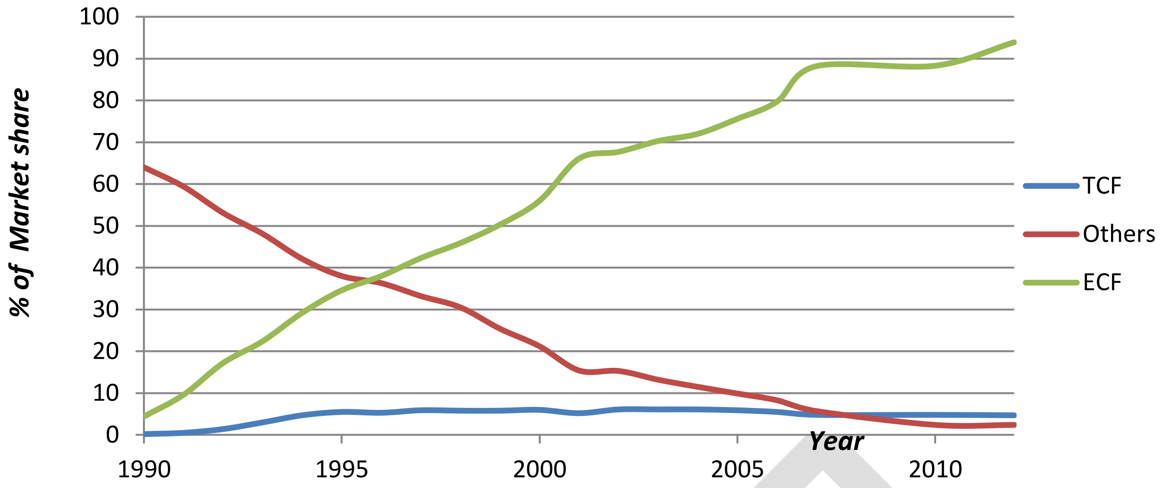

Figure 29. World bleach chemical pulp production between 1990 and 2012[99]

During bleaching chelating agents are used e.g. ethylenediaminetetraacetic acid (EDTA), diethylene triamine pentaacetic acid (DTPA) mainly to form complexes with metals contained in pulp and prevent decomposition of hydrogen peroxide. Acid washing could be considered as possible alternative to complexing agents.

5.1.3 Paper production and converting

Paper and board production will be influenced by the required character of the end-product. Nevertheless, it is possible to distinguish basic paper and board production units common for all product types, as follows:

1. Stock preparation
2. Approach flow system
3. A paper and board machine consisting of:
    - a head box that introduces the suspension of fibres to the wire and creates a
    - uniform dispersion of fibres across the total width of the wire belt
    - a wire section that drains paper web to around 12 – 20% solids
    - a press section that removes more water out of the web by pressing down to
    - about 50% moisture content
    - a drying section that removes the rest of the moisture by heating the web with
    - drying cylinders
    - a reeler that reels the paper web into a roll.
4. Online aggregates (e.g. calender, sizer, coater)
5. Depending on the paper and board grade, there are additional process units (optional) like calenders, sizer, coaters, a coating colour kitchen, winders, rewinders, sheeting plant and a roll wrapping station.

[99] Bajpai, P. Green Chemistry and Sustainability in Pulp and Paper Industry. Springer International Publishing Switzerland 2015.

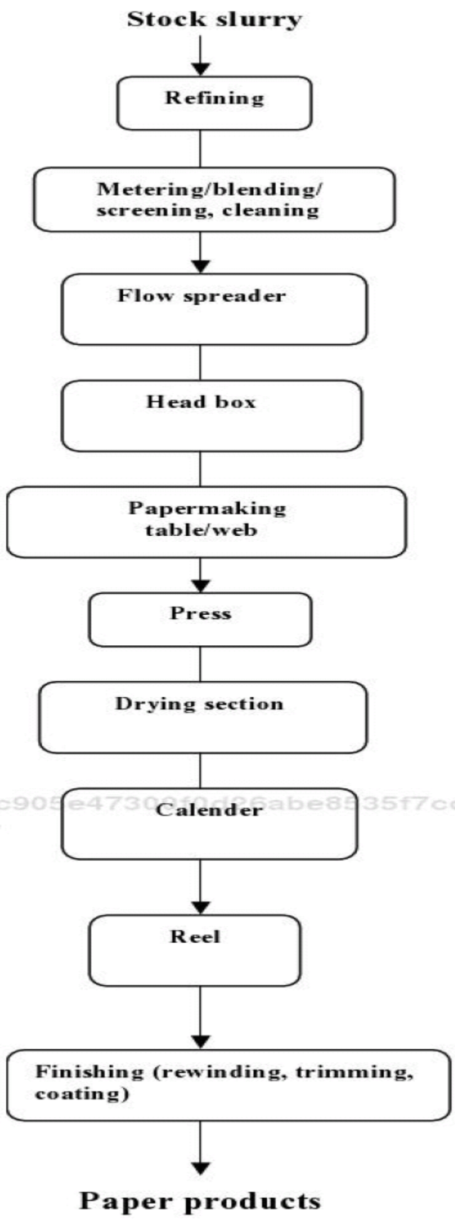

Figure 30.Typical papermaking flow diagram[100]

Paper and board manufacturing processes can take place at the same site as pulp production (integrated mills) or separately at a site of their own (non-integrated mills). Market pulp is an intermediate product sent to the paper mill in form of sheets, bales or rolls, fully dried to 100% Air Dry or wet lap (50% moisture – 60% Air Dry)as, follows**[101]**:

- 100% Air Dry: pulp that is dried to approximately 10% moisture. This pulp commonly goes to market in the form of sheeted bales weighing 250 kg, wrapped with a repulpable wrapper usually of the same grade pulp and secured with 2 or 4 steel wires.

[100] Bajpai, P. 2015. Environmentally Friendly Production of Pulp and paper. NJ, USA Wiley

[101] The World of Market Pulp. 2004. Copyright © 2004 WOMP LLC, Available at: www.worldofmarketpulp.com

- Roll (or Reel) Pulp. The most common grade is fluff pulp for diapers, adult briefs, incontinent pads and feminine hygiene products. Most non-traditional uses for market pulps are shipped in rolls (reels) and often go through a comminution process to shred, cut or defibre the pulp. In most cases roll pulp is drier than baled pulp, often being dried down to as little as 5% or 6% moisture.
- Air Dry Allowance. Since the mid-1940s it has been an accepted industry standard to invoice customers for an inherent 10% moisture in the pulp. This is known as 100% Air Dry.

Generally, depending on the type of pulp used, prior to forming the paper sheet, dried market pulp is rehydrated, while high-consistency pulp from storage is diluted. Pulp fibres may be beaten to increase the fibre-bonding area and thereby improve paper sheet strength (refining process). The pulp is then blended with "wet-end" additives and passed through a final set of screens and cleaners to be finally sent to the paper formation machine. Functional additives aid fulfilling final product requirements e.g. pigments, starch, etc. The final paper product will be made to customer specifications such as in rolls or sheets, and with a particular paper weight, colour and finish.

Different paper and board grades are manufactured from different raw materials with machines that are designed for each grade. However, until now there has been no common understanding in Europe as to which paper grades have to be distinguished from an environmental point of view to describe achievable emissions of paper mills that have implemented BAT.[102]

In Europe, the largest number of non-integrated paper mills are manufacturing fine paper, tissue or speciality papers. However, it has to be borne in mind that in some countries these paper grades are also produced in integrated mills e.g. Nordic countries.

Because of the process specificity the production of tissue paper shortly described separately in the following sub-chapter.

5.1.3.1 Tissue Paper

Tissue is usually a product where the single layers produced in the paper machine are combined in a multi-layer product after the paper machine in a separate unit. This is because of its low basis weight sheet (down to 12 g/m^2 on the wire) commonly achieved through a single large steam heated drying cylinder (yankee dryer). The way of drying the tissue determines most of the tissue characteristics. There are three main types of processes:

- conventional tissue-making,
- through-air drying process (TAD),
- hybrid processes.

The tissue sheet is formed on a moving fabric, where water is removed by drainage. The sheet is then transferred to a felt where more water is removed by pressing and vacuum. The tissue sheet is compressed and then transferred to a Yankee cylinder and dried by adding steam to the cylinder and blowing hot air onto the tissue surface. Finally the tissue is removed from the Yankee cylinder by a creping blade and the sheet is reeled up. The final product of the high required absorbing characteristic used to be produced by more energy intensive: through-air drying (TAD) process.

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102 BREF 2015

The main product properties are softness and smoothness, cleanliness, high absorption capacity and strength. The conversion into finished products is often integrated with the tissue production, i.e. tissue mills often sell their products to the end-consumer (including packaging). Tissue is predominantly made of bleached chemical pulps or deinked recovered. In the case of using paper for recycling, the fillers and fines (very small fibres unsuitable for tissue manufacturing) have to be removed. Normally, a mixture of different shares of virgin and recovered fibres is used. If virgin fibres are used, the paper mill can be integrated or non-integrated into pulp-making. For non-integrated tissue-making mills, additional water is required to repulp the virgin fibres.

5.2. Environmental analysis, innovations and best practices

Best practice in paper production can take the form of improved product quality, the use of lower environmental impact processes and technologies or more effective business strategies. The key to transitioning towards more eco-friendly products is a combination of cleaner technologies, new business models and sustainable behaviours [103]. Mechanisms applied by retailers to drive environmental improvement across product supply chains may include: the use of environmental product declarations; setting minimum environmental criteria for suppliers; dissemination of better management practices across the supply chain; promoting ecolabelled products; applying ecodesign principles to production processes; investing in cleaner technologies; local or regional sourcing or raw materials and optimisation of logistics[104].

Market demands and government legislation are forcing the pulp and paper industry to reduce its impact on the environment. The most obvious environmentally related challenges for the pulp and paper industry include: minimisation of resource consumption (water, energy, fibres, chemical additives), limiting emissions to air and water and making maximum use of production capacities and surplus heat and power in a complex global market.

A brief description of key pulp and paper industry best practices that are listed in this document was compiled from available literature and communication with stakeholders. It is also complemented by information contained in Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. When available, literature resources for additional information are provided.

We anticipate that additional analysis of best-practices will be conducted in the context of the criteria revision with the input from industry stakeholders during the consultation process.

The key environmental challenges of pulp and paper industry can be summarised as follows:

1. Raw material supply control: virgin fibre, recycled paper & non-woody biomass;
    - Use of wood from sustainable managed sources;
    - Optimize the sourcing of recycled fibres;
2. Improvement of the supply chain control
    - Impose material and process requirements to master the multi-supply chain;
    - Management of process and functional chemicals;
3. Fuel and energy consumption, CO_2 emissions and climate change

[103] EIO (2013). Europe in transition. Paving the way to a green economy through eco-innovation. Annual Report 2012. European Commission Report.

[104] Styles, D. Schoenberger H., Galvez-Martos, J.L. (2012) Environmental improvement of product supply chain: Proposed best practice techniques, quantitative indicators and benchmarks of excellence for retailers. Journal of Environmental Management 110, pp. 135-150

- Optimise the use of renewable energy;
- Energy efficiency and reducing consumption of fossil fuels;
- On-site generation of electricity and heat (i.e. CHP);

4. Water consumption
   - Optimize the closure of water circuits;
   - Minimise water consumption, use of water savings techniques;
5. Emissions to water
   - Use environmentally benign bleaching sequences;
   - Minimize the use of poorly biodegradable organic substances and substances that cause eutrophication, such as nitrogen or phosphorus;
   - Reduce the discharge of suspended solids;
5. Emissions to air
   - Reduce sources that contribute to acidification (sulphur);
   - Modernise recovery boilers;
6. Solid waste
   - Implement integrated waste management plan, minimise waste generation and maximise recycling and waste recovery;

In 2011 World Wildlife Fund (WWF) evaluated (using a questionnaire) environmental footprint of some product lines of the biggest pulp and paper companies that participated in their project. The key aspects assessed included:

1. Sustainable fibre sourcing:
   - Use of recycled fibre;
   - Use of credible certified fibre[105];
2. Clean production:
   - CO_2 emissions;
   - Current levels of dry waste that goes to landfill;
   - How much water the company uses;
   - How effectively the mills clean their effluent water to minimize organic load and pollutants from the pulp bleaching process;
3. Transparency and Environmental Management System:
   - Implementation of ISO 14001 certification or equivalent;
   - Is the company reporting according to a standard recommended in the Global Reporting Initiative guidelines?
   - Has the company made its official fibre sourcing policy and actual percentage of recycled and credibly certified fibre use available to the public?
   - How clearly and to what level of detail has the company made air, water and waste emissions data publicly available?

The overall results of the study are shown on Figure 31.[106]

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[105] WWF currently considers the Forest Stewardship Council (FSC) as the certification system with the highest credibility and standard.

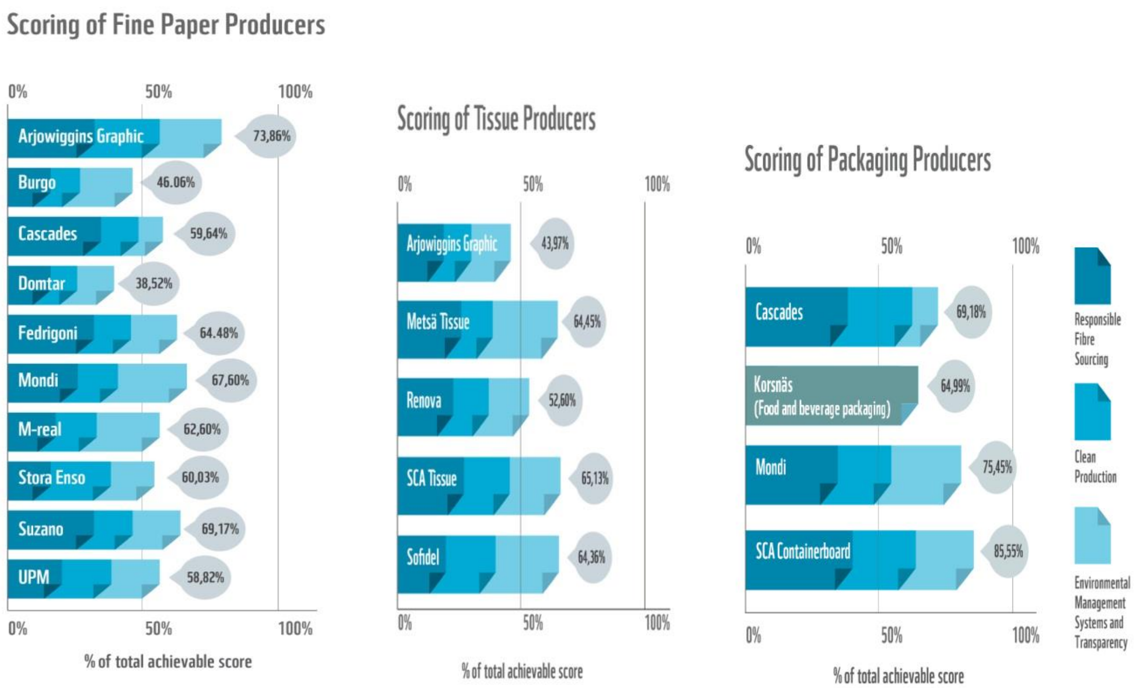

Figure 31. **The best environmental scores of product lines and pulp and paper companies according to WWF paper company index.**

5.2.2. Sustainable Fibre Sourcing

Illegal logging takes place when timber is harvested in violation of national forestry laws. The clandestine nature of illegal logging makes its scale and value difficult to estimate in relation to the global trade in forest products, but strong evidence suggests that it is a substantial and growing problem[107].

Unsustainable industrial logging in virgin or primary forests and the substitution of functioning ecosystems with tree plantations might lead to a loss of biodiversity. Non-sustainable pulp and paper operations have already contributed to conversion/loss of high conservation value forests, illegal harvesting, irresponsible plantation development, breaking human rights and to social conflicts. On the contrary, responsible practices can bring many benefits to forests, local economies and people, particularly in rural areas.[108]

The requirement on sustainable sourcing of wood ensures that illegal and unsustainable sourcing of timber products is not allowed in the EU Eco-labelled products.

106 http://wwf.panda.org/how_you_can_help/live_green/fsc/save_paper/paper_toolbox/papercompanyenvironmentalindex/

107 Copying and Graphic Paper Background Product Report. European Commission Green Public Procurement (GPP) Training Toolkit - Module 3: Purchasing Recommendations, 2008

108 For more information about Sustainable Forest Certifications schemes please refer also to Chapter 3: Market Analysis.

By May 2013, the global area of certified forest, endorsed by FSC and PEFC amounted 417 million hectares, an increase of 8.5% (32.8 million hectares) since May 2012 (see Figure 32). Approximately 7.2 million ha (half of which is in Europe) is double certified, so a more realistic figure for certified forests would be around 410 million ha [109]. Almost all recent growth in certified area is in the CIS sub-region, primarily in the Russian Federation[110]. In 2012, these schemes accounted for 9.6% of the global forests and 26.5% of industrial timber supplies.[111]

Following UNECE/FAO Statistical Report 2012-2013[112], there is an observable grow in the quantity of SFM[113] certified forest area, and the number of CoC certification issued. The proportion of global round wood supply from certified forests was estimated at 28.3% (as to May 2013). The information about the shares of certified forestry per region is given in Table 21.

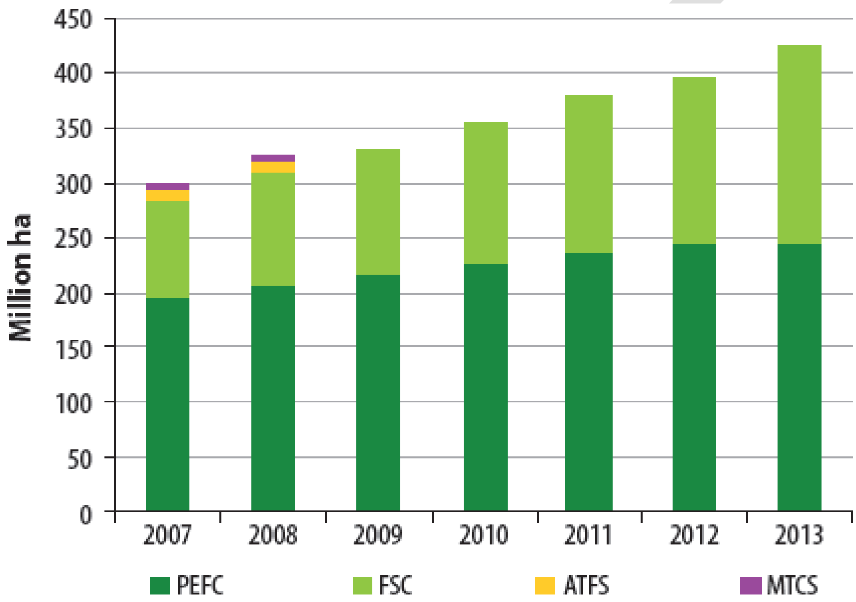

Figure 32. Forest area certified by major certification schemes (2007-2013)[114]

[109] Forest Products. Annual Market Review 2012-2013. UNEC/FAO

[110] UNECE and FAO (2010) Forest products annual market review 2011-2012

[111] UNECE and FAO (2010) Forest products annual market review 2011-2012

[112] UNECE/FAO Statistical Report 2012-1013

[113] Sustainable Forest Management

[114] MTCS, ATFS, SFI, CSA are amalgamated into PEFC data following the date of endorsement. The statistics do not consider an estimated overlap of roughly 7.2 million hectares (by May 2013)

Table 21. Potential global and regional supply of roundwood from certified resources 2011-2013[115]

	Total forest area (million ha)	Certified forest area (million ha)			Certified forest area (%)			Estimated industrial roundwood from certified forest (million m3)			Estimated industrial roundwood from certified forest (%)		
		2011	2012	2013	2011	2012	2013	2011	2012	2013	2011	2012	2013
North America	*614.2*	*201.0*	*198.0*	*215.8*	*32.7*	*32.2*	*35.1*	*227.5*	*224.0*	*244.2*	*12.8*	*12.7*	*13.8*
Western Europe	*168.1*	*85.3*	*95.4*	*100.2*	*50.8*	*56.7*	*59.6*	*201.0*	*224.7*	*236.1*	*11.3*	*12.7*	*13.3*
CIS	*836.9*	*44.3*	*47.5*	*53.4*	*5.3*	*5.7*	*6.4*	*8.5*	*9.1*	*10.2*	*0.5*	*0.5*	*0.6*
Oceania	*191.4*	*12.3*	*13.2*	*11.9*	*6.4*	*6.9*	*6.2*	*3.5*	*3.8*	*3.4*	*0.2*	*0.2*	*0.2*
Africa	*674.4*	*7.6*	*7.3*	*7.5*	*1.1*	*1.1*	*1.1*	*0.8*	*0.8*	*2.2*	*0.0*	*0.0*	*0.1*
Latin America	*955.6*	*16.1*	*14.7*	*15.7*	*1.7*	*1.5*	*1.6*	*3.2*	*2.9*	*1.2*	*0.2*	*0.2*	*0.1*
Asia	*592.5*	*8.1*	*9.5*	*12.5*	*1.4*	*1.6*	*2.1*	*2.8*	*3.2*	*4.0*	*0.2*	*0.2*	*0.2*
World total	*4 033.1*	*374.9*	*385.5*	*417*	*9.3*	*9.6*	*103*	*447.3*	*468.6*	*501.4*	*25.3*	*26.5*	*28.3*

A total of 5 labels currently exist between the schemes, as is illustrated below.

Sustainable virgin	100%	70-100%	0%	0-100%	0-30%
Post-consumer recycled	0%		85-100%	0-85%	70-100%
Pre-consumer recycled		0-30%	0-15%		
Controlled			0%	0-30%	0-30%

Figure 33. Illustration of the 5 current labels from FSC and PEFC.

Basically for all labels, wood is either virgin material sourced from sustainably managed forests, recycled material or controlled material. All labels have a common denominator in that at least 70% of all wood must be either sustainable certified virgin material or recycled material. The FSC recycled and FSC 100% labels go beyond this requirement.

Controlled wood can be considered as the weak point of the FSC and PEFC schemes but because even this type of wood must be legally sourced, it is considered that the

[115] Forest Products. Annual Market Review 2012-2013. UNEC/FAO

requirement for sustainable wood renders a separate requirement for legality of wood obsolete.

Over 182 million ha of forest in 81 countries are covered by FSC certification. In total there are 27,760 FSC CoC certificates in 113 countries (as to July 2014). The number of CoC certifications covered by FSC increased from 15 173 certificates globally in 2009 to 27 246, a growth of 73%.

As of 2013 there were 61 countries that have public forests certified by the FSC and around 30 countries with public forests certified by PEFC, mostly in Europe and North America. Governments in developed countries have promoted green procurement policies as a way of increasing demand for legal and sustainable timber and timber products[116]. By end-2010, a total of 14 countries worldwide had operational public sector procurement policies for wood and wood-based products at the central government level (Austria, Belgium, Denmark, Finland, France, Germany, Japan, Mexico, Netherlands, New Zealand, Norway, Switzerland, United Kingdom) (EU Standing Forestry Committee, 2010). Countries where respective policies or laws exist by 2013 include Australia, China, India, Italy, Republic of Korea and Slovenia[117].

5.2.3. Use of secondary fibre

Of the total raw materials consumed by the European paper industry, secondary fibre (RCF) represented 44.7% and wood pulp 40%; non-fibrous materials made up most of the rest[118,119].

The LCA review concludes that recycling of paper has lower environmental impacts than alternative options of landfilling and incineration[120]. The comparative LCA studies of use of virgin vs recycled pulp showed that deinked pulp has a lower relative impact than referenced virgin pulp (50% mechanical, 50% kraft) for all impact categories evaluated in recycling allocation scenarios evaluated. Deinked pulp also has a consistently lower relative impact when compared against 100% kraft pulp, and relatively lower impact than 100% mechanical pulp for ten out of the fourteen analysed impact categories[121].

Recycling of paper contributes to overall energy savings ranging between 20 and 60% when compared to the use of virgin pulp. Furthermore, through closed loop recycling the extraction and processing of other natural resources in paper production are also saved, including water, chalk, carbonates and titanium dioxide, and some air (74% less sulphur dioxide) and water (35% less chlorine) emissions are avoided[122].

Waste paper recycling is an important source of raw material able to substitute the virgin fibre, and its recovery rate should be increased to maximum possible levels. The energy consumption in waste paper based mills is 30-40% lower than that of an integrated pulp & paper mill. The effluent problem is also considerably less severe for waste paper based mill. A wide range of boards, lower grade writing papers and tissue papers may be produced from waste paper.

[116] FAO. State of the World's Forests 2014. Enhancing the socioeconomic benefits from forests. Rome 2014.

[117] FAO. State of the World's Forests 2014. Enhancing the socioeconomic benefits from forests. Rome 2014.

[118] CEPI Sustainability Report 2013

[119] For more information please refer also to Chapter 3 : Market Analysis

[120] European Environmental Agency (EEA) Paper and cardboard — recovery or disposal? Review of life cycle assessment and cost-benefit analysis on the recovery and disposal of paper and cardboard Technical report No 5/2006

[121] ENVIRON International Corporation Denver, CO. 2012. Life Cycle Assessment of Deinked and Virgin Pulp FINAL, available under: http://www.greenamerica.org/pdf/NatGeo-LCA-Report-2013.pdf

[122] Villanueva, A. and Eder, P. 2011. End-of-waste criteria for waste paper: Technical proposals. JRC EUR 24789 EN – 2011

Nevertheless, the use of recycled fibre has certain constrains e.g. recycled board is for example not suitable for newsprints manufacturing. Recovered paper cannot be efficiently used in all paper grades nor can it be used indefinitely because of shortening up fibre length, and decrease in its bonding capacity, quality and usability. It is roughly estimated that paper can be recycled up to six or seven times until the fibre becomes too short to form a suitable paper sheet. The current average rate in Europe is 3.5[123].

To reach technical quality of the product, the system requires a constant input of virgin feedstock that forms a part of recovery circle. In paper plants running 100% on waste paper input, the quality loss compensation takes place by adjusting the qualities of the waste paper inputs, using waste paper of higher quality (e.g. with high content of chemical pulp) as a substitute of virgin pulp[124,125].

At the same time, waste paper is exported on a large scale, mainly to China, where new large paper mills have been built. This leads to shortages in recycled fibres for some European paper producers. This is aggravated by the relatively high cost of recycling and transporting fibres, when paper consumption is mainly centred on urban areas, whereas pulp and paper factories are usually close to forests, in rural areas.

In the production of recycled paper, the input material for recycling process is covered by a European Standard (EN 643). This standard sets limits on the share of non-paper components generally not exceeding 1,5%. The standard provides a general description of nearly 100 standard paper grades. It defines qualitatively what paper type these grades mainly contain and do not contain, and, to a limited extent, what the non-paper components are allowed. The grades are grouped in five large categories:

- Group 1: Ordinary grades
- Group 2: Medium grades
- Group 3: High grades
- Group 4: Kraft grades
- Group 5: Special grades

The share of printing ink in average recovered paper mixtures amounts to about 2% by weight. However yields of de-inked pulp (DIP) are only between 75% and 85%, because besides the printing ink and adhesives, fragments of paper fibres and parts of the mineral fillers and coating pigments are also removed[126].

One of the main constrains of recovered printed paper recyclability are difficulties in pulp de-inking to obtain the product of appropriate quality and brightness. European recovered Paper Association (ERPC) recommends using “Deinkability Scores” as the assessment scheme of de-inking performance and the final properties of the recovered printed paper substrate.

Some finished paper products do not enter the normal recycling circuits as they are neither recyclable not recoverable. This is the case of tissue paper, wallpaper or papers used in food packaging, among others. Globally speaking, it is estimated that these products account for around 20% of total paper and board production[127].

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[123] CEPI Suistainability Report. 2013.

[124] Villanueva, A. and Eder, P. 2011. End-of-waste criteria for waste paper: Technical proposals. JRC EUR 24789 EN – 2011

[125] JRC 2006. Development of a Model of the World Pulp and Paper Industry. Technical Report Series. EUR 22544 EN

[126] Guide to an optimum recyclability of graphic and printed papers. 2008. European Recovered Paper Council.

[127]Magnaghi, G. Recovered Paper Market in 2012. BIR GLOBAL FACTS & FIGURES.

Following the results of the Environmental Paper Company Index 2011, the producers in the packaging category are using the highest rates of recycled fibre (two producers use over 70% of recycled fibre). In the tissue paper category only 3 producers out of the 5 surveyed use over 50% recycled fibres. As tissue products are generally disposed of after their use, high content of recycled fibre is of importance for this category. The lowest amount of recycled fibre is used in the fine paper sector. Half of the surveyed producers used less than 4% of recycled fibres for their paper production[128].

5.2.4 Chemicals Consumption

On a global scale, paper consists of approximately 98% of natural material. 89 % constitute chemical and mechanical pulps and paper for recycling, 8% are added fillers and coating pigments, mainly in the form of China clay and calcium carbonate. The remaining 3 % include chemical additives (see Figure 34). Slightly more than half of this is starch, which is also derived from renewable raw materials, and one tenth of it is aluminium compounds, e.g. the traditional chemical papermakers' alum (aluminium sulphate). Only 1.1 % of the raw materials used for paper and board production are synthetic chemical additives (speciality chemicals)[129].

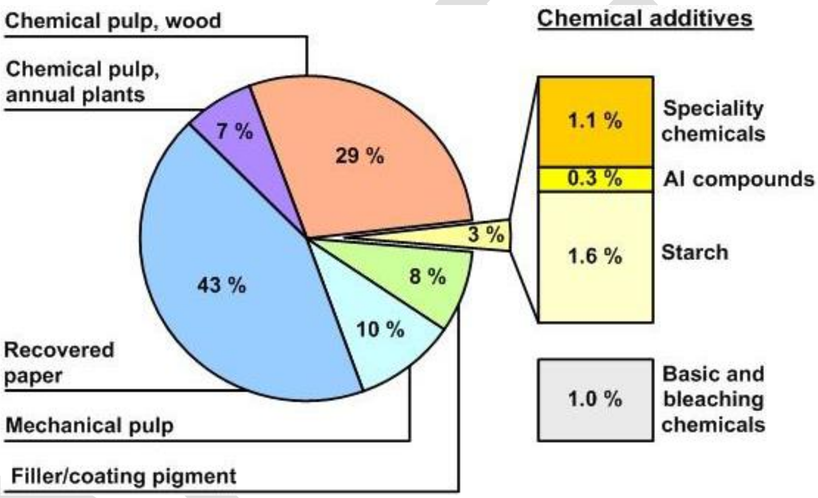

Figure 34. Raw material consumption of paper and board on the basis of a dry content of product in relation to the world paper production of 375 million (volume shares)[130]

Increase in the use of non-fibrous raw materials (minerals, chemical substances) stems mainly from targeting more efficient use of feedstock and improvement of the paper products' functionality. Chemical additives used in papermaking generally might be classified into three groups—general (commodity) and two classes of specialty chemicals—process and functional, which can be described as follows:

1. Process chemicals: Used as a core chemicals or aids during pulping and bleaching process:

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[128] http://wwf.panda.org/how_you_can_help/live_green/fsc/save_paper/paper_toolbox/papercompanyenvironmentalindex/companyfibresourcing/

[129] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015.

[130] Zellcheming. 2008. Chemical additives for the production of pulp and paper. Functional essential – ecological beneficial. Deutscher Fachverlag

- to optimize the production process e.g. retention aids, chelates, coagulants, flocculants, fixative agents, biocides, and defoamers/antifoam additives,
- used in the chemical formulations of chemical/semi-chemical pulping (e.g. caustic soda, sodium sulphate) and bleaching (e.g. hydrogen peroxide, chlorine dioxide, oxygen).

2. Functional chemicals (Table 22): Functional chemicals directly affect paper quality and paper properties like color, water repellency, strength, printability, etc. Typical examples of such functional chemicals are dyes, coating binders, and strength and sizing additives. The boundary between process and functional chemicals is not very definite as process chemicals may either significantly influence performance of functional chemicals and/or affect sheet properties directly. About 90% of all chemical additives belong to functional additives[131] that might be grouped according to the following functions:

- Sizing: Increasing water-resistance properties of paper to maintain a specific writing quality and/or printability, mainly AKD (alkyl ketene dimer) and ASA (alkenyl succinic anhydride),
- Strengthening: Wet-strength additives (mainly: epichlorohydrin, melamine, urea formaldehyde and polyimines), which ensure that paper such as tissue paper retains its strength when it gets wet. Whereas dry-straitening chemicals, such as cationic starch and polyacrylamide (PAM) derivatives, improve paper mechanical properties (burst index, tera index, etc.) through increment of the interconnection within fibre matrix.
- Binders: Natural (e.g. starch, carboxymetyl cellulose) and synthetic (styrene acrylic or butadiene) are used to improve water retention and as coatings aids.
- Fillers, coatings, retention agents, pigments: Fillers are used to reduce the consumption of other materials or to improve some specific paper properties. Retention agents have a function of adhering filler to the paper structure. An additional feature of a retention agent, e.g. polyacrylamide, is to accelerate the dewatering during paper making. Fillers, coating and pigments represents the largest pulp and paper chemical segment in terms of volume. In particular, fillers are widely used by papermakers to reduce the amount of fibres[132].
- Pigments and optical brightening agents: To increase whiteness, a combination of pigments and an optical-brightening agent are often used. The most commonly used pigments are blue and violet dyes.

Table 22. Main process and product aids and their application in the paper industry[133]

Product aids	Purpose	Examples	Remarks
Fillers	Improve printability properties, opacity, brightness, smoothness and gloss; replace (saving) fibres	Kaolin or clay, talc, lime, gypsum, titanium dioxide, calcium carbonate	

[131] Bajpai . P. 2015. Pulp and Paper Chemicals, In: Pulp and Paper Industry, pp. 25-273. Elsevier

[132] http://www.freedoniagroup.com/brochure/22xx/2293smwe.pdf

[133] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015.

Product aids	Purpose	Examples	Remarks
Sizing agents	Improve surface quality; make paper hydrophobic	Modified starch, modified natural resins, wax emulsions, synthetic products like alkyl ketene dimers and maleic acid anhydride copolymers	Some may be toxic to bacteria when they are cationic; however, they have high retention to the fibre
Fixing agents	Improve adsorption of additives to fibres	Alum [$Al_2(SO4)_3$], cationic amines	Mostly cationic products which may be toxic to bacteria
Dry strength agents	Improve strength properties in dry conditions	Modified starch	Some may be toxic to bacteria when they are cationic
Wet strength agents	Improve strength properties under wet conditions	Urea formaldehyde polymer, melamine formaldehyde polymer, Epichlorohydrin condensates	Usually toxic to bacteria, some increase the AOX
Dyes	Give paper a certain colour and/or brightness	Azo compounds, quaternary ammonium compounds	Difficult to eliminate; some are toxic; may contain heavy metals
Optical brighteners	Give paper a white impression	Chemicals based on 4,4-diaminostilbene-2,2-disulphonic acid	Some cationic substances may be toxic
Coating chemicals	Give paper certain surface properties	Pigments, binders, wet strength agents, dispersion and lubrication agents, defoaming agents, slimicides	Binders must be destabilised before mixing with other WW, otherwise they may disturb the clarification
Greaseproof or waterproof agents	Give paper grease- or water-repellent properties, e.g. baking papers, coated drink cups, fast food wrappers and pizza boxes	Perfluorinated compounds (e.g. based on fluorocarbon resins (FC) and perfluoropolyether (PFPE)) are applied to impregnate some papers; for adhesive labels, fluorocarbon resins are used to prevent the penetration of the adhesive. The fluorochemicals are designed so that they bind to the fibres	Persistent and bioaccumulative; PFCs used for paper impregnation do not contain PFOS but may contain FTOH and PFOA in the lower ppm range, trace contaminants
Retention aids	Retention of fibres, fines and fillers; increased production by improving dewatering; decreased emission of pollutants	Alum, sodium aluminate, polyaluminiumchloride, starch products, gums, anionic polyacrylamides, nonionic polyacrylamides, cationic polymers, bentonite	Mostly cationic products
Surfactants	Cleaning of felts, wires and machinery; cleaning of water circuit system; dispersion of substances	Acidic and alkalic surfactants	May cause floating sludge
Defoaming agents	Prevention and destroying of foam	Fatty acid ethoxylates, poly-oxi-ethylene, fatty acid derivates, higher alcohols, phosphoric acid esters,	De-aeration agents may lower the oxygen input in WWTP

Product aids	Purpose	Examples	Remarks
		vegetable oil products	
Biocides (slimicides)	Prevention of growth of microorganisms	Organic bromine, sulphur or nitrogen compounds, quaternary ammonium compounds, chlorine dioxide, hydrogen peroxide	Some contain AOX, they are toxic when reaching the WWTP in higher concentrations

In 2012 more than half of the non-fibrous material used in the paper industry was calcium carbonate. Other minerals used in papermaking include talc, kaolin and bentonite[134], which are described below:

- Calcium carbonate is the most widely used mineral in papermaking. It's used as a filler and coating pigment and helps to produce paper with high whiteness and gloss, and good printing properties.
- Bentonite is used in pitch control, i.e. absorption of wood resins that tend to obstruct the machines, to make the conversion of pulp into paper more efficient as well as to improve paper quality. Bentonite also offers useful de-inking properties for paper recycling.
- Talc is used with both uncoated and coated rotogravure papers to enhance printability and reduce surface friction, improving productivity at the paper mill and print house. It also improves mattness and reduces ink scuff in offset papers. It is used as a pitch control agent as well (talc "cleans" the papermaking process by adsorbing any sticky resinous particles in the pulp).
- Kaolin is used as a filler to bulk up paper and coat its surface. Use of kaolin reduces the amount of wood pulp needed, enhances the optical properties of paper and improves its printing characteristics.

As specified above, a range of chemicals used during paper making are functional chemicals that impart or enhance specific sheet properties or serve other necessary purposes. Additives such as alum, sizing agents, mineral fillers, starches and dyes are of common use. Chemicals for control purposes such as drainage aids, defomers, retention aids, pitch dispersants, slimicides and corrosion inhibitors are added as required by the process.

Not all papermaking chemicals are added to the wet stock. Sizing solutions are often applied to the dried sheet at a later stage in the process (e.g. at the size press) and pigment coatings are used for the better quality publication grades. Increased paper mill chemical and mineral consumption is anticipated mainly for coatings. The highest tonnage additive is clay, over half of which is used as part of surface coating formulations.

Chemical additives are usually formulations of different chemical substances rather than uniform compounds - they only develop the desired capabilities when mixed. Besides, they can contain by-products originating from product manufacture (e.g. monomers, residues of by-products). The expected discharge of chemical additives to water is directly related to the retention of the chemicals in the paper sheet (retention in the process) and their elimination in the waste water treatment plant. Since functional chemicals are designed to give paper a particular characteristic, for reasons of cost and efficiency, they generally have a relatively high level of retention in the cellulose fibres.

[134] CEPI Sustainability Report 2013.

Process chemicals are usually not retained to the same extent in the finished paper sheet. A certain amount is therefore discharged via the mill effluent[135, 136]. In this regard a comprehensive assessment of the risks to the environment, data on retention in the paper product, on biodegradability, toxicity or other detrimental effects on the environment should be considered.

Residual contents of chemicals used during processing, such as talc or sodium silicate from de-inking, may still be found in the paper product and consequently also in waste paper[137].

5.2.5. Pulp and paper production related emissions

In general, the nature and magnitude of paper pollution depending on the process (e.g. mechanical or chemical, bleaching sequences used) and will also be determined by the age and technology used, fuel, and the novelty of abatement techniques. The most significant emissions from pulp and paper industry stem from pulping and bleaching stages, where the pollutants might be release into air, water, or remained as form of solid waste. Table 23. shows parameters important to demonstrating continuous improvements towards a minimum impact mill.

Direct emissions from best practice mechanical and chemical pulping processes are minimal due to the recovery of excess heat from the process. The mechanical pulping process requires relatively high electricity consumption, which results in indirect emissions. However, the utilisation of best practice in plants will limit these indirect emissions. [138]

Table 23. Important parameters to be controlled when evaluating the approach towards minimum impact mill[139]

Water	Air	Solid waste	Other
Water usage	Particulate matter	Solid waste generation	Accidental release
Bleach plant effluent	Total reduced sulphur	Solid waste disposal	Non-compliant event
Final effluent	Methanol	Landfill	Energy use/energy transport
BOD	Chloroform	Recycled	Transport
COD	Chlorine	Energy	Site appearance
Suspended solids	Chlorine dioxide	Hazardous waste	Odour
AOX	CO/CO_2	Elimination	Noise

[135] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015.

[136] Zellcheming. 2008. Chemical additives for the rpodiuction of pulp and paper. Functional essential – ecological beneficial. Deutscher Fachverlag

[137] Villanueva, A. and Eder, P. 2011. End-of-waste criteria for waste paper: Technical proposals. JRC EUR 24789 EN – 2011

[138] Healy, S., Schumacher, K. 2011. Product classification and its implication on competitiveness and carbon leakage. Pulp, paper and paperboard. Öko-Institut

[139] Bajpai, P. 2015. Green Chemistry and Sustainability in Pulp and Paper Industry. Springer International Publishing Switzerland. 258 pp

Dioxins and furans	NOx	
Colour	SO_2	
Biological tests	VOC	
Nutrients	Dioxins and furans	
Heavy metals	Opacity	
Safety	Hazardous pollutants	Air

5.2.5.1. Air emissions

Commonly, the air emissions are as follows: volatile organic compounds (VOCs), particulate matter (PM10 and PM2.5), sulphur oxides (SOx), nitogen oxides (NOx), H_2S, Cl_2, ClO_2, methanol, acrolein, acetaldehyde or formaldehyde. It should be considered that the character of emission is related to the process unit such as paper machine, energy source used, recovery boilers, lime kilns, kraft recovery furnace, brown stock washer systems, bleach towers, etc.

Air emissions of hydrogen sulfide, methyl mercaptan, dimethyl sulfide, dimethyl disulfide and other sulphur compounds are the cause of the odour characteristic of pulp mills utilizing the kraft process. The key air pollutants emitted are related to the combustion of fuels for energy production (NOx, SO_2, CO_2, particulate matter).

The reduction in air emission is mainly achieved by investing in technological solution and improvement in the abatement systems. A brief summary of the emission levels from boilers for different fuels is provided in Tables 5.7, 5.8, and 5.9.[140]

Techniques which are commonly used to control emissions of particulate matter (dust) from combustion plants operated on site in pulp and paper mills are fabric filters (FF) and electrostatic precipitators (ESP). Sometimes mechanical/inertial collectors (cyclones/multicyclones) are also used before the exhaust gas enters the filters or as a stand-alone technique in older and smaller biomass boilers (Table 24).

Table 24. Range of achieved emissions of particulates from steam boilers for different fuels and control measures applied (dry gas, standard conditions) in European plants

Fuels	Daily average (mg/Nm^3 at 6 % O_2)	Yearly average (mg/Nm^3 at 6 % O_2)	Emission control technique
Gas	<5	<5	Combustion control
0.05 % S fuel oil	<5	<5	Fuel selection and combustion control
<1 % S fuel oil	310 – 590	450	Some plants do not apply any abatement technique and measure

[140] For more information about the magnitude of emissions related to the type of process and fuel used as well as the best abatement techniques please refer to JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. 2015. prepared by the EIPPCB, European Union

			dust twice a year (2)
<1 % S fuel oil	5 – 100	20 – 55	Fuel oil selection and ESP (2)
>1 % S fuel oil	≤20	≤10	ESP
Bark, other biomass, and mixed fuels	1 – 300 (1)	1 – 250 (1)	For higher values cyclones; normally ESP or fabric filter
Coal and mixed fuels	1 – 300 (1)	1 – 250 (1)	For higher values cyclones; normally ESP or fabric filter;

The use of low-sulphur fossil fuel is the most common and often the most economical way to control SO_2 emission. In fluidised bed boilers, injection of lime into the boiler is an efficient measure. Secondary control technologies include spray dry scrubbers, sorbent injection processes and wet scrubbers (wet scrubbers are however not applied in the sector with the exception of recovery boilers) (Table 25)

Table 25. Achieved emission levels of SO_2 from auxiliary boilers for different types of fuels and control measures applied (at 6 % O_2, dry gas, standard conditions)

Fuels	Daily average (mg/Nm³ at 6 % O_2)		Yearly average (mg/Nm³ at 6 % O_2)		Emission control techniques applied
	(mg/Nm³)	(mg/MJ)(2)	(mg/Nm³)	(mg/MJ)(2)	
Gas	5	1	5	1	Low-sulphur content
0.05 % S fuel oil	10	3	10	3	NA
1.5 % S fuel oil	50	15	50	15	Scrubber
Biomass	1 – 30	15	1 – 20	10	Clean bark and wood residues (1)
Mixed fuels (e.g. bark, coal, fuel oil, sludge, gas)	35 – 77	No data	6 – 75	No data	Dry scrubber, injection + ESP or FF
0.5 % S coal	150	60	100	40	Dry scrubber, injection
1.5 % S coal	200	80	150	60	Dry scrubber, injection

NB: NA= not available

(1) Biosludge and fibre sludge may increase the sulphur content of the fuel and thus the emissions. On the other hand, a German biomass boiler reported daily average values of 0 – 2 mg/Nm³ which resulted in an annual average value of 0.63 mg/Nm³ (

(2) Reference is made to the effective heat value of the fuel.

A possible source of additional nitrogen, and thus nitrogen oxides, is sludge from biological treatment facilities and chemical flocculation of effluents. Some fossil fuels, such as coal and heavy fuel oil also have a comparably high nitrogen content. In addition to the fuel-bound nitrogen, the thermal formation of NO_X also determines the overall NO_X emissions of a combustion plant.

However, the emission of NO_X is also influenced by the amount of excess air, the temperature and the temperature distribution in the furnace. Due to lower combustion temperatures, the thermal formation of NO_X is low in fluidised bed reactors.

Table 26. Achieved emission levels of NO_X from auxiliary boilers for different fuels and control measures applied

Fuel	Daily average		Yearly average		Emission control techniques applied
	mg/Nm^3	mg/MJ	mg/Nm^3	mg/MJ	
Gas	60 – 150	40	60 – 120	30	Low-NO_X burner or DLN technique
0.05 % S fuel oil	200	50	150	40	Low N fuel, low-NO_X burner, SNCR
1.5 % S fuel oil	240	60	200	50	Low-NO_X burner, SNCR
Biomass	100	45	80	40	SNCR
Biomass	75 – 470	No data	190 – 290	80 – 95	Without SNCR (3 boilers)
Mixed fuels (e.g. bark, coal, fuel oil, sludge, gas)	130 – 330	No data	150 – 300	No data	Fluidised bed boilers
0.5 % S coal	125	50	100	40	SNCR
1.5 % S coal	75	30	60	25	SCR

Carbon monoxide and hydrocarbon emissions are primarily related to the amount of air during the combustion process. Combustion favouring low emissions of CO for example requires the use of high furnace temperatures and sufficient oxygen supply for complete incineration of organic substances. Excess of combustion air will however tend to increase the NOX emission. Therefore aiming to keep emissions of both NOX and CO low will, to some extent, is counterproductive.

5.2.5.2 Waste generation

Wastewater generation, solid wastes including sludge generating from wastewater treatment plants are other issues of importance in paper production. Thus, effective disposal and treatment approaches are essential. The significant solid wastes such as lime mud, lime slaker grits, green liquor dregs, boiler and furnace ash, scrubber sludges, wood processing residuals and wastewater treatment sludges are generated from different mills (Table 27). Disposal of these solid wastes causes environmental problems because of high organic content, partitioning of chlorinated organics, pathogens, ash and trace amount of heavy metal content.[141]

[141] Bahar K., Zeynep, C., Orhan. I. 2011. Pollution Prevention in the Pulp and Paper Industries. Eds: Broniewicz, CC BY-NC-SA 3.0 license. © The Author(s) Open Access:

Table 27. Typical solid wastes type and sources[142, 143, 144]

Source	Waste type	Waste characteristic
Wastewater treatment plant	Sludge	• Organic fraction: wood fibres, biosludge • Inorganic fraciton: clay, calcium, etc. • 20-60% solid content
Caustic process	Dregs, muds	Green liquor dregs consisting of non-reactive metals and insoluble materials, lime mud
Power Boiler	Ash	Inorganic compounds
Paper mill	Sludge	Colour waste, fibre clay including slowly biodegradable organic substances such as cellulose, lignin
Rejects		

5.2.5.3 Water consumption and related emissions

In paper industry, water is used practically at all stages, including wood debarking or chip making, pulping, bleaching, paper recycling, and finishing. The consumption level will vary depending on the grade/type of paper to be produced and techniques applied.

Following Savant et al.[145] pulp and paper sector is after primary metals and chemicals industries, the third largest emitter of wastewater. This has driven to a development of different wastewater treatment (WWT) techniques but also solutions that facilitate closing water circuits in pulp and paper mills.

Wastewater from papermaking process contains a variety of organic and inorganic contaminants that mostly originate from tannins, lignins, resins, and chemicals used during the process. The wastewaters generated include high concentration of chemicals such as sodium hydroxide, sodium carbonate, sodium sulfide, bisulfites, elemental chlorine or chlorine dioxide, calcium oxide, hydrochloric acid, etc. The major problems of the wastewater are related to the high organic content, dark brown coloration, adsorbable organic halide (AOX), toxic pollutants, etc.[146]. Because of differences in technology used, the emission parameters set in Table 28 should be treated indicatively.

http://www.intechopen.com/books/environmental-management-in-practice/pollution-prevention-in-the-pulp-and-paper-industries

[142] EPA Office of Compliance Sector Notebook Project. 2002 Profile of the Pulp and Paper Industry. 2 ed. Washington

[143] H. Nurmesniemi, H., Poykio, R., Keiski R. L. 2007. A case study of waste management at the Northern Finnish pulp and paper mill complex of Stora Enso Veitsiluoto Mills. Waste Management, 27, p. 1939

[144] Pajpai, P. 2015. Green Chemistry and Sustainability in Pulp and Paper Industry. Springer International Publishing AG Switzerland

[145] Savant, D.V., Abdul-Rahman, R., Ranade, D.R., 2006. Anaerobic degradation of adsorbable organic halides (AOX) from pulp and paper industry wastewater. Bioresource Technology 97, pp. 1092

[146] Sumathi,S. and Hung., Y. T. 2006. Treatment of pulp and paper mill wastes, In: Waste treatment in the process industries. Eds: Wang, L.K, Hung, Y.T., Lo, H.H., Yapijakisp. 453 497 . Taylor&Francis. USA.

Table 28. Characteristic of wastewater generated in various pulp and paper processes[147]

Process	Parameters						
	pH	TS (mg/l)	SS (mg/l)	BOD_5 (mg/l)	COD (mg/l)	N (mg/l)	Color (Pt-Co)
TMP white-water	4.6	-	127	1541	2713	7	-
TMP	4.2	-	810	2800	5600	12	-
CTMP	6.2	-	500	2500	7300	-	-
Kraft mill	8.2	8260	3620	-	4112	350	4667.5
Bleach Kraft mill	10.1	-	37-74	128-184	1124-1738	2	-
Sulfite mill	2.5	-	-	2000-4000	4000-8000	-	-
Pulping	10	1810	256	360	-	-	-
Bleaching	25	2285	216	140	-	-	40$^{(1)}$
Bleached pulp mill	7.5	-	1133	1566	2572	-	4033
Wood preparation	-	1160	600	250	-	-	-
Paper making	7.8	1844	760	561	953	11	Black
Newsprint mill	-	3750	250	-	3500	-	1000
Chip wash	-	-	6095	12,000	20,000	86	-
Digester house	11.6	51,583	23,319	13,088	38,588	-	16.6

(1) Unit optical density (OD) at 465 nm

The wastewater flow of bleached kraft pulp mills vary between 20 and 90 m^3/ADt as shown and for unbleached kraft pulp mills between 14 and 80 m^3/ADt. Following information gathered through EIPPCB data collection by the yearly averages of COD concentration values for non-integrated paper mills ranged from 17 mg/l to 119 mg/l for coated and uncoated graphic paper and from 27 mg/l to 140 mg/l for tissue paper. ETS reported daily averages of COD concentrations with values for tissue mills from 27 mg/l up to 500 mg/l after biological treatment[148].

Closed-cycle mills might be considered a major step to reduce environmental impact of pulp and paper industry as they offer more flexibility at the level of resource management (e.g. wastewater discharge and reduction of use of fresh water, at source waste separation and recycling). Zero liquid discharge or closed-cycle systems

[147] Ashrafi, O., Yerushalmi, L., Haghighat, F. 2015. Wastewater treatment in the pulp-and-paper industry: A review of treatment processes and the associated greenhouse gas emission. Journal of Environmental Management 158, p. 146

[148] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015.

implemented in a mill enable the recovery of clean process water from the effluent and recycle it back into the mill[149].

The implementation of the holistic system of water management requires a systematic recycling and reuse of process water that will result in the reduction of the quantity of freshwater used. This will not only provide the basic advantage of reduction of fresh water consumption and consequent discharge of the effluent but would also result in the other additional major advantages such as;

1) Substantial recovery of fibres giving better yield from the raw material;

2) Savings in capital required for treatment of effluent;

3) Less storage areas, energy for pumping etc.,

The complete water circuit closure at a mill should be treated individually. Today there are no kraft mills operating full time that completely recover all bleach plant effluent. One CTMP mill, the sodium-based bleach plant of a sulphite pulp mill and a few producers of corrugating media and Testliner using recycled fibre have realised zero effluents to water[150].

There is a difference in water management between integrated and non-integrated pulp mills. In an integrated mill, the pumpable pulp comes from the pulp process to the papermaking process. Waste water from pulping and from papermaking is often treated in one single treatment plant. However, separate treatment plants are also used at integrated mills. In non-integrated pulp mills, the market pulp is dewatered and dried.

Enhancing of process water recycling in paper and board machines might result in increase of the concentration of colloidal and dissolved organic and inorganic constituents in these streams. The closed-up water systems can have an adverse effect on the runnability of the machine, the quality of the end product and even the production costs due to increased use of chemicals. These potential negative effects need to be controlled. The possible advantages and disadvantages of reducing water consumption are given in Table 29.

Table 29. Possible advantages and drawbacks of increased closure of water circuits in paper mills

Possible advantages of closing up the water circuits	Possible drawbacks of closing up the water circuits
Improved retention of soluble material in the paper web	Higher concentrations of dissolved and colloidal materials in water circuits
Reduced energy requirements for heating and pumping	Risk of slime production leading to deposits and web breaks
Better dewatering properties on the wire, which leads to energy savings in the dryer section	Risk of lower product quality, e.g. concerning brightness, strength, softness, porosity
Less investment costs for reduced equipment	Increased consumption of process aids
Saving raw materials due to lower losses	Risk of corrosion (higher concentration of chlorides)
Higher reduction efficiencies of waste water	Higher risk of blocking of pipes, shower nozzles, wire

[149] Bajpai, P. 2005. Closed-cycle bleach plant In: Environmentally Benign Approaches for Pulp Bleaching, pp 229-267, Elsevier

[150] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015.

treatment	and felts
Reduced total releases to water bodies	Problems of hygiene control for tissue, food contact and medical applications

The measures adopted to reduce water consumption in existing mills should be approached in stages. Figure 35 gives a schematic overview of the major steps, tools, techniques and the water consumption trend when this stepwise approach is implemented. The measures can be classified into four groups: systematic water management and appropriate white water treatment, fresh water savings and substitution, advanced white water treatment and recirculation, and in-line treatment of process water with recirculation.

Purification of industrial waste waters for process water reuse represents a major step in water savings and in closing the chemical processes. Reducing water consumption results in reduction of effluents requires additional implementation of a physico-chemical, biological or mechanical treatment or their combination depending on the type and load of the waste water generated. Adapted and adequate techniques should be used to reduce costs and magnitude of emissions.

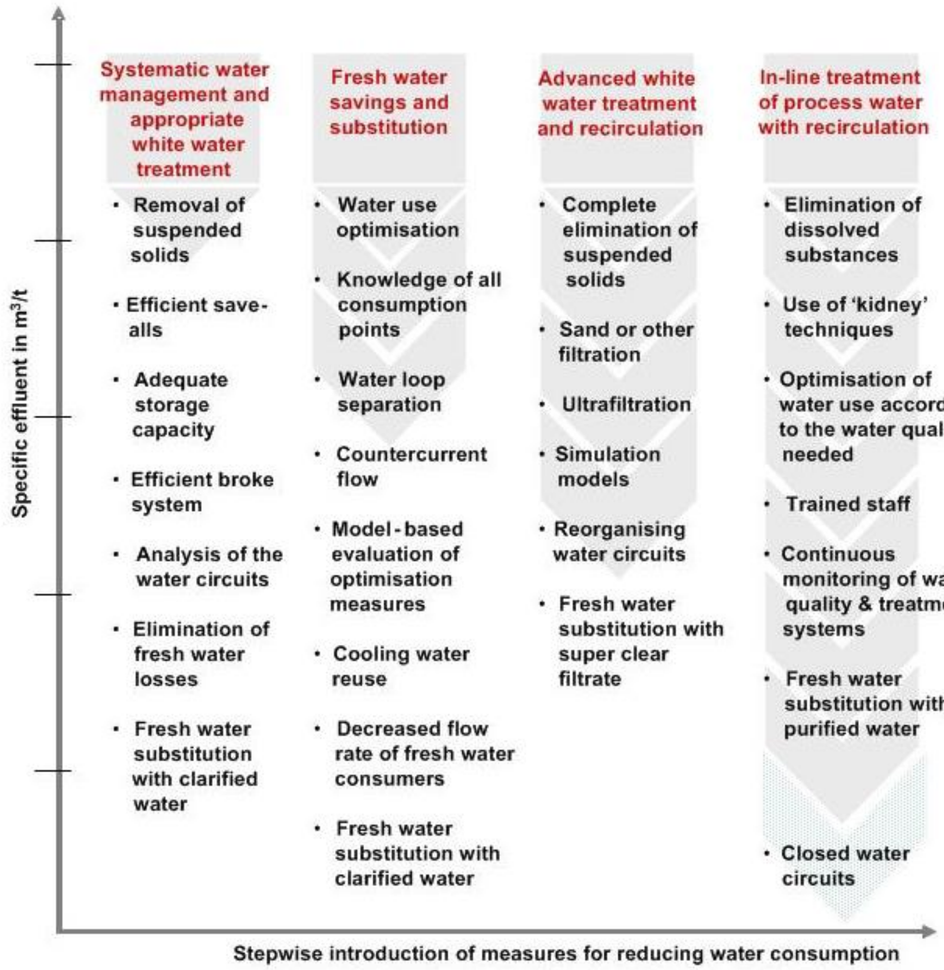

Figure 35. Steps towards lower water consumption and lower pollution load to the environment

Typically pulp and paper mill effluent treatment includes three stages[151]:

I. Primary effluent treatment: neutralization, screening, sedimentation, and flotation/hydro-cycloning to remove suspended solids. Many mills operate primary clarifiers that can remove up to 95% of settleable solids in the process effluent;

II. Biological/secondary treatment. This stage significantly reduces the organic content and toxicity of the effluent due to active biodegradation by microorganisms (i.e., bacteria, protozoans) living in the treatment plant and using the effluent as a source of food (carbon). The most commonly used biological treatment systems in the pulp and paper industry are Aerated Stabilization Basins (ASB) and Activated Sludge Treatment (AST). A key feature of these systems is aeration by surface or submerged aerators, and the addition of nutrients (nitrogen, phosphorus) to maintain a healthy population of microorganisms. ASB and AST systems typically reduce BOD5 by over 80% and COD by 50% to 90%. Following data gathered by EIPPCB the pollution load reduction efficiencies by 85 – 96 % for BOD5; 75 – 90 % for COD can usually be achieved with activated sludge[152]. Combined systems such as activated sludge combined for example with moving bed reactors or trickling filters often achieve the highest removal efficiencies.

III. Tertiary treatment. This involves chemical precipitation to remove certain chemicals, reduce toxicity, suspended solids, and colour.

5.2.6. Energy reduction

The production of pulp and paper requires use of power and steam. According to the International Energy Agency (IEA) Report[153] pulp and paper industry is the fourth largest industrial consumer of energy (about 6% of the world's total industrial energy consumption), using 6.4 EJ (10^{18} J) in 2005.

Energy costs account for between 16 % and 30 % of paper and pulp production costs. Producing one tone of paper requires on average around 11.5 GJ of primary energy, depending on the raw material and fibre furnish used, the paper grade and quality manufactured, and technique applied[154]. In 2011, about half (55 %) of the energy used by the industry came from biomass and most of the rest (36.2 %) from natural gas.[155]

The energy consumption levels can vary widely depending on the type of products, raw material composition, paper grade, process equipment, measurements point installed, and whether pulp and paper are produced in the same plant (integrated plant) or if the pulp for paper production is bought on the market (non-integrated plant). For these reasons, when comparing energy consumption data one has to keep in mind lack of uniformity between data report[156]. Refining, grinding, pressing and drying are generally the largest energy consumers of paper mills. The most energy demanding step of paper manufacturing is drying section.

Energy benchmark can be used as a tool to estimate energy saving potential for the industrial sector. Nevertheless, energy use in the pulp and paper industry is complex and

[151] SAPPI. Water Use and Treatment in the Pulp and Paper Industry Volume 5/August 2012

[152] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015

[153] International Energy Agency (IEA). 2008. Worldwide trends in energy use and efficiency—key insights from IEA Indicator Analysis

[154] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015

[155] https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Energy_Efficiency_and_CO2_Reducton_in_the_Pulp_and_Paper_Industry.pdf

[156] Blum et al. 2005. Revision of best available technique reference document for the pulp an dpaper industry: use of energy saving techniques, UBA and IPTS Munchen

non-homogenous, mainly because of limited comparability between different of installations due their specificity. Within one paper grade there are differences in raw material composition, product properties and installed process equipment. Therefore the relevant system borders and reference values of the subsystems are to be considered when assessing the energy situation[157].

At a lower level of aggregation, specific energy consumption (SEC), is often used as indicator for the amount of energy required to produce one physical unit of product (e.g. Mg of pulp)[158, 159]. In this line Laurijssen et al. (2013)[160] studied the options to benchmark the specific energy consumption (SEC) per unit produced of similar processes within different paper mills in order to identify energy improvement potentials at process level.

Figure 36 indicates subsystems to be considered when comparing energy balances of pulp and paper mills and shows the main energy flows (input and output) in the upper part of the figure. Relevant subsystems that consume energy are compiled within the three processing areas of pulp production, processing paper for recycling and papermaking. Fibre feedstock, products manufactured and residues are also indicated because their type, amount and characteristics may also have an influence on the specific energy consumption of the mill.

[157] Blum, O., Maur, B., Oller, H-J. 2007. Revision of Best Available Technique Reference Document for the Pulp & Paper Industry. Ue of energy saving techniques. Umwelt Bundessamt

[158] Salta, M., et all (2009) Energy use in the Greek manufacturing sector: a methodological framework based on physical indicators with aggregation and decomposition analysis. Energy, 34, p. 90

[159] Worrell, E. et all (1994). Energy consumption by industrial processes in the European Union. Energy, 19, p. 113

[160] Laurijssen et al. 2011. Benchmarking energy use in the paper industry: a benchmarking study on process unit level, Energy Efficiency 6, p. 49

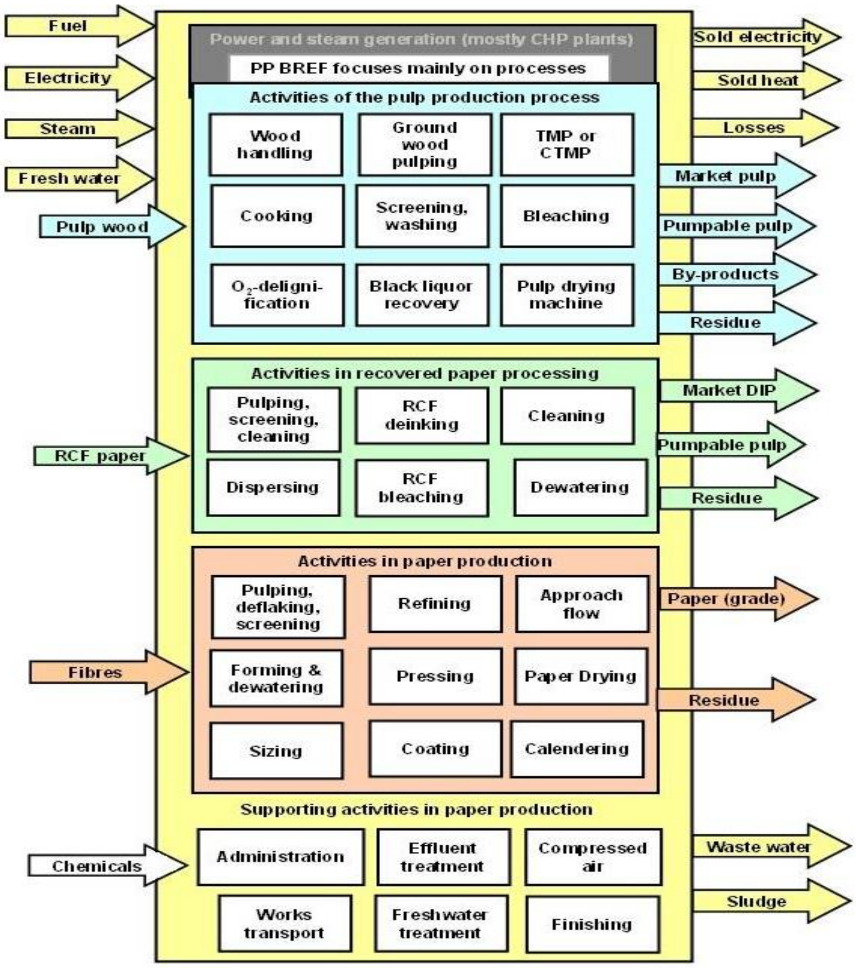

Figure 36 Schematic overview of subsystems to consider when comparing energy balances of pulp and paper mills[161]

The Reference Document of the European Commission on Best Available Techniques in the Pulp and Paper Industry (BAT/BREF) defines "Best practice energy benchmarking" as the process of comparing actual steam and energy consumption with the levels of best practice used in the mills that apply similar processes and manufacture similar products. The reference level should be formed by energy consumption figures together with the technologies used. This methodology allows quantification of improvement potential in energy efficiency. Use of similar models is the most appropriate method for determining the mass energy balance of the process and the entire mill. The three steps of systematic energy efficiency evaluation includes:

a) Step 1: the evaluation of the actual energy situation and the relevance of corrective actions;

b) Step 2: the use of a method for locating, quantifying and optimising potential; and

c) Step 3: the identification of a way of monitoring and safeguarding the optimised situation.

Table 30 shows some examples of energy consumption during pulp and paper making process (for integrated mills, the specific energy consumption values refer to the total paper production including mechanical pulping or processing of paper for recycling). The values are indicative and derived from different data sources.

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[161] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015

Table 30. Specific energy consumption directly used in the manufacturing process and the production-related ancillary installations of some example pulp and paper mills[162]

Type of pulp/paper produced	Range of energy consumption		Data source (No of mills)
	Units	from – to	
Non-integrated kraft pulp	Power (kWh/ADt) Heat (kWh/ADt) (7)	700 – 800 3 800 – 5 100	**(1) (5 mills)**
Integrated uncoated wood-containing paper (includes mechan. pulping (MP) and may refer to GW, TMP or other types of fibres) (5)	Power (kWh/t) (6) Heat (kWh/t) (7)	1 200 – 1 400 1 000 – 1 600	**(2) (1 mill);** **(4) (2 mills)**
Integrated coated wood-containing paper **(includes mechan. pulping (MP) and may refer to GW, TMP or other types of fibres) (5)**	Power (kWh/t) (6) Heat (kWh/t) (7)	1 200 – 2 100 1 300 – 1 800	**(2) (2 mills);** **(3) (8 mills);** **(4) (3 mills)**
Integrated TMP-based printing paper (> 90 % TMP)	Power (kWh/t) Heat (kWh/t)	2 500 – 2 700 330 (8)	**Afconsult** **(1 mill)**
Non-integrated coated wood-free paper	Power (kWh/t) (6) Heat (kWh/t) (7)	600 – 1 000 1 200 – 2 100	**(3) (5 mills);** **(4) (2 mills)**
RCF without deinking (packaging) paper	Power (kWh/t) (6) Heat (kWh/t) (7)	300 – 700 1 100 – 1 800	**(2) (1 mill);** **(3) (11 mills);** **(4) (7 mills)**
RCF with deinking (graphic) paper	Power (kWh/t) (6) Heat (kWh/t) (7)	900 – 1 400 1 000 – 1 600	**(2) (1 mill);** **(3) (7 mills);** **(4) (4 mills)**
RCF-based cartonboard (with deinking)	Power (kWh/t) (6) Heat (kWh/t) (7)	400 – 700 1 000 – 2 700	**(2) (1 mill);** **(3) (4 mills);** **(4) (5 mills)**
Non-integrated tissue mill (no TAD use)	Power (kWh/t) (6) Heat (kWh/t) (7)	900 – 1 200 1 900 – 2 300	**(2) (2 mills);** **(3) (4 mills)**
RCF-based tissue mill (no TAD use)	Power (kWh/t) (6) Heat (kWh/t) (7)	800 – 2 000 1 900 – 2 800	**(2) (1 mill):** **(4) (3 mills)**
Wood-free speciality paper	Power (kWh/t) (6) Heat (kWh/t) (7)	600 – 3 000 1 600 – 4 500	**(2) (3 mills);** **(3) (3 mills)**

(1) Swedish EPA, statistical data of Swedish kraft pulp mills, 2005.

(2) PTS, Examination studies: Energy optimisation in European mills (not published), Munich 2004 to 2007.

(3) PTS, Internal data collection of German pulp and paper mills (not published), Munich 2004 to 2006.

(4) Institution for Paper Science and Technology GmbH, Questionnaire-based survey (not published) Darmstadt, 2007.

(5) For integrated wood-containing paper, it should be noted that the combined specific energy consumption of papermaking and mechanical pulping is a directly proportional function of the share and type of mechanical pulp in the furnish. Power consumption for TMP (thermomechanical pulp) is normally higher than for PGW/SGW (pressurised/stone groundwood) and

[162] Blum, O., Maur, B., Oller, H-J. 2007. Revision of Best Available Technique Reference Document for the Pulp & Paper Industry. Ue of energy saving techniques. Umwelt Bundessamt

much higher than for RCF (recovered fibre).

(6) No primary energy is considered, except for gas (lower calorific value) for IR or air dryers or shrink ovens. The power plant is outside the system boundary. To convert the purchased power demand into primary energy used, the energy yield of electricity production of the given country (if known) or at EU level has to be taken into account. e.g. at EU-25 level the total primary energy for generating 1 kWh electricity is 2.62 kWh cumulated energy requirement (source: Global Emission Model for Integrated Systems GEMIS, data taken from EU DG-TREN 2003: European Energy and Transport Trends to 2030 (PRIMES)).

(7) Heat consumption figures exclude heat for electricity production. To convert from [kWh] into [MJ] multiply [kWh] by 3.6; to convert from [MWh] into [GJ] multiply [MWh] by 3.6.

(8) The power consumption for the TMP-refining operation is 2 500 – 2 700 kWh/t of pulp. Of this electricity input, 75 – 80 % is recovered as low-pressure steam, which mainly covers the steam consumption in the paper mill. If everything operates according to good practice, only approx. 1.2 GJ/t (or 330 kWh/t) of additional heat in the form of steam is required.

Table 31 shows typical electricity consumption for the production of different types of paper.

Table 31. Typical electricity consumption for the production of different types of paper[163]

Product	Electricity (kWh/t)
Newsprint	500-650
Uncoated mechanical	550-800
Uncoated wood - free	500-600
Coated mechanical	550-700
Coated wood-free	650-900
Kraft papers	850
Tissue and specialty	500-3000
Boxboard	550
Container board	680

The energy consumption during paper process for tissue differs from the traditional system, mainly because of specificity of the drying system to make tissue depending on the required characteristics (softness, absorption, etc.). Apart from the tissue-making process, there are additional processes that can significantly influence the energy consumption of a tissue mill[164]:

- Integrated deinking will require more energy;
- CHP/cogeneration will require more natural gas consumption;
- Electrical steam boilers will require more electricity;
- Biomass boilers will require less fossil fuel.

[163] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015

[164] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015

Energy consumption (ranges) for conventional tissue mills can be seen in Table 32.

Table 32. Energy data range for conventional tissue mills[165]

Type of mill	Heat consumption (MJ/tonne)	Electricity consumption (kWh/tonne)
Virgin fibre mills	5.4 – 10.5	887 – 1 422
With additional processes (1)	5.4 – 18.04	887 – 2 012
Mills with TAD process (2)	11.6 – 21	1 432 – 2 730
Recycled fibre mills	7.3 – 11.4	987 – 1 805
With additional processes (1)	6.7 – 12	987 – 3 130

(1) Additional processes can be on-site CHP, cogeneration, electrical steam boiler or biomass boiler.

(2) These are full mill consumption figures from 8 mills that have TAD machines. Most of these mills also have conventional paper machines on site and may have RCF processes.

The use of heat recovery systems plays an important role in the energy efficiency of the pulp and paper industry. In Europe, the industry produces about 51 % of the electricity it consumes, most (95.2 %) from combined heat power installations (CHP). In 2011 the industry bought 63.6 TWh of electricity, sold 10.5 TWh of electricity, and produced 55.1 TWh of electricity (CEPI, 2013).

The electricity/steam consumption ratio at paper mills enables efficient use of co-generation of heat and power (CHP)[166] and CHP is therefore considered as a benchmark and widely applied within a paper industry. Spain, the United Kingdom, Finland, Germany and Italy meet more than 25% of the total electricity demand of their pulp and paper industry using CHP. Additionally, Spain and the United Kingdom have the highest percentage of CHP use in the pulp and paper industry in Europe (although Finland and Germany have the largest installed CHP capacity), with estimated CHP usage rates of 61% and 40% respectively[167].

Combined heat and power (CHP) plants in the pulp and paper industry normally apply steam turbines and/or gas turbines (GT). Different configurations might be used depending on whether all the steam generated is fed to different steam consumers (simple cycle) or GT and HRSG (heat recovery steam generators) are combined with a back-pressure steam turbine or an intermediate steam extraction condensing turbine (combined cycle - CCGT). The benefit of combined heat and power production (CHP) is a better overall efficiency and flexibility. For CHP plants using fossil fuel or biofuels (this is the case for most pulp mills), the overall efficiency with a back-pressure turbine is 85 – 90 %. The power to heat ratio is approximately 0.30 in many cases. For CCGT with steam turbine with power production for internal use the efficiency is ranged between 85 -92% (power to heat ratio 0.40 – 1.10), whereas for CCGT with steam turbine with

[165] ETS 2008

[166] Combined Heat Power Installations are covered by Large Combustion Plants (LCP) BREF

[167] International Energy Agency (IEA).2007. Tracking Industrial Energy Efficiency and CO2 Emissions.

power production for the market the efficiency ranges from 75 to 80% (power to heat ratio 1.50 –2.00)[168].

In Europe, about 18 % of all mills produce both virgin pulp and paper, on the same site. Integrated pulp and paper mills can be more efficient than stand-alone mills[169]. Stand-alone pulp mills have less scope for using waste heat and so are inherently more energy intensive[170]. The most efficient mills are integrated mills that can benefit from extensive heat recovery systems which take advantage of waste heat produced from different processes; it also means that the process could generate net heat export[171]. According to Price et al.[172] integration of the pulp and paper production might optimize the energy use due to the following three reasons:

- It avoids energy consumption for intermediate drying of the pulp which can be of the order of 3 GJ/tonne of pulp or some 25 % of the total heat requirement for a Kraft pulp mill;
- While stand-alone pulp mills may have excess steam that cannot be used (due to black/green liquor recovery or from heat recovery), an integrated mill can use this excess heat to serve the additional heat use of the paper machine;
- Process integration of the different processes may result in a further optimization of the steam use on site.

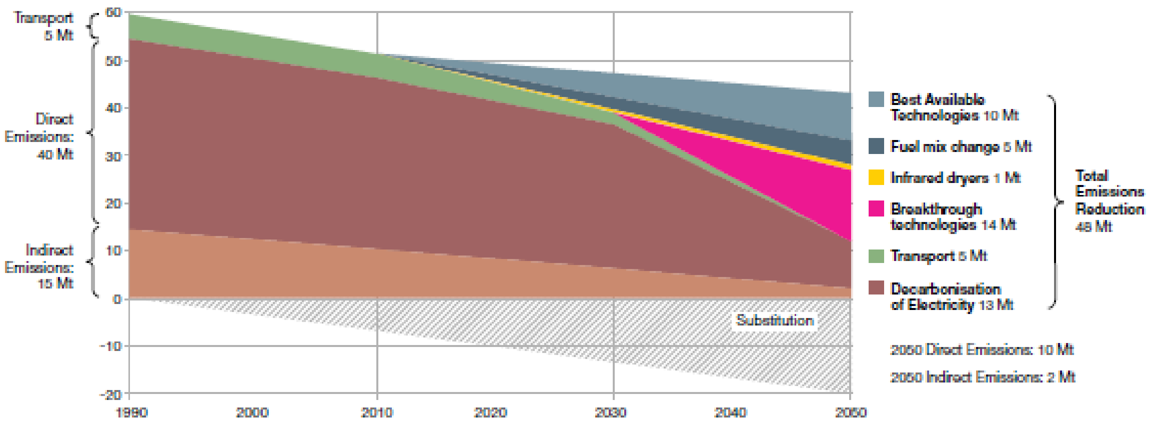

Figure 37. Emission Reduction Projection 1990 -2050 (in million tonnes)

Pulping sector is covered by Emission Trading Directive 2009/29/EC[173] that contains a range of implementing measures to be adopted by the Commission after agreement by the Member States. As a result of the consultations, pulp and paper is on the list of energy-intensive industries with a risk of 'carbon leakage' (pulp has a trade intensity

[168] JRC Science and Policy Reports. 2015. Best Available Techniques (BAT) Reference Document for the Production of Pulp, Paper and Board. European Union 2015

[169] https://setis.ec.europa.eu/system/files/Technology_Information_Sheet_Energy_Efficiency_and_CO2_Reducton_in_the_Pulp_and_Paper_Industry.pdf

[170] International Energy Agency (IEA). 2008. Worldwide trends in energy use and efficiency—key insights from IEA Indicator Analysis

[171] Ecofys. 2009. Methodology for the free allocation of emission allowances in the EU ETS post 2012 Sector report for the pulp and paper industry. By order of the European Commission. Available at: http://ec.europa.eu/clima/policies/ets/cap/allocation/docs/bm_study-pulp_and_paper_en.pdf

[172] Price, L., Worrell, E., Neelis, M., Galitsky, C. and N. Zhou . 2007. World best practice energy intensity values for selected sectors, Lawrence Berkeley National Laboratory, LBNL- 62806 Rev. 1, June 2007

[173] Directive 2009/29/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 23 April 2009 amending Directive 2003/87/EC so as to improve and extend the greenhouse gas emission allowance trading scheme of the Community, OJ L 140, 5.6.2009, p. 63–87

above 30 % and paper above 10 %, and a CO_2 cost above 5 %). The large share of biomass within paper sector results in reduced CO_2 intensity[174].

The core strategy of the European Commission Roadmap for a low-carbon economy by 2050 is to get the highest possible value from resources. Where possible, mills will be part of an industrial system that optimises the use of raw material, energy and waste. The Roadmap scenario's starting point is an 80% CO_2 reduction by 2050. For the pulp and paper industry, as indicated on Figure 37, this translates into a reduction from roughly 60 Mt CO_2 in 1990 to 12 Mt CO_2 by 2050, covering 40 Mt direct emissions, 15 Mt indirect emissions from electricity purchased and 5 Mt transport emissions.

[174] Bajpai, P. 2016. Pulp and Paper Industry: Energy Conservation, Technology & Engineering Elsevier, 290 pp

6. Concluding remarks

The pulp and paper industry is a large manufacturing sector which, like many other sectors, has historically been perceived as being highly polluting. The sector is heavily influenced by many policy initiatives, technical standards and legislation.

The recently published (2014-2015) BREF values are likely to have a significant impact on the ambition level of EU Ecolabel criteria relating to air and water emissions and to energy use on-site (both fuel and electricity).

At the European level, the industry is well co-ordinated to tackle the increasing regulatory challenges and has embraced the voluntary EU Ecolabel for copying and graphic paper and for tissue paper – 2 of the most popular of the 32 EU Ecolabel product groups (of which 5 are paper-based) with currently valid criteria.

The paper market faces great challenges in the face of a newsprint market that appears to be in terminal decline and a stagnant copying and graphic paper market. Overall however, these decreases are offset by increases in demand for tissue paper, packaging and speciality papers. Paper recycling rates in Europe are quite high already at around 70% although there is significant demand from Asia for European recovered paper as their cargo ships return under-loaded back to Asia.

Information in the LCA literature basically confirmed the obvious, that the use of fossil fuels in pulp mills, grid electricity in paper mills and the production & use of chemicals were the three main sources of adverse environmental impacts and that forestry was not so significant with regards to almost all impacts (exceptions being POF and EP). The industry has already identified several steps to minimise these impacts although it must be borne in mind that pulp and paper mills are huge multi-million euro investments where long investment cycles are typical and where one day of lost activity is expensive. For these reasons, radical shifts in process technologies only occur intermittently.

Making paper from recovered fibres had lower environmental impacts than making it from virgin pulp, but other factors like the quality of the fibre, technical properties of paper produced, contamination in lower recovered paper grades and of course, transport and collection efficiency of recovered paper have to be considered when making any fully informed decision on what is/are the optimum fibre source(s).

Overall, it is believed that the EU Ecolabel can help encourage further environmental improvements in the pulp and paper industry which will also bode well for license holders in terms of future cost-competiveness when CO2 taxes increase and energy self-sovereignty as more emphasis is placed on biomass and on gasification technologies.

Detailed discussions with all stakeholders about how to strike the correct balance between ambition and practicality will be vital to ensuring that these criteria continue to being so successful and these developments will be captured in the series of Technical Reports that will be produce during the revision process.

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List of abbreviations and definitions

AOX	Absorbable Organic Halogens
BAT	Best Available Techniques
BLG	Black liquor gasification
BREF	Best Avalable Technique Reference Document
CEPI	Confederation of European Paper Industry
CTMP	Chemi-thermo-mechanical pulp
DIP	Deinked Pulp
DS	Dry solid
EC	European Commission
ECF	Elementary Chlorine free
EIPPCB	European IPPC Bureau of the Institute for Prospective Technology Studies at the EU Joint Research Centre in Seville
EPD	Environmental Product Declaration
EU	European Union
EU ETS	The EU Emissions Trading System
FAO	Food and Agriculture Organization of the United Nations
FLEGT	Forest Law Enforcement, Governance and Trade Action Plan
FSC	Forest stewardship Council
GPP	Green public procurement
GW	Groundwood pulp
IPP	Integrated Product Policy
IPPC	Integrated Prevention and Pollution Control
ISIC	International Standard Industrial Classification of All Economic Activities
ISO	International Standards Organization
LCA	Life Cycle assessment
OBA	Optical brightening agent
PCR	Product Category Rules
PEF	Product Environmental Footprint
PEFC	Pan European Forest Council
RCF	Recycled Fibre
REACH	Registration, Evaluation, Authorisation and Restriction of Chemicals
SFI	Sustainable Forestry Initiative
TCF	Totally Chlorine Free
TMP	Thermo-mechanical pulp
UNEP	United Nations Environment Programme

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