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The Future of Paper Recycling in Europe:

Opportunities and Limitations

The Limits of Paper Recycling
COST E48

THE FINAL REPORT OF COST ACTION E48
"THE LIMITS OF PAPER RECYCLING"

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LIST OF ABBREVIATIONS

AF&PA ....American Forest & Paper Association

BIR ....Bureau of International Recycling

CEPI ....Confederation of European Paper Industries

CEN ....European Committee for Standardization

COMIECO .....Consorzio Nazionale Recupero e Riciclo degli Imballaggi a base Cellulosica

COST ....Co-operation in Scientific and Technical Research

CTP ....Centre Technique du Papier

DIFTAR ....Different Tariffs system for waste collection

ERPA ....European Recovered Paper Association

FPS ....Forests, their Products and Services

GPP ....Gross Primary Productivity

HG & PS ......High Grade Deinking and Pulp Substitutes

INGEDE ....International Association of the Deinking Industry

LCA ....Life Cycle Analysis

MC ....Management Committee

OCC ....Old Corrugated Containers

OMG ....Old Magazines

ONP ....Old Newspapers

P&B ....Paper and Board

PBS ....Paper Bale Sensor

PTS ....Paper Technology Specialists

REACH ....Registration, Evaluation and Authorisation of Chemicals

RP ....Recovered Paper

SAICA ....Sociedad Anónima Industrias Celulosa Aragonesa

SWOT ....Strategic planning method used to evaluate Strengths Weaknesses Opportunities and Threats

TAPPI ....Technical Association of the Pulp and Paper Industry

WRAP ....Waste & Resources Action Programme

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FOREWORD

by Barry Read
Chief Executive (The Paper Industry Technical Association)
& participant in COST Action E48

When working on a book that looks into the future, it is almost impossible for the individuals involved (myself, at least) to avoid the temptation to look back over your shoulder and reflect on the events that lead to the publication of the book.

Almost exactly thirty years ago, when I embarked on a career in the Paper Industry, recycling technology was very much in its infancy and supplies of raw material (known then as ‘Waste Paper’) were both abundant and of a high quality (as mills were able to select the ‘waste streams’ most appropriate to their requirements). Nonetheless, the industry faced numerous technical challenges to convert this new ‘raw material’ into products capable of competing with their Virgin Fibre counterparts and researchers (in both research institutions, industry and supplier organisations) had a vital role to play in developing our understanding of the recycling processes and how they could be best utilised to produce high quality papers.

The 1980’s / 90’s were very much a ‘Golden Age’ for recycling technology; seeing the introduction of exciting new technology, such as multiple loop flotation deinking systems, dispergers, fractionation and much more into mainstream papermaking.

Over the years, the industry has continued to develop new technologies and strategies in response to new challenges that have arisen and ‘Recovered Paper’ has risen to be the dominant source of fibre within Europe in 2008, with over 66% of paper in use being collected for recycling. Such extensive recycling gives rise to a new set of challenges; challenges which the industry (and researchers serving the industry) continue to respond to in a positive manner.

Ironically, it is the ‘Drive to Recycle’ that now creates the most significant challenges as ‘Recovered Paper Collection Systems’ capture the last few percent of what is achievable, often bringing with it material which is less desirable to the Paper Industry; whilst CO_2 emission concerns (leading to the incineration of Paper as a non-fossil fuel) and the development of the Far Eastern Paper Industry currently create alternative markets for Recovered Papers. Whilst we cannot and should not deny others access to this sustainable source of material, we should, at least, ensure that only papers no longer viable for use in the manufacture of new papers are condemned to a ‘final use recycling option’ such as incineration or composting; effectively ‘borrowing’ a little more of the fibre for a little longer before it is assigned to its final fate and lost forever.

To achieve this, the Paper Industry may be obliged to take a more proactive role in the collection and recovery systems delivering Recovered Papers and we have already seen companies investing in their own Material Recycling Facilities (increasingly located on mill sites). Could it be that the Paper Industry will need to supervise the 'Urban Forest' in a similar manner to that required to oversee forestry operations in the Virgin Fibre arena?

Whatever happens, it seems inevitable that the industry will be required to develop greater understanding of the fibre flows in recovery and recycling, new technologies to sort Recovered Paper and address the inevitable new challenges that will arise.

COST Action E48 "The Limits of Paper Recycling" provided (and even though ended continues to provide) an excellent forum to lay the foundations of the research groups and research / industrial partnerships that will address these issues in future research projects. During the four years of the action, old relationships were renewed and new relationships formed that will endure into the foreseeable future; relationships that will form the nucleus of the teams that will respond to the challenges arising in the second decade of the 21st Millennia and beyond.

Paper has already been described, by greater authorities than myself, as probably being the one truly sustainable material known to mankind and I have little hesitancy in suggesting that paper will still be widely used thirty years after the publication of this book. I sincerely hope that many of the Early Stage Researchers, who played such an active role in COST Action E48, will be in a position to pass on their knowledge and experience to the Young Researchers and Papermakers of their time and that the COST Organisation will continue to encourage and support much needed and relevant Actions to ensure that the Limits of Paper Recycling are achieved and surpassed.

I cannot close this foreword without expressing gratitude to both Jan-Erik Levlin and Harald Grossman for their efforts in driving this action forwards. Both gentlemen laboured above and beyond what could be expected of them resulting in the Action being hugely successful and appreciated by the industry.

Barry Read

INTRODUCTION

What is COST?

COST - the acronym for European Cooperation in Science and Technology - is the oldest and widest European intergovernmental network for cooperation in research. Established by the Ministerial Conference in November 1971, COST is presently used by the scientific communities of 36 European countries to cooperate in common research projects supported by national funds.

The funds provided by COST - less than 1% of the total value of the projects - support the COST cooperation networks (COST Actions) through which, with €30 million per year, more than 30,000 European scientists are involved in research having a total value which exceeds €2 billion per year. This is the financial worth of the European added value which COST achieves.

A "bottom up approach" (the initiative of launching a COST Action comes from the European scientists themselves), "à la carte participation" (only countries interested in the Action participate), "equality of access" (participation is open also to the scientific communities of countries not belonging to the European Union) and "flexible structure" (easy implementation and light management of the research initiatives) are the main characteristics of COST.

As precursor of advanced multidisciplinary research COST has a very important role for the realisation of the European Research Area (ERA) anticipating and complementing the activities of the Framework Programmes, constituting a "bridge" towards the scientific communities of emerging countries, increasing the mobility of researchers across Europe and fostering the establishment of "Networks of Excellence" in many key scientific domains such as: Biomedicine and Molecular Biosciences; Food and Agriculture; Forests, their Products and Services; Materials, Physical and Nanosciences; Chemistry and Molecular Sciences and Technologies; Earth System Science and Environmental Management; Information and Communication Technologies; Transport and Urban Development; Individuals, Societies, Cultures and Health. It covers basic and more applied research and also addresses issues of pre-normative nature or of societal importance.

Web: http://www.cost.esf.org

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CHAPTER ONE

COST ACTION E48

1. Background & Motivation

Recycling of paper and board (p&b) has a long history in Europe. With a total collection rate of 62,6 % for CEPI countries in 2005[†], Europe is the world leader in p&b collection and recycling. Recovered p&b already measures up to virgin fibres as a raw material for the paper industry and there is no doubt that every effort will be undertaken to further increase the utilisation of this resource for papermaking. The main drivers for this have always been primarily financial and then, to a lesser degree, either the lack of virgin fibres in some countries or even environmental considerations or constraints.

A thorough SWOT (Strength, Weaknesses, Opportunities & Threats) analysis of p&b recycling would, however, detect a number of challenges which are worth considering: In the last few years the global demand for recovered p&b has grown dramatically as a result of increased demand in the Far East countries (notably China), some of which depend largely upon recovered p&b imports due to a lack of domestic fibre resources. Simultaneously, the production capacities of paper mills in Europe based predominantly or entirely on recovered p&b has been significantly increased. Furthermore, there is increasing competition for the used/recovered p&b for non-papermaking purposes. Obvious impacts of these developments are increasing prices and deteriorating qualities of recovered p&b, but not, as yet, severe bottlenecks in supply as of now.

The background of the Action can therefore be described by the following statements:

- Recovered paper is an indispensable raw material for the European paper industry;
- Quality of the recovered paper determines its future utilisation options;
- The critical balance between prices, availability, demand and supply determines the future of recovered paper.

Against this background a group of European researchers launched an initiative dedicated to the identification of the limits of paper recycling in Europe and to developing ideas how these limits could possibly be extended by either development of collection strategies and technology or through research and education. This initiative was taken within the framework of the oldest European research co-operation programme COST (Co-operation in Scientific and Technical Research). COST Action E48, started in March 2005 and today comprises 18 European countries and some 30 individual research organisations. The work within the Action is organised into three working groups focusing on collection quality issues, technological constraints and legislative aspects. The overall objective is the development of scenarios on how p&b recycling might develop in Europe and what measures are appropriate to address the threats ahead.

[†]By 2008 the Total Collection Rate had risen to 66.6%, despite the economic slowdown in the second half of that year.

2. Objectives & Expected Benefits

The main objective of the COST Action E48 "Limits of Paper Recycling" is to collect facts, data and experiences and to develop, on the basis of this information, scenarios which – in a meaningful way – will help develop a better idea on how an ecologically and economically optimised utilisation of recovered paper within Europe could look like. In order to do this it is important to identify ecological and economical limits beyond which paper recycling would no longer be a reasonable option. Once these limits are identified, the paper industry will be in the position to undertake targeted approaches aiming at extending these limits – or to make in-time decisions to prepare for a gradual re-substitution of recycled fibres by virgin fibres. The availability of such well and comprehensively investigated scenarios are an important prerequisite for the European paper industry to undertake means which enable it to maintain an as high as possible level of sustainability and at the same time remain competitive in Global Markets. Thus the way will be paved for targeted approaches in various fields, the aim of which is to safeguard the raw material base for the European paper industry for which recovered paper plays an important role and, at the same time, help the industry on its way towards sustainability.

The expected benefits of the results from this Action include:

- a sound base for:
  - targeted research activities regarding recovered paper treatment technologies
  - providing necessary arguments for discussions with governments and governmental organisations, in order to avoid any further obstacles that reduce the attractiveness of recycling used paper products;
- guidelines for the design of recycle-friendly paper products;
- guidelines for more effective, tailor-made collection strategies for used paper products;
- background information for investment decisions, taking into account likely changes in raw material markets.

In order to achieve these benefits, it has been necessary to collect data and gain a better understanding of the following areas:

- mid-term development of the European paper industry's raw material markets, including availability of different types of recovered paper;
- expected improvements in existing processing techniques as well as expected new technologies arising in:
  - equipment technology (particularly recycled pulp treatment techniques with improved selectivity as well as techniques by which fibre properties can be regenerated);
  - process technology (control techniques, quality management, sensors etc.);
  - process chemistry (not necessarily restricted to deinking processes);
- mid-term development of quality standards for all major paper and cardboard grades, including upcoming new standards for properties?;
- pros and cons of established or planned collecting systems;
- quality and volume of recovered paper resources not yet exploited;

- the future composition of recovered paper with respect to potentially detrimental substances;
- feasible development in national and European legislation relevant to paper recycling.

3.Work Programme

The activities of E48 have focused on three scientific areas:

Limits Governed by the Characteristics of Recovered Paper & Board

This implied the characterisation and evaluation of, for example:

- the potential quality of existing resources for recovered paper and cardboard as well as those which might additionally be exploited in the mid or long-term;
- the impact of foreseeable trends in paper converting and paper finishing on the quality (recyclability) of the product;
- the various strategies for the recovery of used paper and cardboard products;
- the impact of these recovery strategies on the quality of the paper recovered.

Limits Governed by Pulp Preparation Technologies

This implied the:

- assessment of the state of the art and future potentials of recovered paper pulping techniques as well as those for cleaning and improving recycled pulps (this not only includes machinery but also the chemicals used for these process steps as well as process operation strategies (design of process chains including sensor technology and control systems);
- identification of changes in the composition of recovered paper in terms of non-paper components, their accumulation and the microbial activities in extremely narrowed or even closed water circuits and the potential impacts of all these effects on both processes and product quality;
- the recyclability of different raw material.

Limits Governed by Market Developments, Legislation & Sustainability Aspects

This implied the identification of the mid-term development of supply and demand of recovered paper, through, for example:

- monitoring of world-wide, mid- and long-term investment projects for new production capacities for recycled fibre based paper and cardboard;
- identifying current and future trends in legislation with direct or indirect impacts on paper and cardboard recycling;
- predicting the consumers' attitude towards recycling based products and the future importance of environmentally sound processes and products;
- evaluating future product quality requirements to be met by major grades or at least those relevant for recycling and their implications;
- assessing the potential contribution to sustained paper recycling by the converting industries, i.e. by the recycling-oriented design of paper and cardboard products.

4. Participating Countries & Institutions

A total of 30 institutions from 18 countries have been represented in the Action. They are listed in Appendix 1. In addition to the ones mentioned in this list, CEPI, the Confederation of European Paper Industries has participated very actively in the Action.

5. The Organisation

The organisational structure has consisted of a Management Committee controlling the Action and three Working Groups, one for each Scientific Area. The Action and its MC have been chaired by:

- Jan-Erik Levlin, Finland, Chair, jan-erik.levlin@iki.fi
- Harald Grossmann, Germany, Vice chair, harald.grossmann@gmx.net

The running of the Action between the MC meetings has been taken care of by a Steering Group consisting of the Chairs and the WG coordinators; see below.

The Action has carried out its work mainly by:

- arranging joint MC/WGs meeting twice a year in which:
  - the national representatives have described relevant research and provided information on collection and sorting systems in their respective countries;
  - experts have provided information on relevant aspects such as process technology, legislation etc;
  - the main objectives of the Action, the scenarios, have been discussed;
- compiling information relevant to recycling from the participants with the aid of questionnaires;
- forming Task Forces to compile and discuss special questions, including “Competitiveness of paper recycling” (Elena Bobu, Bartek Stawicki), “Collection and sorting” (Ruben Miranda), ”Statistics” (Ilpo Ervasti), “Publication” (steering group and others).

The duration of the Action has been four years, 30 March 2005 – 29 March 2009.

According to the scientific areas defined above, the various activities of the Action have been organised and taken care by three Working Groups as follows:

WG 1: The Development of Recovered Paper Quality

Coordinators:

- Angeles Blanco (ablanco@quim.ucm.es)
- Andreas Faul (andreas.faul@INGEDE.org)

This group focused on:

- the effects of modern converting technologies (including e.g. printing technologies and those by which paper and cardboard is combined with other materials) as well as market trends in the converting industry on the future composition of recovered paper in terms of type and amount of e.g. printing inks, adhesives, films and foils;

- the strategies by which paper is recovered and their impact on recovered paper quality, in particular in terms of its components (share of graphic papers, packaging papers and others) as well as non-paper material and impurities.

WG 2: Treatment Technologies & Future Recycled Pulp Quality

Coordinator:
- François Julien Saint-Amand, francois.julien-saint-amand@webctp.com

This group focused on:
- the assessment of existing and future recovered paper treatment technologies and their potential contribution to safeguard or even improve recycled pulp quality;
- the assessment of cleaning processes employed in the paper industry for the treatment of recycled pulps and the type and amount of rejects generated by these techniques;
- the development of techniques for the treatment of residues from recycled pulp stock preparation systems as well as their impact on further utilisation or disposal of the treated residues.

This WG has worked in close cooperation with COST E46 “Improvements in the Understanding and Use of Deinking Technology”

WG 3: Legislative aspects, market trends and societal issues.

Coordinator:
- Arie Hooimeijer, email: a.hooimeijer@kcpk.nl

This group focused on:
- the monitoring and assessment of the potential impact of legislative developments within the European Union as well as in their member countries on paper recovering or paper recycling (this includes e.g. waste disposal legislation, agreements on trade and tariffs, waste legislation);
- the collection of data on the basis of which a better estimation of the world wide raw material supply and the world-wide demand for recovered paper can be made;
- the following, assessment and prediction of market trends which have an impact on the future demand for various paper grades;
- the predicting of the consumers’ attitude towards paper recycling in general and its readiness to use products containing recycled pulp rather than those made from virgin pulps;
- the assessment of recycling as a part of the strive for a sustainable society.

For further information on the Action, see the web page www.cost-e48.net

6. Major research projects on Paper Recycling

The assessment is based on the project data received from the responsible country representatives involved in the COST Action E48.

All active countries have reported their data. The project data reported is grouped by type of project reported: international, bilateral or national. Based on the received information, there are, identified as most significant and directly dealing with recycled paper issues, around sixty national, four bilateral and four international projects or scientific R&D projects in the field of paper recycling in Europe recently finished or on-going. International and bilateral projects are described in more detail. Due to their high number, national projects are further grouped by general theme of research and presented in a tabled-style report in Appendix 5.

6.1. International Projects

ECOTARGET – New & Innovative Processes for Radical Changes of the European Pulp & Paper Industry

www.ecotarget.com

The ECOTARGET project ran between November 2004 and October 2008 and was coordinated by Catharina Ottestam, from STFI-Packforsk AB, Sweden. It involved 26 institutions from 9 participating countries, namely France, Greece, Sweden, Austria, Germany, Switzerland, Finland, Spain and Netherlands. ECOTARGET was an EU-funded (within the EU Sixth Framework Programme) four-year research project, aiming at supporting the pulp and paper industry in Europe with innovative new processes, from making pulp to producing paper. The overall objective of ECOTARGET was to enhance the competitiveness of the pulp and paper sector of Europe while at the same time improving the eco-efficiency. The project consisted of six Subprojects, each divided into two or three Working Packages. Subproject 2 was devoted solely to recycled fibre supply and reducing waste and increasing the use of recycled fibres. Subproject 2 was lead by François Julien Saint Amand, from CTP, France. The aim of the Subproject 2 was to develop new solutions to increase recycling rates and improve recycling eco-efficiency. A stronger focus was put on graphic papers where the potential to increase recycling, and thus save wood resources, is the highest. The objectives were (WP2.1), to improve raw material quality by developing new sensors which replace humans by automatic recovered paper control; (WP2.2), to develop new and simplified deinking processes and equipment to improve energy efficiency and reduce rejects; and (WP2.3), to investigate new approaches to reduce solid waste, i.e. deinking sludge and coarse rejects.

SORT IT – Recovered Paper SORTing with Innovative Technologies

www.sortit.eu

SORT IT is a currently running project, which started in May 2008 and has a duration of 36 months. It is coordinated by Jean-Yves Escabasse, from PTS Munich and Kai

Blasius, from PTS Heidenau, Germany. It involves 14 institutions, plus CEPI and INGEDE, from 8 participating countries, namely Germany, France, Netherlands, Norway, Austria, Romania, Sweden and Spain. SORT IT is an EU funded (within the EU Seventh Framework Programme) three-year project. SORT IT aims at developing new technologies for a more efficient and profitable sorting of recovered paper and board from various collection systems. Its main objectives are to enable sustainable and cost effective paper recovery from pre-sorted streams at more than a 95% yield for all recyclable paper and board grades, to provide recovered qualities allowing the best possible re-use in paper & board products, to enable paper recovery from paper-containing waste streams and provide raw materials meeting the users' specifications by implementation of online quality assessment techniques.

MODELPACK – Advanced Quality Prediction Tool for Knowledge-Driven Packaging Design & Manufacturing in European SMEs

www.aidima.es/modelpack

MODELPACK is a currently running project, which started in December 2006 and has a duration of 36 months. It is coordinated by José Vicente Oliver, from AIDIMA, Spain. It involves 14 institutions from 7 participating countries, namely Spain, Belgium, Ireland, Greece, Germany, Poland and Sweden. The project aims at improving the international competitiveness of European corrugated board industries, which are mainly SMEs, and of related sectors by an integrated, transnational research approach. Research is carried out by RTD performers in order to expand the knowledge base and improve the overall competitiveness of participating SMEs. The project will enable SMEs to increase their added-value in producing corrugated board, being one of the most valuable packaging materials, from alternative resources with high proportion of recycled fibres. For the European corrugated board industry the variability in raw materials (packaging grade papers) with increasing percentages of recycled fibres is a very common technical problem. The difficulty of predicting the properties of paper products produced from heterogeneous sources puts several limitations, which therefore lead to severe economic losses and only a comprehensive characterisation enables their better utilization. The expected integrated results of the project are to predict the quality of packaging from alternative raw materials with a special regard to feasibility, risks, costs, profit and energy inputs.

SERECARB – SElective REcovery of Calcium CARBonate in Paper Sludge

www.serecarb.millvisionweb.eu/

SERECARB is a currently running project, which started in February 2008 and has a duration of 24 months. It is coordinated by Jean-Yves Escabasse, from PTS Munich and Adrian Manoiu, from PTS Heidenau, Germany. It involves 6 institutions from 3 participating countries, namely Germany, Austria and Netherlands. SERECARB is an industrial research project. Currently, the paper industry is confronted with huge amounts of sludge. The sludge contains a high content of water, up to 40%, and a fair proportion of minerals, around two-thirds of the dry content, half of it being calcium carbonate. The project consists of developing a new process based on selective recovery of calcium carbonate from paper mill effluents and sludge, purification, conversion into precipitated calcium carbonate (PCC) and reuse as filler in paper making. The main target group of the project is deinking mills, which produce large volumes of effluent and sludge containing high amounts of calcium carbonate. The interest for deinking mills is, on the one hand, the reduction of effluent and sludge to be disposed of, and on the other hand the production of PCC, a raw material that can be used on-site, thus avoiding the purchase of fresh filler material. Alternatively, PCC can be sold to other mills or other industries. Expected results are a proof-of-concept, demonstration pilot plant and validation of the papermaking value of produced PCC.

6.2. Bilateral Projects

Based on the reported data, there is little R&D activity in the form of bilateral projects or cooperation on the European level. Activities of this kind are mainly taking place through the DIGIDEINK and FLEXO Task Forces/Projects, in which CTP (France) and INGEDE (Germany) have had successful cooperation through the years, dealing with deinkability properties and efforts to increase the deinking potential of digital and flexo prints. France and Germany, through cooperation between CTP and Pagora (France) and PTS (Germany), were involved in a project dealing with the understanding of the sizing of difficult pulps, namely deinked and high-yield pulps. Croatia and Slovenia, through a cooperation between the Faculty of Graphic Arts, University of Zagreb, and the Pulp and Paper Institute, Ljubljana, are involved in a bilateral project dealing with the deinking mechanism, a new formulation of the graphic materials and waste water.

6.3. National Projects

Reported R&D national projects are primarily classified according to the country (Table 1 on page 21). It is clearly visible from the data reported that, regarding the national projects, Germany and France (23 and 17 projects, respectively) are the main centres in Europe for RP R&D research. They are followed by Spain (9 projects), while other countries have a much lower number of reported projects (mainly one or two). There are also a few countries that have reported no recent or current national R&D projects, such as the United Kingdom, Bulgaria, Hungary and Italy. Finland (*), on the other hand, has a large Biorefinery programme, with more than fifty projects included. However, they are mostly indirectly linked to pulp and paper, so they are not mentioned as separate projects.

In addition to classification by country, data was further classified into six larger research areas which fit under the general RP scope. The defined research areas under which the projects are further classified are:

- Deinking Process and Furnishes (Deinking Process Improvements, DIP Characterization and Improvements); Stickies;
- Recycling Process and Recovered/Recycled Paper Properties in General; Others;
- Collection, Sorting; RP Trade Quality Issues;
- RP for Packaging Papers, Improvements;
- Recycling Process Rejects; Other Uses of RP; Biorefining.

For each research area, the total number of projects and number of projects per specified country is presented in the tables in Appendix 5. Ink and stickies removal is the most researched area with about 25 projects in total. The projects are equally distributed between the subtopics areas of Deinking Process and Furnishes, with each of them consisting of 10 projects, while the stickies research area consists of 5 projects. About half of the total number of projects in this research area belong to national projects of France, and make up over half its total number of projects as well. Germany, on the other hand, has national projects in all of the defined research areas, with projects dealing with ink and stickies removal, and RP for packaging papers make up over half of its total project count. The second largest research area concerns Recycling Process and Recovered/Recycled Paper Properties in General and Other subjects and consists of 12 projects. This is probably due to its widely defined project subjects, as the projects placed in this research area deal with general and other processes and properties. The rest of the research areas are about equally researched, with about 6 to 8 projects placed in each.

Country	Number of National Projects
Croatia	2
France	17
Germany	23
Finland	(see Appendix on page 174)
Latvia	1
Poland	1
Romania	2
Slovenia	1
Spain	9
Sweden	2

Table 1: R&D Projects reported by Country

CHAPTER TWO

THE STATUS OF PAPER RECYCLING IN EUROPE

1. Introduction

Paper is a recyclable material; recovered paper has therefore been a valuable raw material for the paper industry since the early 20th Century and today it is the most important single source of fibre used in papermaking, providing about half of the total fibre used for papermaking in Europe. The main drivers leading to increased paper recycling have traditionally been economic, i.e. limited availability and, hence, higher costs of virgin wood fibres, but during the last decade environmental and ecological concerns have become increasingly important. As the Paper Industry strives towards full sustainability, recycling becomes an ever more important component of the supply chain.

The aim of this chapter is to describe the present status of paper recycling in Europe and thereby to create a basis for an estimation of its future. This will include the following aspects, all of which are important for the understanding of paper recycling and its future:

- Definitions;
- Statistics;
- Collection and sorting systems being applied;
- Current composition and quality of recovered paper;
- State-of-the-art treatment technologies for recovered paper;
- Use of recovered fibres in different paper grades;
- Use of recovered paper for non-paper purposes;
- Market and trade issues;
- Legislation and regulations.

Aspects influencing paper recycling are thus not only of a technical, but largely also of an economical, ecological, social and legislative nature, all interrelated in a rather complex manner.

2. Definitions

Basic Definitions related to Recovered Paper & Calculation of Variables

There are several organisations which are responsible for the monitoring of recovered paper related definitions and corresponding calculation methodologies. These organisations include:

- **CEPI** (The Confederation of European Paper Industries)
- **ERPA** (The European Recovered Paper Association)
- **BIR** (The Bureau of International Recycling)
- **CEN** (The European Committee for Standardisation)
- **INGEDE** (International Association of the Deinking Industry)

The European Paper Industry needs commonly accepted methodologies and definitions, which could be adopted for use in all member countries, to define the grades and qualities of Recovered Paper. In this chapter, the COST Action E-48 has collected material and definitions from the above mentioned sources and commented on them with a view of developing recommendations for definitions to be used in recovered paper related research. This work could also be developed to provide updated methodologies and definitions relevant to commercial aspects of the trade in Recovered Paper.

Classification of Recovered Paper (European):

Used paper and board collected separately and in general processes according to the European Standard List of Recovered Paper and Board Grades EN 643.[9]

The list of European Standard Grades of Recovered Paper and Board (EN 643) divides recovered paper into 57 grades and gives a general description of the standard grades by defining what they do and do not contain. It clearly states that collected paper extracted from mixed waste streams in refuse sorting stations is not suitable for use in paper industry, even though this practice occurs widely.

In the EN 643 European List of Standard Grades the recovered paper grades are grouped to 5 main groups, which are subdivided into sub groups:

- Group 1 Ordinary grades (Sub Groups 1.01 – 1.11)
- Group 2 Medium grades (Sub Groups 2.01 – 2.12)
- Group 3 High grades (Sub Groups 3.01 – 3.19)
- Group 4 Kraft grades (Sub Groups 4.01 – 4.08)
- Group 5 Special grades (Sub Groups 5.01 – 5.07)

However, for many statistical and commercial purposes the recovered paper grades are divided into four main groups:

Mixed Grades:

Including other types of recovered paper e.g. mixed papers and boards (including EN643 grades 1.01, 1.02, 1.03, 5.01, 5.02, 5.03, 5.05). In Eurostat trade statistics, HS code: 470790.

OCC:

Old Corrugated Containers; kraft sack and wrapping paper (old and new) i.e. containing mainly unbleached sulphate pulp. CEPI classification: Grades for Corrugating (including EN643 grades: 1.04, 1.05, 4.01, 4.02, 4.03, 4.04, 4.05, 4.06, 4.07, 4.08, 5.04). In Eurostat trade statistics, HS code: 470710.

ONP & OMG:

Old Newspapers and Magazines; old and over issue newspapers and magazines, telephone directories, brochures etc. (including EN643 grades: 1.06, 1.07, 1.08, 1.09, 1.10, 1.11, 2.01, 2.02). In Eurostat trade statistics, HS code: 470730.

HG & PS:

High Grade Deinking and Pulp Substitutes; woodfree printing and writing papers, bleached board cuttings and other high-grade qualities coming mainly from printing plants and converters, as well as from offices (including EN643 grades 2.03, 2.04, 2.05, 2.06, 2.07, 2.08, 2.09, 2.10, 2.11, 2.12, 3.01, 3.02, 3.03, 3.04, 3.05, 3.06, 3.07, 3.08, 3.09, 3.10, 3.11, 3.12, 3.13, 3.14, 3.15, 3.16, 3.17, 3.18, 3.19, 5.06, 5.07). In Eurostat trade statistics, HS code: 470720.

Comment:

The purpose of the standard is to classify recovered paper for subsequent recycling and to ensure that recovered paper is not to be considered as ‘waste’ by the industry and society. Most European countries have developed their own internal, historical classification system for recovered paper. However, it is important that EN 643 should be adopted for use in all EU member states, not least of all to simplify cross border trade.

The EN 643 description of the standard grades is brief, and for this reason additional special specifications between buyer and suppliers are necessary.

Definitions related to recovered paper grades and calculation of different variables may vary considerably from country to country. That is why, in many cases, precise comparison between different grades in different countries is not always possible and values of different variables are not exactly comparable between countries and some geographic regions.

The current EN643 standard is the subject of much debate and criticism, with the fundamentals elements of a new standard gradually emerging. Any future revision of EN643 is likely to incorporate amendments to the grouping system to accommodate the current needs of the Recovered Paper Industry Sector and the Pulp, Paper & Board Sector.

Classification of RP (USA):

In the USA the recovered paper classification system: “Guidelines for Paper Stock: PS-2008” defines a much broader area, including various aspects of the contract, including:

I.) The purchase agreement
II.) Fulfilments by the seller
III.) Fulfilments by the buyer
IV.) Miscellaneous practises
V.) Arbitration
VI.) Grade definitions.

Comment:

The United Stated system defines the allowable shares of prohibited materials and total “out throws” (contaminating materials) by individual recovered paper grade. That is why the US classification is easier (than the EN 643) to use as a guideline in recovered paper trade. When the European classification system is revised, more detailed definitions in this respect should be considered

Collection of paper and board:

Separate collection of paper and paper products from industrial and commercial outlets, from households and offices for recovery. (Collection includes transport to the sorting/processing or recycling plant/paper mill).[16]

Comment:

Usually, statistical collection figures are based on apparent collection (utilisation plus exports and minus imports of recovered paper). It is difficult to get reliable collection data from recovered paper collectors because fragmentation in the sector is fragmented and the large number of companies / organisations involved. That is why collection in most countries is calculated from utilisation and net trade figures. Paper industry sources usually supply reliable information for recovered paper utilisation, but recovered paper utilisation volumes in other end use sectors, such as moulded products, insulation and composting are not well documented.

This, however, leads to a belief that actual recovered paper total collection and utilisation figures may already be higher than the official statistics indicate.

Collection rate:

The ratio between collection and consumption of paper & board in a given region.

Comment:

The collection rate refers to total recovered paper collection. However, today over half of all fibre used by the paper and board industry globally is recovered paper. That is why it is vital to define a commonly accepted calculation methodology for the collection rate of individual recovered paper grades. This means that the collection rates of each individual recovered paper grade (ONP & OMG, OCC, HG & PS and Mixed grades) would have to be compared with corresponding paper and paperboard consumption figures, for instance:

- ONP & OMG compared with newsprint and wood-containing printing & writing paper;
- OCC compared with containerboard;
- HG & PS compared with woodfree printing & writing papers;
- Mixed grades compared with carton boards and other paper & board grades.

Even so, this system would still not give a precise picture of the collection activity, but if generally accepted, would better describe the situation. A more detailed calculation system for collection activities is needed.

Energy recovery:

Incineration of recovered paper (RP) in power plants with power or heat generation and use.[19] In some EU member states this is described as ‘Energy from Waste (EfW), which presupposes that recovered Paper is considered to be a ‘waste’.

Moisture:

Recovered paper and board should normally be supplied with moisture of not more than the naturally occurring level i.e. in equilibrium with the atmosphere. This is normally taken to be a maximum of 10% moisture.

When the moisture content is higher than 10% (of the air-dried weight), the reduced fibre present (attributable to the moisture in excess of 10%) may be reclaimed as a discounted price for the material to reflect the quantity of fibre present.

Comment:

The EN 643 standard includes general definitions for unusable materials, paper and board considered detrimental to production and non-paper components. However, no exact limits for the 'acceptable inclusion rates', e.g. unusable material by individual recovered paper grade, are given. This makes it necessary for both the buyer and the seller in the recovered paper trade to have a mutual understanding and agreement regarding the quality issues for each transaction.

Clear guidance concerning these issues must be taken into account when updating the definition system in Europe, i.e. during a revision of EN 643.

Non paper components:

These consist of any foreign matter in the recovered paper and board which, during subsequent processing, may cause damage to machines or interruptions to production, or may reduce the value of the finished product, such as: metal, plastic, glass, textiles, wood, sand and building materials, synthetic materials and synthetic papers.[9]

Paper consumption:

A country's Paper consumption is used in calculating the paper collection rate, as it is generally assumed to describe the paper and board collection potential in a country. In Europe (CEPI) the paper and board consumption is calculated through domestic deliveries and paper imports. In other regions, apparent paper consumption (paper production + net trade of paper) is the most common means to calculate paper consumption.

Comment:

The most reliable means to estimate the paper collection potential in a country would however be a "modified paper consumption" which takes into account the net trade volume of traded converted paper and board products as well as boxes and papers used for packaging of imported goods.

Paper Recycling:

The reprocessing of recovered paper in a production process either to produce saleable paper or to produce some other saleable product, typically this includes composting but excludes energy recovery.[16, 19]

Comment:

The reprocessing to convert recovered papers into saleable paper (processing into new paper and board), which is the total amount of recovered paper for paper industry utilisation, can be defined quite reliably by using e. g. CEPI statistics.

There appears to be no reliable, coherent data about RP utilisation available outside the paper industry in Europe.

Recovered Paper (RP):

Used paper and board separately collected and in general processed in accordance with the European Standard List of Recovered Paper and Board Grades.[16]

Recovered Paper Collector:

An organisation or individual who separately collects used paper and board; they may also be involved in processing (sorting, handling), transport, and trade activities.[16]

Comment:

In the future, the waste management companies' role in the paper collection chain seems likely to become more important than it is today. Therefore more attention should be paid to controlling separate collection/sorting of recyclables like paper and board. The EU waste hierarchy clearly favours material recycling over recovery (including energy use). However, should recovered paper be 'contaminated' during the waste collection process, recovery for energy generation is permitted. That is why recovered paper should in all circumstances be treated as raw material, not as waste.

Recovered Paper Utilisation:

Use of recovered paper as raw material put into the pulper at the paper mill.[17]

Recovery:

The underlying principle of waste management policy, including re-use, material recycling, composting and energy recovery as well as exports to similar purposes[18]

Recycling rate:

The ratio between RP utilised for Recycling including RP net trade, and paper and board consumption.[16]

Sorting:

Manual sorting: Labour-intensive process of materials separation into distinct classes done by hand according to different paper and board grades.

Mechanical sorting: Process of separation, done by machines, based on the physical properties of the materials such as size, stiffness or weight. In mechanical sorting different units exist, such as screens (disk, star, drum screens), ballistic separators, gap separators (acceleration of material over, or into, a gap between conveyor belts) or "paper spikes".

Automatic sorting: Process of separation based on mechanical sorting coupled with sensors, such as: colour cameras, colour sensors or near infra-red sensors.

Sorting efficiency:

Ratio between refused and total unwanted materials detected.

Sorting purity:

Quantitative assessment of homogeneity after sorting. Ratio of the amount of desired paper or board from one grade to the total amount of materials accepted during sorting.

Utilisation rate:

The ratio between recovered paper utilisation and paper & board production.[17]

Waste:

Any substance or object which the holder discards or intends or is required to discard.[16]

Comment:

Paper and board products, once they have been collected and processed for further recycling, become a valuable secondary raw material and should no longer be considered as waste.

Unusable materials:

Material unusable in the production of paper and board typically consisting of "non-paper components and paper and board detrimental to production". Recovered paper and board should in principle be supplied free of unusable materials, but for where specific grades a certain proportion of unusable materials can be agreed upon between purchaser and supplier, it shall refer solely to the element described as "paper and board detrimental to production".

3. Statistics

3.1. General

As stated previously, globally, recovered paper is already the most important source of fibre in paper and paperboard manufacturing. In 2006 the global paper and board industry used 196 million tons of recovered paper in the production of 383 million tons (these figures do not include recovered paper utilised outside the paper industry). Thus the global recovered paper utilisation rate was about 51%. Global consumption of other fibrous raw materials was as follows: 43 million tons of mechanical & semi-chemical wood pulp, 131 million tons of chemical wood pulp, and 17 million tons of non-wood fibres.

The importance of recovered paper as a raw material in the paper industry has increased dramatically during the last decade. In 1996, recovered paper provided 40% of all fibre used in the paper industry. By 2006 this share had increased to 51%.

Basically, the global paper and board production equals the consumption. At the same time the recovered paper utilisation equals the collection, globally. This means that the global recovered paper collection rate is 51% as well. However, there are significant regional variations between recovered paper collection and utilisation.

The recovered paper utilisation and collection rates do not necessarily reflect the true situation (fibre recycling) because in most cases the recovered paper that is collected, delivered to a paper mill and loaded into a pulper does not include only fibre but also several other substances such as minerals, starch, additives, inks, coating materials, non-paper components etc.

In addition, the amount of process losses varies depending on paper and board grade, e.g. in packaging grades the average process loss varies from 8% to 12% and in publication papers from 15% to 20%. In tissue production the losses can be between 35% and 40%. The amount of losses depend on the quality demands of the produced paper and board itself as well as the quality and grade of the input recovered paper.

Thus, official collection and utilisation rates do not exactly describe fibre recycling but give an average picture about paper and board rotation.

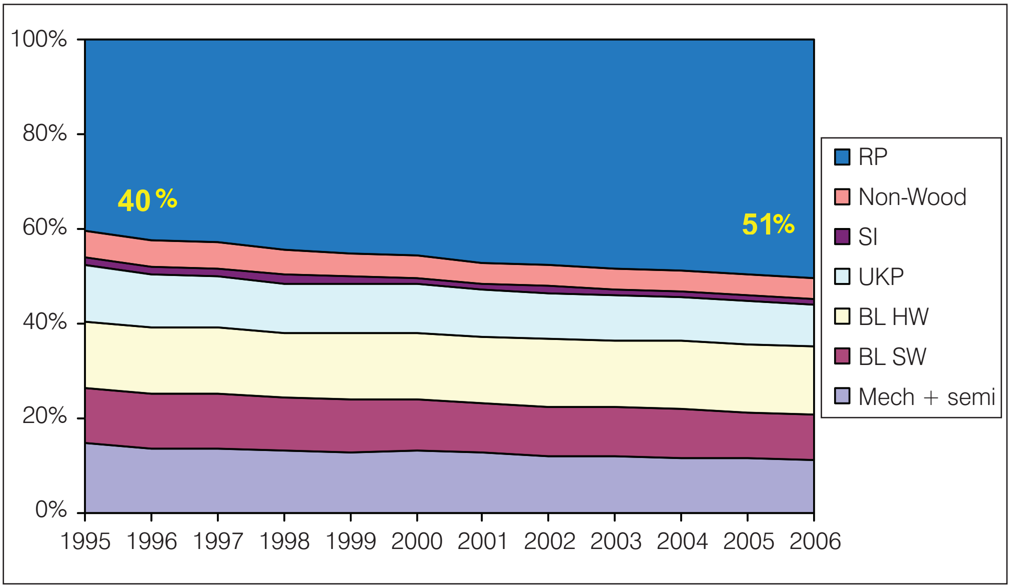


Figure 1: World – Shares of different paper & board industry fibres of consumption 1995-2006 *(Source: Pöyry)*

3.2. Recovered Paper Collection

Due to the large number and various sizes of organisations involved in the collection of recovered paper, there is no reliable basic collection data available in most countries. Normally, collection volumes are therefore calculated through recovered paper consumption and trade statistics.

There are great differences in collection volumes and collection rates between countries. A limited number of countries collect the main share of all recovered paper, globally. In 2006, the thirteen most important countries (Figure 2) collected 153 million tons or 78% of all recovered paper, globally. These countries include the USA, Japan, China and Germany which together collected 55% of all recovered paper globally.

In countries where the collection potential, i.e. the paper and board consumption per capita and the level of environmental consciousness is high, the collection rate is also high and well above the global average. These countries include industrialised countries such as the Republic of Korea, Japan, developed Asian countries and most

European countries. In the USA, the collection rate is slightly above the global average. In China and developing countries with a low per capita paper consumption (and low environmental consciousness), the collection activity is well below the global average collection rate of 51%.

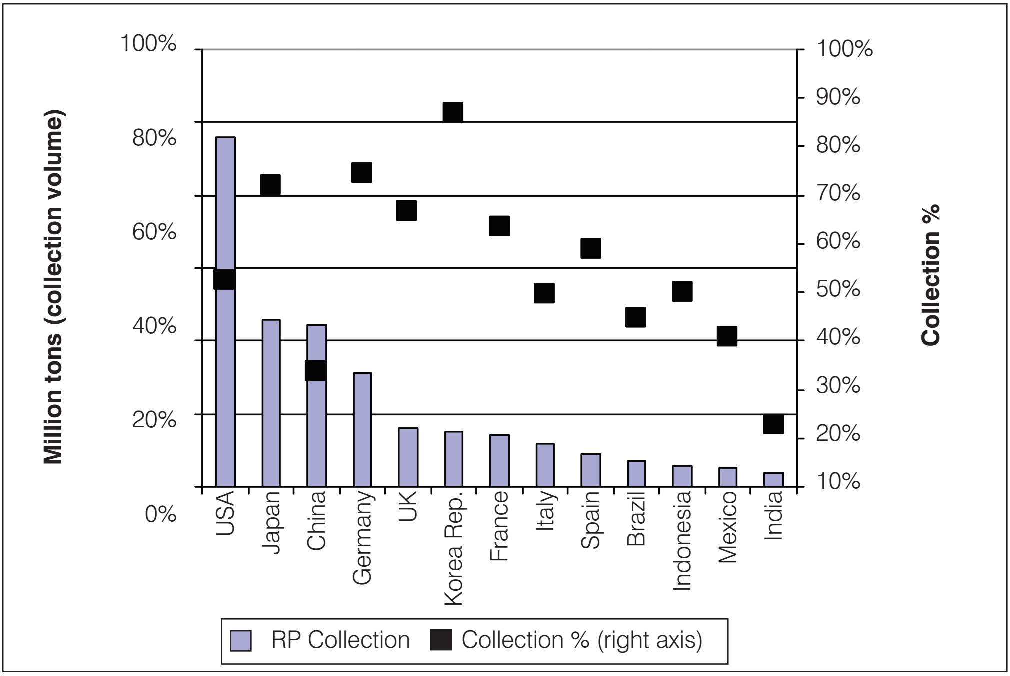


Figure 2: Recovered paper collection volume and collection rate in selected countries in 2006
(Source: Pöyry)

Historically, the collection rate has only been calculated for total recovered paper. This is quite understandable as the collection rates have been modest and there has been no shortage of recovered paper.

When developing recycling, easy sources such as trade, converting and industrial sources in densely populated regions are typically exploited first. However, effective collection requires utilisation of household and office sources to achieve reasonable collection rates.

Usually, companies planning new investments in recycled paper based production are not interested in "general" total recovered paper figures but in the localised availability of individual recovered paper grades such as white grades, OCC and Old Newspapers & Magazines. Therefore the idea to separately calculate the recovered paper collection and collection rate for the main grades has been extensively discussed. The availability of this kind of information would make it possible to analyse and compare collection activity and availability of different grades in different countries or other geographical areas. This is especially important due to an widely predicted shortage of the best recovered paper grades in international markets.

The recovered paper collection rate is the relation between paper collection volume and paper consumption. When calculating the collection rate for an individual RP grade, the collection volume of a RP grade should be compared to the consumption of corresponding paper and board grades. So far, collection rates have not been calculated for individual recovered paper grades because a generally accepted calculation methodology simply does not exist.

3.3. Recovered Paper Utilisation

Recovered paper utilisation volumes and utilisation rates vary greatly by country. In 2006 the thirteen most important countries (Figure 3) utilised 155 million tons of recovered paper. This is about 79% of the global RP utilisation. Already the most important four countries, namely China, the USA, Japan and Germany utilise over 108 million tons, or 55% of global recovered paper.

Not surprisingly, countries with vast forest resources and a strong wood pulp industry have based their raw material sourcing on virgin fibres. In these countries the recovered paper utilisation rate has been modest, i.e. below the global average. These countries include the USA, Canada, the Nordic countries, Russia and Brazil. The low utilisation rate in a country is not necessarily a result of a low recycling activity; it can reflect the fact that paper production considerably exceeds the paper consumption.

For example: in the Nordic countries, the paper production was about 28 million tons in 2006. During the same year the paper consumption was 4.4 million tons. In spite of a high collection activity (3 million tons and average collection rate, based on paper

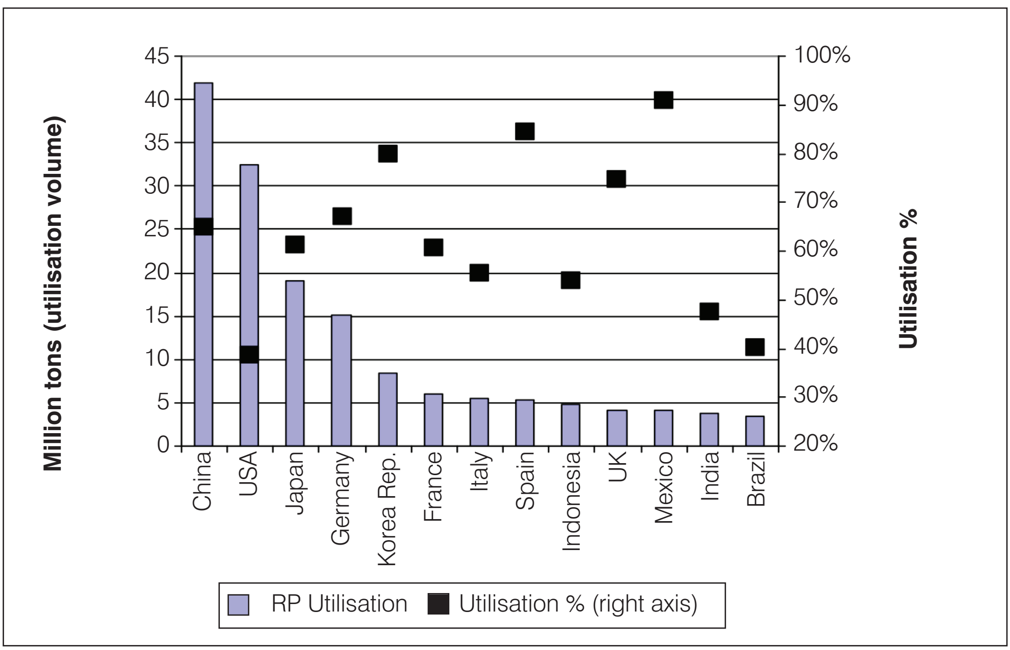


Figure 3: Recovered paper utilisation volume and utilisation rate in selected countries in 2006
(Source: Pöyry)

consumed in the region. of about 70%), the utilisation rate was only about 11%. The majority of paper produced was exported, consumed and recycled in other countries. Due to the differing structure of internal markets, the utilisation rate of an individual country is not a valid metric describing recycling activity. In fact, due to the growth in international trade, the collection rate (rather than the utilisation rate) is a more reliable reflection of the recycling activity in a specific region or country.

Countries with considerably high paper and board production but limited forest resources and pulp industry have effectively utilised recovered paper in their production. These countries include e.g. Japan, Germany, the UK, Spain, China, the Republic of Korea and Mexico.

In general, the "collection rate" provides the best benchmark for the importance given to "recycling" by the society within a given region, state or country.

3.4. European Recovered Paper Statistics

As a geographical region, Europe consists of over 40 distinct member states. When considering recycling statistics, there is no unambiguous concept of 'Europe'; therefore it is impossible to provide exact figures for European paper production or recovered paper collection.

European countries may be divided into different country groups such as the EU (27 countries) or the CEPI (Confederation of European Paper Industries) group, which has 18 member countries. The member states participating in the COST E-48 Action is also a country group and consists of 18 member countries (as described elsewhere in this book).

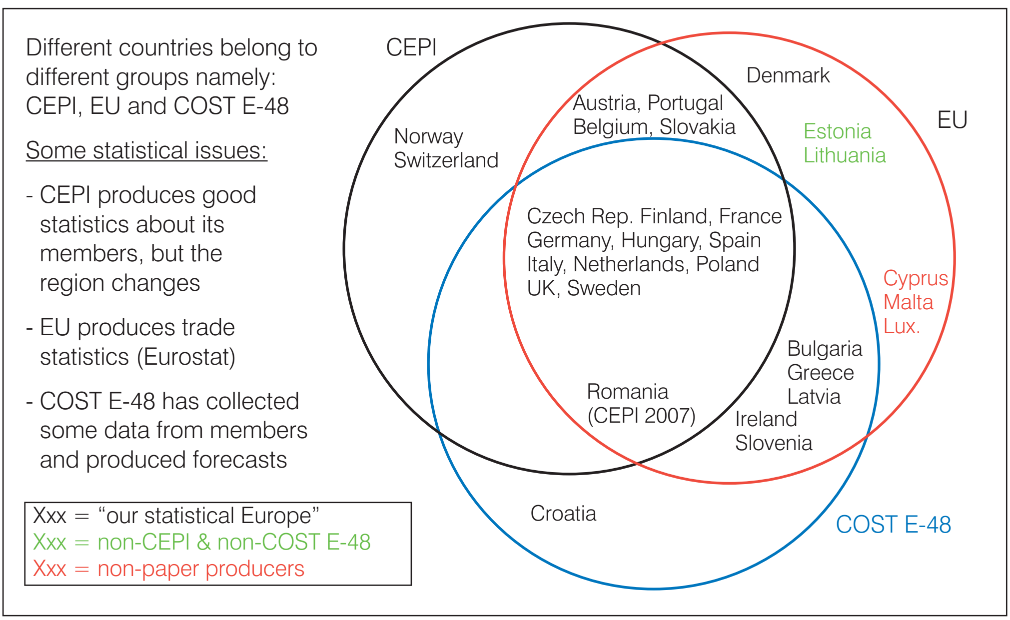


Figure 4: Different country groups (EU 27, CEPI and COST-E48) *(Source: Pöyry)*

2006 1000 tonnes	Country Group	Paper & Board		Recovered Paper			
		Production	Consumption	Collection	Utilization	Collection %	Utilization %
Austria	2	5213	2113	1502	2384	71.1	45.7
Belgium	1	2056	3833	2295	1136	59.9	55.3
Bulgaria*	3	201	326	117	121	35.9	60.2
Croatia	6	251	319	99	195	31.0	77.7
Czech Republic	1	1042	1474	644	456	43.7	43.8
Finland	1	14149	1209	858	734	71.0	5.2
France	1	10003	10911	6999	6050	64.1	60.5
Germany	1	22655	20807	15546	15244	74.7	67.3
Greece	3	510	1245	430	429	34.5	84.1
Hungary	1	546	876	475	419	54.2	76.7
Italy	1	10008	11694	6001	5578	51.3	55.7
Latvia	3	73	131	72	50	55.0	68.5
Netherlands	1	3367	4120	2888	2346	70.1	69.7
Norway	5	2109	876	673	474	76.8	22.5
Poland	1	2855	3924	1393	1019	35.5	35.7
Portugal	2	1630	1061	626	340	59.0	20.9
Romania*	3	392	678	267	263	39.4	67.1
Slovakia	2	889	491	245	197	49.9	22.2
Slovenia	3	700	394	160	365	40.6	52.1
Spain	1	6353	7856	4638	5371	59.0	84.5
Sweden	1	12066	2271	1536	2037	67.6	16.9
Switzerland	5	1698	1656	1279	959	77.2	56.5
UK	1	5589	12298	8015	4172	65.2	74.6
Total		**104355**	**90563**	**56758**	**50339**	**62.7**	**48.2**

Country group code describes the country and its membership in different country groups:

1 – EU (27)+CEPI+COST E-48

2 – EU (27)+CEPI

3 – EU (27)+COST E-48. *Romania and Bulgaria EU member since 2007

4 – EU (27)

5 – CEPI

6 – COST E-48

Table 2: Selected European countries - Paper & board and recovered paper statistics in 2006

Countries with a long history of paper manufacture have generally developed good statistical systems. CEPI acts as a central repository of this information and regularly updates statistics of its member countries.

Whilst all European countries consume paper, some European countries are very small and/or they do not have paper or board production of their own. Reliable statistics, concerning paper and recovered paper, is available only for some of these countries.

Over many years CEPI has developed a robust statistical system to collect and process data from national member associations. However, due to confidentiality reasons (e.g. only a limited number of companies in some countries or paper grades), the detailed raw data is not available for public distribution. Based on this data, CEPI is in a position to provide aggregated data related to recovered paper in a format where no individual company can be identified. A reliable system to collect and analyze annual data from all EU-member states needs to be developed as a part of an overarching need to develop a detailed reporting system where information is divided by recovered paper grade. This can only be achieved with active industry participation.

Some of the countries belong to more than one of the groupings. Table 2, opposite, summarises paper & board and recovered paper statistics in selected European countries. Countries with small paper and board production, missing statistics or lack of reliable historical time series are not included in the table.

3.5. Europe – Recovered Paper & Other Fibres

An interesting phenomenon of recovered paper is that due to recycling the same fibre multiple times, an individual fibre may be included in the statistics more than once. The fibre starts its life in the forest and may be harvested and used (amongst other things) for pulp production. The pulp will be used to make paper which, after use, is either collected for recycling (returning the fibre to the loop) or disposed of (removing the fibre from the loop).

The European fibre flow can be illustrated by using an allegory of a waterwheel. The wheel does not rotate without a virgin fibre injection to drive the wheel. Europe is a net exporter of recovered paper and board, so some fibres are exported from Europe as paper. On the other hand, Europe is a net importer of paper and board which is being imported together with goods, mainly from Asia and especially China.

In 2005 the EU recovered paper collection rate was 62.5%. This means that 55.6 million tons of paper and board was collected for recycling. The EU exported about 7 million tons of recovered paper outside the region, mainly to Asia. Finally 48.7 million tons were utilised in paper manufacturing, but due to process losses and related factors about 85 to 90% of this volume (about 43 million tons) ended up in the paper or board product. Thus, a continuous injection of virgin pulp is necessary to keep the waterwheel rotating.

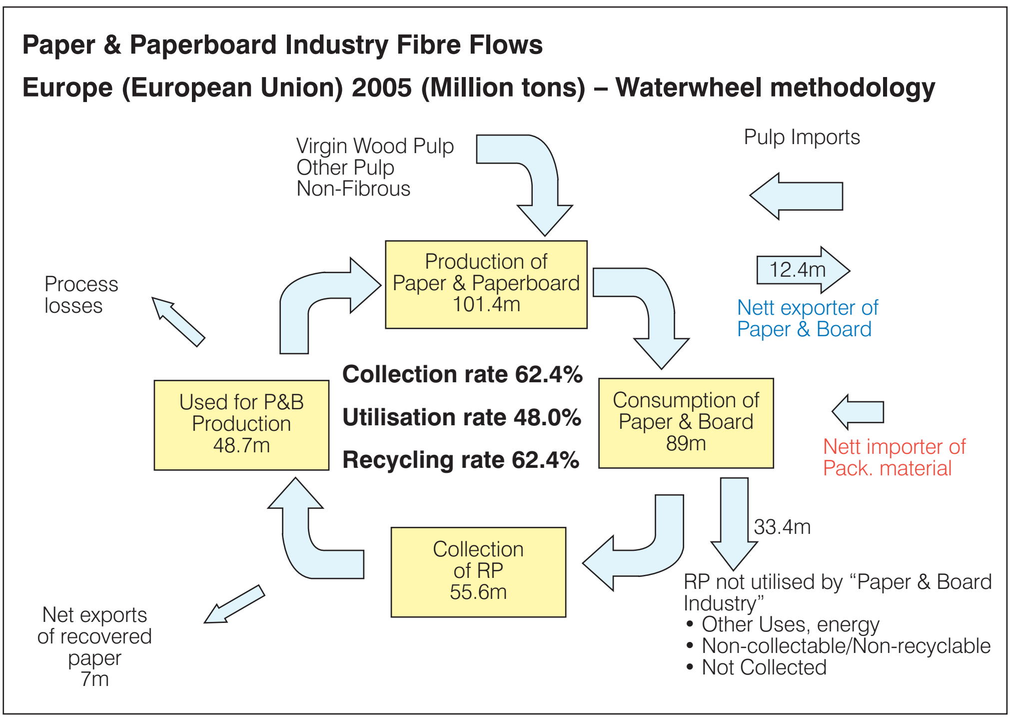


Figure 5. Paper and Paperboard Industry Fibre Flows in Europe in 2005
(Source: Pöyry)

Whilst it is possible to produce some individual paper and board grades by using 100% recovered paper as raw material on a regional basis (such as Newsprint production in the UK), recovered paper cannot be the sole raw material on a larger european wide or global scale.

Without the injection of virgin fibre and other raw materials, like minerals and additives, the European waterwheel would cease rotation within a few months.

3.6. Europe – Historical Development & Forecast

When seeking to establish the future limits of paper recycling it is essential to review the historical development to try to find general patterns in the market as well as to predict development trends for the future.

COST-E48 carried out a forecasting project to analyse the historical development and to forecast future development in Europe. This project included 25 European countries which have or have had paper production. The countries were divided into four geographical regions:

- **Northern Europe:** Finland, Latvia, Norway and Sweden;
- **Western Europe:** Austria, Belgium, Denmark, France, Germany, Ireland, The Netherlands, Switzerland, and the UK;
- **Southern Europe:** Greece, Italy, Portugal, Slovenia and Spain;
- **Eastern Europe:** Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovakia.

The study region consists of countries from within the EU, CEPI and COST E48 boundaries. However, the total study region is large enough to be regarded as quite reliably representing the general development in the wider Europe.

Members of the COST Action E48 interviewed paper industry experts in 16 countries during the early part of the year 2008. When taking into account different variables i.e. paper production, paper consumption, recovered paper collection and recovered paper utilisation, the interviews covered 85.2 to 87.9% of the total European volume in each of the categories. Thus the results of the interviews can be considered as giving a reliable overview of the future development of the entire European paper industry.

Historical data (1995 – 2005) covers all countries. Statistical material was sourced from CEPI and Pöyry data banks. The reliability of the data for individual countries was verified by the appropriate national representatives of the COST-E48 action.

In case of a “no” answer from an individual country for future development (from the base year 2005 up to 2015), the country in question was assumed to follow the average pattern of other countries within the same country category.

The main findings of the project for the study region include, for the period from 2005 to 2015:

- Paper and board production is forecast to grow from 101 to 122 million tons;
- Paper and board consumption is forecast to grow from 91 to 101 million tons;
- Recovered paper collection is estimated to grow from 55 to 71 million tons;
- Recovered paper utilisation is estimated to grow from 49 to 62 million tons.

The downturn in global business activity which started in the latter part of 2008 and rocked both the financial and the industrial sectors may, at best, delay these developments.

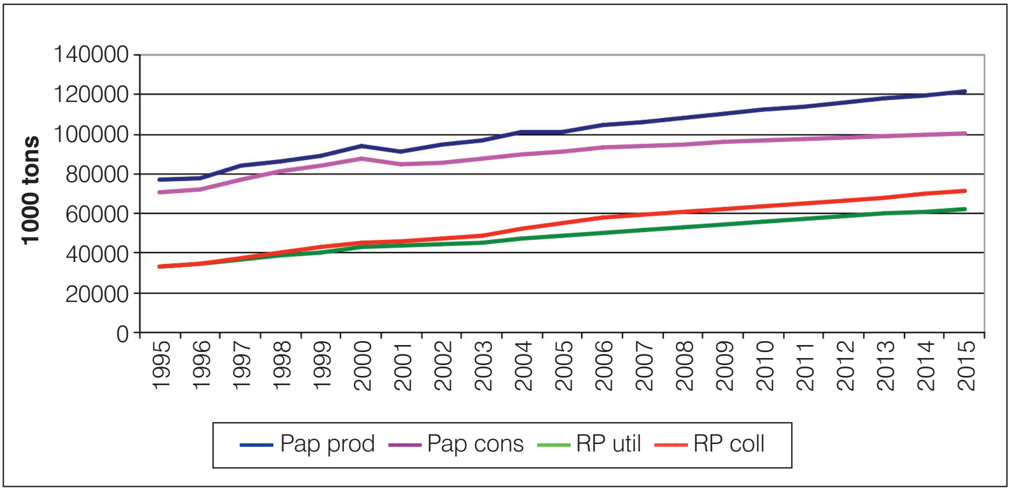


Figure 6: Forecast development of paper production and consumption, recovered paper utilisation and collection in the European study region 1995 to 2015

Recovered Paper Collection Development

The recovered paper collection rate is predicted to grow in the study region (total Europe) from 60% in 2005 to 71% by 2015. This corresponds to a potential increase of 16 million tons of paper collected in Europe.

Western and northern Europe have the highest collection activity in the past and these regions will continue to be active collectors in the future.

Both southern Europe and eastern Europe are expected to increase collection activity in the coming years.

The increase in the volume of paper collected will be somewhat bigger than the volume utilized in Europe.

Collection rate forecasts (based on the study results) are shown in chart on Figure 7.

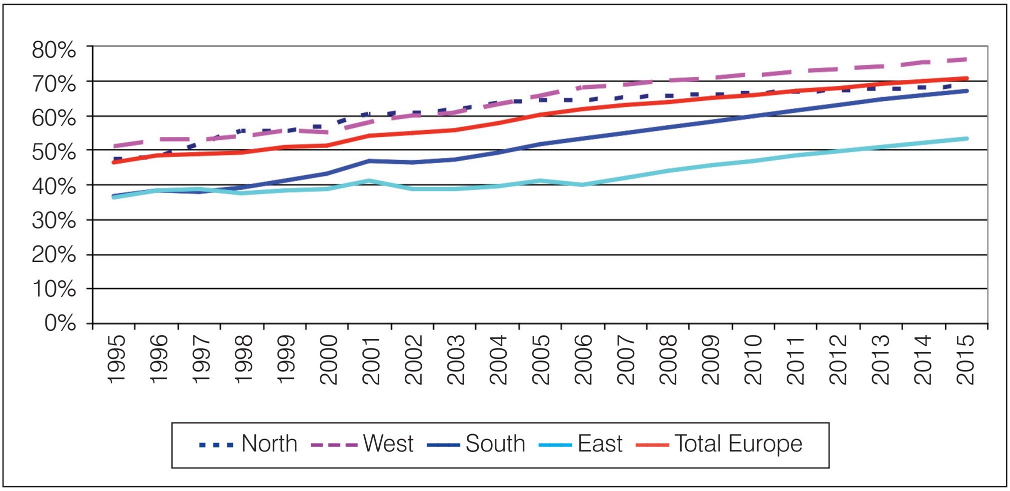


Figure 7. Recovered paper collection development in the European study region 1995 to 2015 (forecast)

Recovered Paper Utilisation Development

For the whole study region (total Europe) the recovered paper utilisation rate is forecast to grow from 49 million tons to 62 million tons, i.e. from 48% in 2005 to 51% by 2015.

However, due to reasons mentioned earlier, great regional differences occur and will continue to do so.

In southern and western Europe the utilisation rate has historically been highest. By 2015 the utilisation rate in both of these country categories is predicted to reach a level of 65%.

The utilisation activity is expected to grow fastest in eastern Europe, a growth from 40% in 2005 to 54% by 2015. This suggests that a great number of new paper industry projects are expected in this region to utilize additional recovered paper as raw material.

In northern Europe the recovered paper utilisation rate is expected to stay at the present level in the future i.e. close to 12%.

The study also indicates that the overall volume of recovered paper utilized in Europe will increase less than the volume collected. This would suggest that the export of recovered paper from Europe could increase from the present level, but above all it implies that the availability of recovered paper should not limit the production of recovered fibre based paper in Europe. The availability of certain grades of sufficiently high quality could, nevertheless, become an issue.

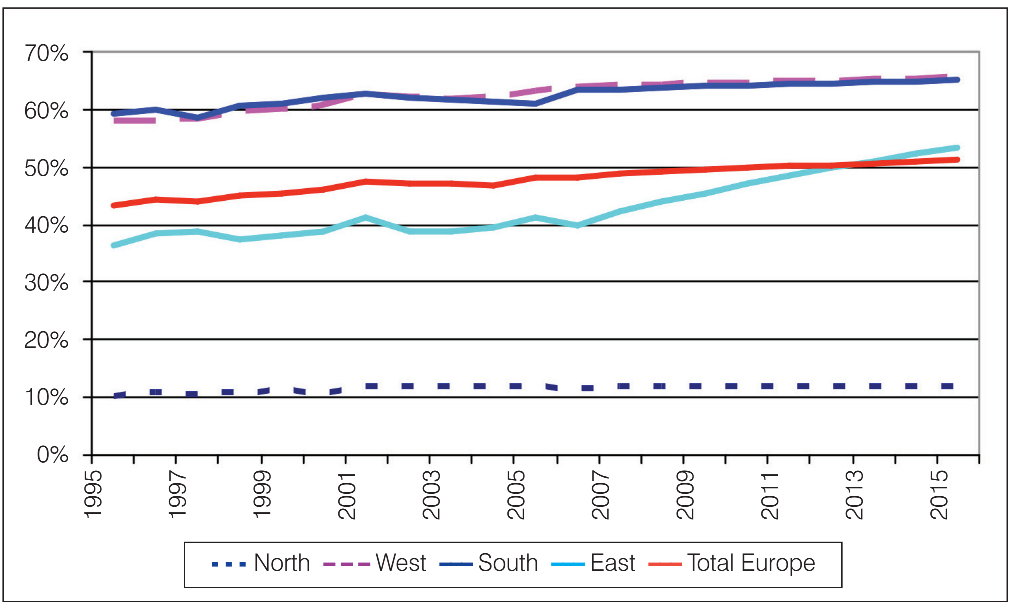


Figure 8: Recovered paper utilisation development in the European study region 1995 to 2015 (forecast)

4. Collection & Sorting Systems

4.1. Different Types of Collection Systems

Kerbside - door-to-door collection systems, where household is asked to leave their recyclable wastes on the kerbside on specified dates to be separately collected for recycling. Concerning paper and board kerbside collection, it has to be properly prepared (without plastic wrappings and inserts, the cardboard flattened) and packed (some countries require use of special bags or the municipality might provide a special container (bin) or the public are asked to secure papers (with string) for collection).

Blue Bins – convenient, easy-to-use wheeled bin collection for recycling paper and board from households. The blue bin is provided to households to allow separation and storage of paper and cardboard for recycling. The contents of the bin are collected by special services and taken to a materials recovery facility where they are sorted. There are different sizes of blue bins but their volume normally does not exceed 360 litres. Bins are collected from the kerbside every few weeks, depending on the service, according to scheduled collection dates.

Public Containers – system based on placing containers of different colours for separation of different wastes within the community. Containers must be accessible to all and the spacing of containers should be set to be within easy reach of all citizens (i.e. not too far distant from the home).

Recycling Yards – system requiring the waste producer (consumer) to carry the recycling materials to a specific location, where containers for different categories of recyclable materials are available.

Collection Shops - places where paper and cardboard can be sold. Shops pay for grades of recovered paper: mixed, white, OCC and Old Newspapers and Magazines. To maximise the price paid for the recovered paper, people are encouraged to sort it before selling. Usually this kind of collection technique does not need any further sorting.

Recycling Centres (see Recycling Yards) – designed for all types of waste, usually operated by municipalities. These are manned sites, where people can bring their recyclable wastes. Recycling centres frequently contain material reclamation facilities.

Drop Off Recycling Parks – special places, where you can deposit separated paper and board or other wastes. Drop-off recycling park resembles other recycling facilities with recycling bins, but there are containers underground for storing larger amounts of waste.

Generally speaking, the way of collecting recovered paper depends on the collection region (rural, urban), its characteristics (population and housing structure, kind of industry) and customers for the collected recovered paper

Recovered paper and board collection may be categorised as:

- Industrial collection (from businesses)
- Private collection (from households and individuals)

Collection from industrial operations is recovery from business operations and sites where unwrapping is carried out (e.g. supermarkets), offices, authorities and administration, including the return of recovered paper from converting facilities (e.g. printing houses and corrugated board plants) as well as over–issues (the surplus) of news and magazines.[1] The basic division of collection methods for recovered paper is presented in Figure 9.

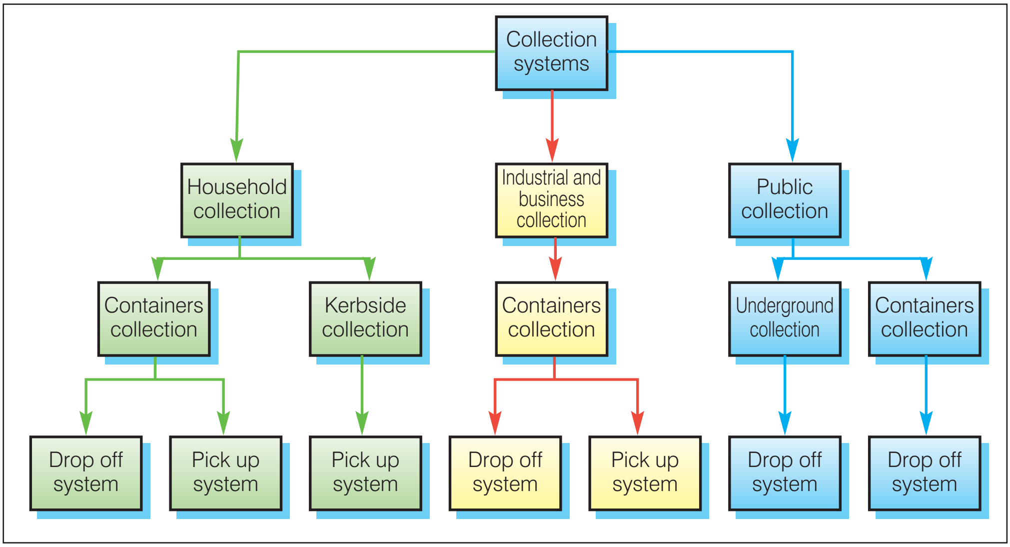


Figure 9: Basic collection systems [2]

In highly developed countries with an established high collection rates, the ratio of material generated between these two sources, as a percentage total collection, is approximately equal. The situation changes in countries with low collection rates, where collection systems are mainly focused on industrial sources. Experience shows that industrial and commercial paper and board collection is much more easily carried out and often referred to as the 'low hanging fruit'. Countries with high collection rates have a capacity to collect more than 90% of the used paper from industrial collection sources, as demonstrated by The Netherlands, Spain and Germany.

In countries where the collection system is in the early stages of development, the industrial paper collection is the primary source of recovered paper. Additional effort is made to collect paper from paper, printing and converting firms, which provides a high quality recovered raw material. It is therefore important to keep collecting this material separately.

In contrast, households and public collection is more difficult and a multitude of different collection methods have been developed. There are several collection systems already in existence: kerbside collection, blue bins, public containers, recycling yards, collection shops/centres or drop-of recycling parks. One of the most common techniques of collecting paper used in the majority of countries is the blue bins and similar container systems. Less economically developed countries are now introducing similar systems. Unfortunately, in the early stages the efficiency of these systems is not high. It is affected by an insufficient number of containers and the inconvenience of accessibility in parallel with low consumer awareness.

In well established systems, such as Germany, where paper collection through blue bins was introduced much earlier and has become a part of everyday life, this gives the best results. Unfortunately, blue bins are not suitable for board, as its stiffness and volume hinders collection. Therefore, in Spain a "door-to-door" system is being introduced for collecting board. Kerbside collection is practiced in many countries and gives satisfying results. In comparison with recycling yards or recycling centres, where people have to transport their wastes by car, this method is more accessible for people.

In some countries (Bulgaria for example), the main portion of recovered paper originates from collection shops. People manually sort paper themselves to secure a better price. The advantage of this kind of collection system is that no further sorting is needed.

It has been said that the paper arising from industrial and commercial sources is the easiest, cleanest and most economical to collect. Nevertheless, the predicted demand for recovered paper and board is anticipated to grow substantially, outstripping the quantity of material available via this route; which is why it is so important that other sources and collection methods are being developed.

The type of recovered paper can be classified in a few ways, depending on the following classification factors:

- Composition: Recovered paper is classified into main groups which in turn consist of several grades
- Pre- and post-consumer recovered paper: Depending on where the recovered paper was extracted from the supply chain, it is defined as pre-consumer recovered paper or post-consumer recovered paper.

Post-consumer recovered paper	Pre-consumer recovered paper
Comprises paper, board, and fibrous material recovered from retail stores, material collected from households, offices, schools, clubs etc. That kind of raw material can be collected at each individual point of generation (so-called pick-up collection system), from kerbsides by collecting associations, material can be also carried to a centralized collection point by consumers.	Is defined as paper and cardboard material recovered from manufacturing and converting. Pre-consumer recovered paper collection, in the form of over-issues and converting residues such as shavings and cuttings requires pick-up systems, traditionally organised via the recovered paper dealers, who use containers at individual points of generation. Most pre-consumer collections are handled in the pick-up mode.

Table 3: Post and Pre-consumer recovered paper[2]

To maintain a satisfactory level of collection and purity of collected material, not only is it necessary to identify suitable locations for the containers (clean, accessible by automobile and close to home) should be ensured, but also a balanced division of activities (promotion of separate collection, sorting at source etc.) must be encouraged[2, 3]

4.2. Correlation between Collection System & Collection Rate

There is no direct correlation between the collection system and the collection rate. According to a survey carried out within the COST Action E48, in which various collection and sorting systems in different European countries were studied, neither the type nor the share of the different collection systems utilised seemed to have a significant influence on collection rates. Similar collection rates can be seen to be obtained in different countries with different collection systems as:

- municipal (or state) organisations;
- municipal + private organisations;
- municipal + private + others organisations (charity organisations, etc.).

A well functioning, robust collection system is essential, but the kind of system does not seem to be really important. The quality of recovered paper, however, is greatly affected by the collection system (see chapter on page 41).

It is also necessary to point out that collection systems generally evolve with the collection rates. In the case of countries with low collection rates, the major source of recovered paper is commercial and industrial collection, and consequently the collection systems are adapted to collect this type of recovered paper. In this case, only big containers at the site of the arising are used. However, for obtaining high collection rates, the office and household recovered papers also need to be collected. Consequently, new collection systems, such as “blue” containers, start to be installed in the bigger cities. When the collection rates start to increase, more containers are installed and new and more complex collection systems can be introduced, such as the “door-to-door” collection of commercial board, “pick-up” collection of household recovered paper, etc.

Within the duration of the COST Action E48, the environmental awareness of the citizens has been identified as one of the most crucial drivers for achieving higher collection rates (see chapter on page 45) and this continues to grow. In countries with low collection rates, the most important stage in increasing the collection rates of recovered paper is the development of environmental awareness through education and campaigns. Collection systems in these countries, although less developed, are similar to those used in other countries with much higher collection rates, but citizens do engage with the recycling ethos and the collection systems are of almost no use. This is true in some East European countries in which a lot of effort is made to provide, for example, “blue containers” in big cities which are not used and, consequently, the collection rates are notably lower. Environmental awareness particularly influences the collection from domestic households. In the case of countries with established very high collection rates, in which a very positive environmental attitude is widely developed, improvements in the collection systems can have some influence on the increase of the collection rate and their optimization can provide a further increase in the collection rate.

4.3. Correlation between Collection Rate & Environmental Awareness

The key to any recycling programme is participation, which is greatly influenced by motivation. People could be motivated by extrinsic or intrinsic rewards. Usually, extrinsic rewards consist of a payment for collected materials. This solution can be very effective, but extrinsically-motivated behaviour does not continue on its own when the inducement is withdrawn. On the other side, intrinsic rewards fulfil a person's need to have an impact on their world, producing satisfaction to individuals. For these reasons, intrinsic behaviour tends to last longer than extrinsically-motivated behaviour. An extensive study conducted in Sweden[47] showed that the moral motives significantly lower the cost associated with households' recycling efforts. Furthermore, moral motives can, in some cases, be the cause of inefficient policy outcomes when introducing economic incentives to promote recycling efforts,

Studies show that the more knowledgeable people are about recycling, the more likely they are to do it and feel satisfied with their actions. Thus, regardless of the motivation, the environmental education, awareness campaigns and positive examples are effective means for developing environmentally-responsible behaviour in people.[48, 49]

In Europe, the main sources of paper collection are 50% from printing, converting, trade and industry, 40% from households, and 10% from offices. Future potential for increasing collection rate is mainly related to the households, as the industrial sources are already utilised to a significant extent.[50] Considering that household collection consists of numerous small sources, which create pressure on the costs and the quality of recovered paper, environmental education and the raising of awareness are very important factors for increasing collection rate of recovered paper in this area.

Environmental education could be accomplished by different means: audio-visual programs for schools, civic and community groups; educational curricula and class projects; community events, fund raisers, and contests. All of which have been tried with varying degrees of success.

Environmental awareness could by promoted by different channels, such as: press conferences and kits, especially when an awareness campaign is starting; public service announcements; mass media – broadcast, newspaper, magazine; press release; printed materials - direct mail, newsletters, utility bill inserts, door hangers, posters, bumper stickers.

In the survey on general parameters influencing the future competitiveness of paper recycling in Europe, the partners of the COST Action E48 were asked to rank the importance of different means on improving paper collection efficiency in their

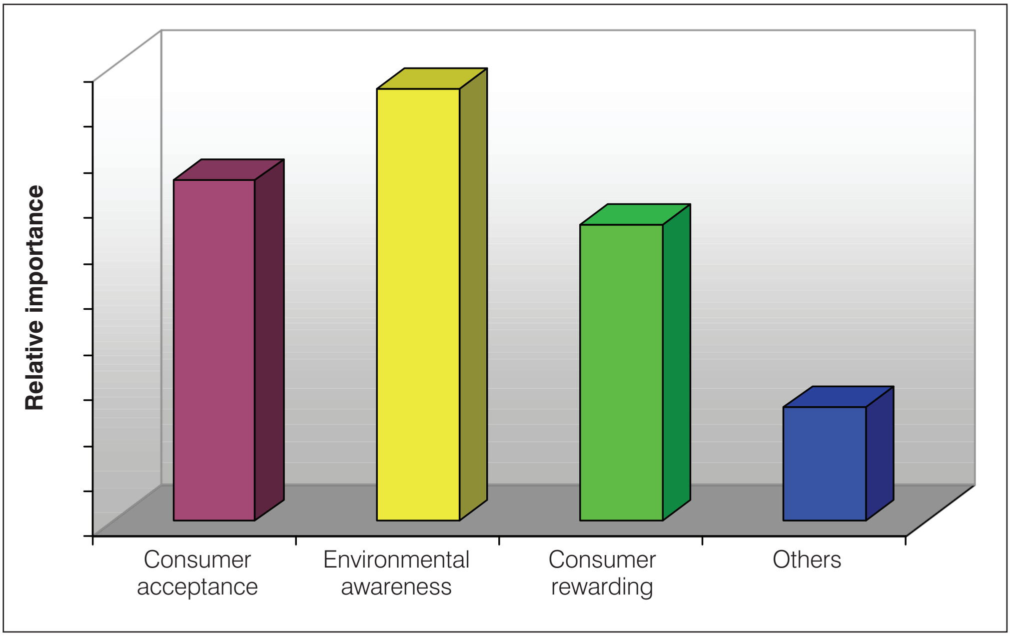


Figure 10: Relative importance of different means to improving collection of recovered paper and board

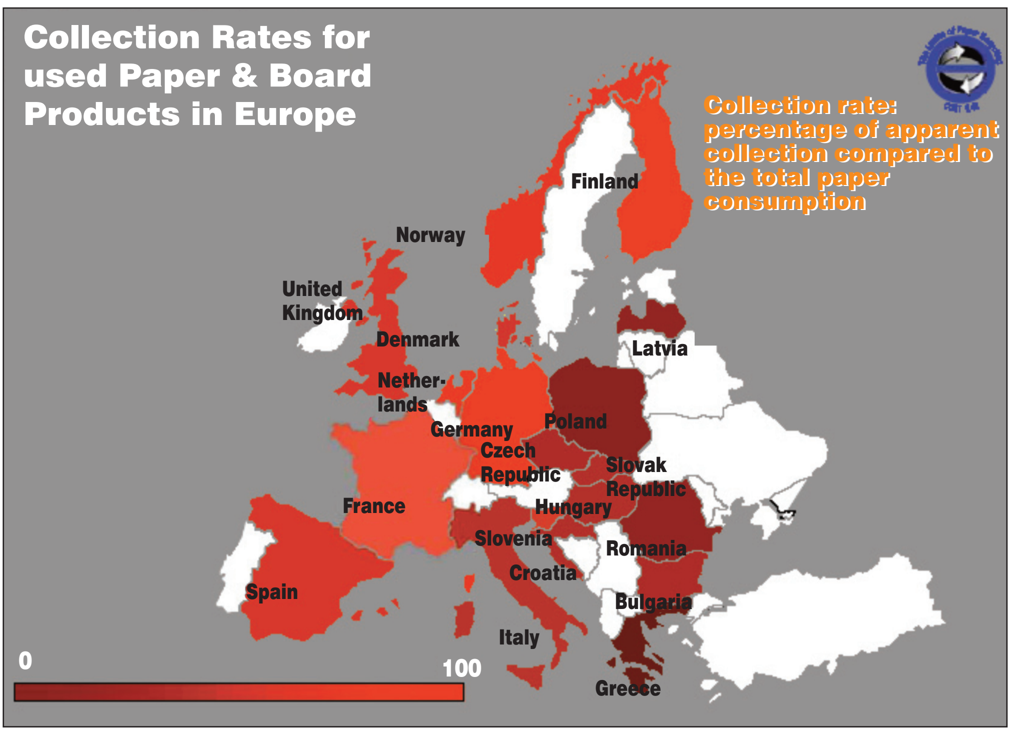


Figure 11: Collection rates for used Paper and Board Products in countries participating in COST E48

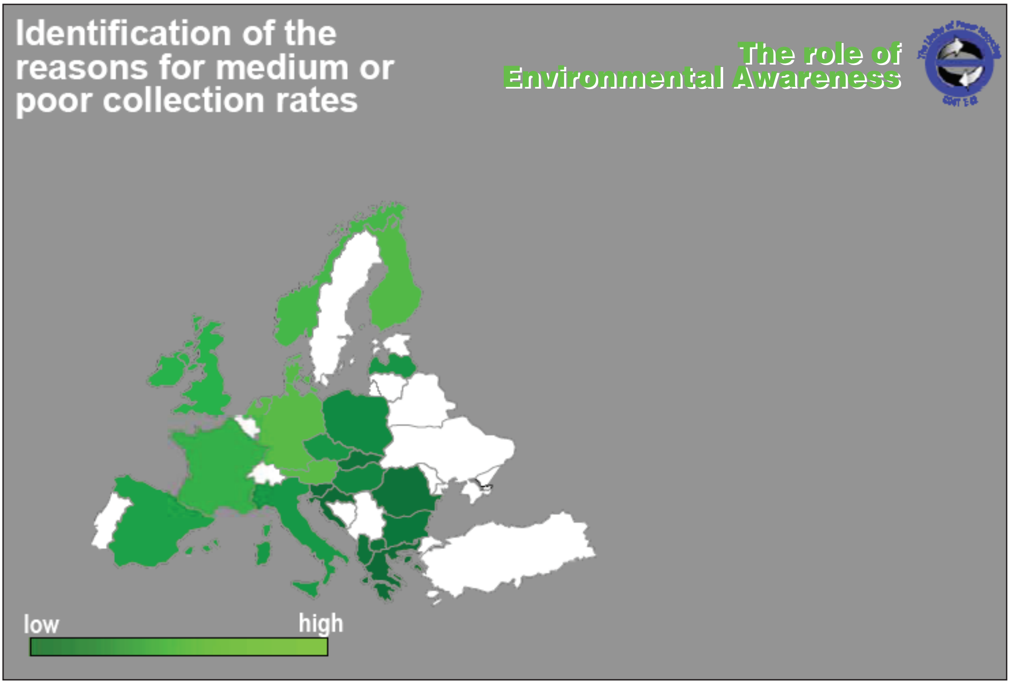


Figure 12: The role of environmental awareness in paper recycling – countries participating in COST E48

country.[51] General results, expressed as an average of 19 countries, show that society's environmental awareness is the dominant prerequisite for an efficient recovery of used paper and board products (Figure 10).

The above mentioned survey was based on detailed questionnaires, which included all aspects that could influence the competitiveness of paper recycling. Since the answers to various questions were quantified by related values, it was possible to see the evidence of the relationships among factors that are impacting the competitiveness of paper recycling. Thus, good correlations were found between environmental awareness and the quality of recovered paper and collection rate (Figure 12).

The graphs above show clearly that the household collection could be substantially improved by increasing the environmental awareness of consumers. It is interesting to note that a statistical evaluation of the "CEPI study on the collection systems in Europe" leads to a similar conclusion. The CEPI study includes a survey on collection systems in 30 countries, based on current statistical data and questionnaire answers (only 15 answers). The Task Force of COST E48 Action combined the answers with statistical data in order to find driving forces and influences on the collection rate of used paper and board. One of the conclusions of the statistical analysis confirmed that the environmental consciousness is the main driving force for increasing collection rate.[52]

One can conclude that as more people and organizations are consciously aware that they can make a positive difference by separate collection of used paper products, more secondary raw material will be available for the paper industry, contributing to sustainable development in Europe.

4.4. State of the Art of Sorting Systems/Technologies applied

White, unprinted and woodfree, bleached pulp based on recovered paper is considered to be one of the highest value grades. Recovered paper and board derived from printing and converting operations (pre-consumer RP) is usually clean, i.e. no significant contraries or foreign matter, and easy to collect regularly in reasonable quantities. Post-consumer recovered paper is more difficult to manage. It may be sorted at source, such as newspaper and white printed paper and board at households or brown corrugated cases at supermarkets. Where, paper and board are not sorted at the source and are mixed, these have a lower value and are more likely to contain contraries, like broken glass, plastics and other kinds of solid contaminants. It has been found that as more used paper and board products are collected and recycled, they tend to contain higher proportions of contaminants. Mixed collection can reduce the cost of collection but simultaneously reduces the value of the material for recycling.[20, 21]

Despite many technical developments, sorting of recovered paper subsequent to collection continues to be a predominantly manual, labour–intensive activity at a level that is increasing as the recovered paper becomes more and more heterogeneous and contaminated with non–paper components. If recovered paper is a component of a co-mingled collection of different materials for example, its sorting will be especially troublesome and will require sophisticated separation technologies.

In the first instance, sorting systems can be divided into manual, mechanical or automatic systems. The manual sorting can be carried out by small sorting companies with a relatively low productivity in the range of 5000 to 20000 tons annually. Larger sorting centres use a combination of all three systems. It is said that complete elimination of manual sorting is impossible and unprofitable. The number of people required to sort depends on the sorting equipment applied and type of recovered paper.[2, 3]

Mechanical separation technologies were developed specifically for fibre recycling and recently have become more widely used in the belief that they are more cost effective for sorting papers into their marketable components. Nevertheless, to achieve both a high level of productivity and satisfactory quality of recovered paper it is essential to apply a suitable sorting system. Nowadays many various separation lines are available on the market. The main factors that the characteristics depend upon are efficiency and the quality of recovered paper that can be processed.[3]

State–of–the–art sorting processes for recovered paper are usually comprised of four steps. The first step consists of charging the sorting plant and ensuring a constant flow. In the second step, mechanical sorting is carried out. The third step is carried out by a sensor–based sorting unit, where unwanted objects are identified and separated. The fourth and last step is manual sorting, performed in order to remove residual unwanted materials. Additionally, loosening and singling stages may be implemented along the process to provide better conditions for the single sorting operations.

Manual sorting is still the most common method for removal of unwanted materials, often carried out without any further preparation except flow control. Mechanical solutions are well established and are used to support the manual sorting. In mechanical sorting the separation is based on physical properties like size, stiffness or weight. Several screen systems (disk, star, drum screens), ballistic separators (rotating screens), gap techniques (acceleration of materials over or into a gap between conveyor belts) and special applications such as the paper spike or deinking screens are currently operated.[2, 3, 8]

The preparation of the unsorted paper is decisive for the efficiency of the single separation steps of paper recovery. For an efficient sorting, the recovered paper has to be loose and free of plastic bags, in particular. Typically, personnel are required to check the input to sorting plants and manually open any visible plastic bags or similar items. In standard mechanical screening, large objects are often mistaken: posters are often removed where they should be kept in and corrugated board is accepted when it should be removed. When it comes to sensor–based sorting only the surface of an object is assessed. Paper products are often non-heterogeneous themselves, e.g. the cover of a magazine is made from a different type of paper and is converted in another way than the pages. Magazines and commercials packed in plastic foils may mistakenly be identified as plastic only. In such cases, sensors only detect the properties of the thin layer, but the main raw material content is not assessed. Moderate shredding can improve this situation.[2, 3, 8]

To achieve greater harmonization in the field of the paper industry, to improve the implementation of the EN 643 standards and to facilitate commercial relationship between paper mills and recovered paper merchants in Europe, special attention should be paid to development and improvement of collection methods, sorting systems and sorting techniques.[9]

5. Current Composition & Quality of Recovered Paper (including Quality Monitoring)

5.1. EN 643 – Recovered Paper Grades & use of Recovered Paper Standards – Quality

Recovered Paper is a valuable Raw Material for Paper Manufacturers and demand is increasing. The reasons for this include:

- Price Competitiveness
- Sources of Good Quality Recovered Papers (although these can be compromised by co-mingled collections)
- Growing and Diversifying uses for paper produced from Recovered Fibres

Recycling helps make efficient use of natural resources and supports sustainable development. Wood fibre can be recycled several times and paper can be made from recycled fibre alone. However, some input of Virgin Fibre will always be required to ensure that the ‘Paper Loop’ remains sustainable.

In order to be recycled, papers and boards must be collected and, wherever possible, segregated (sorted) at source to separate white papers from brown papers. Typically, specific categories of papers can be used for the production of graphic papers whereas others are used for the production of packaging materials. We distinguish two main families: deinking furnishes and packaging recycling furnishes often called packaging furnishes. Unfortunately, in reality, this distinction is much more complex. The origin of papers (office, converting shavings, etc.), categories of papers (packaging materials, writing/ printing papers, sanitary papers), type of fibre used to produce the papers (bleached/ unbleached fibres, chemical or mechanical processed fibres) and utilisation of papers all have to be taken into consideration in the collection systems (household, industry, etc.) and all these considerations lead to large variety of recovered papers and boards. In order to limit the range, the EN 643 standard "European List of Standard Grades of Recovered Paper and Board" was created to define the 57 possible grades of recovered papers classified into five groups (ordinary, medium, high, Kraft and special grades). This classification of raw material qualities was subsequently adapted to market needs. [9]

EN 643 has been adopted by Standards bodies throughout Europe, and endorsed by the European paper industry. It defines grades and combinations of the types of recovered papers that are acceptable for recycling.

In its current version, EN 643 gives a general description of the standard grades by defining what they do and do not contain. The description of the standard grades is brief and for this reason it is recognized that specific contractual arrangements between buyer and supplier for standard grades with special specifications will still be necessary to meet individual requirements. In response to this ‘requirement’, a revision has been discussed for some years. This proposed revision should lead to a standard with clearer definitions on the levels of contamination and the composition of the individual grades.

Quality of recovered papers and boards will depend on many parameters: moisture content, unusable material content (including non-paper components and paper and board detrimental to production) and the possible variety of papers entering in the composition.

5.2. Non-paper & Non-recyclable Fractions Content in Recovered Paper

Two of the most decisive criteria governing the future utilisation of recovered paper are grade and quality. This is a rather complex function of various factors. However, the non–paper and non–recyclable, undesirable components in the recovered paper are an important factor influencing the quality of Recovered Paper as a raw material. Undesirable components (contaminants) could either be inherent components of paper products like inks, adhesives, plastic films, metal foil laminations and the like, or simply dirt or waste unintentionally collected alongside the paper products. The paper industry has limited influence on these factors – in contrast to those who collect the paper and even more to those who design paper products and convert them. In the past the paper industry has made steps to raise awareness of this crucial area – with limited success so far.

Recovered paper is the most important raw material used in paper production in Europe. The tonnage of recovered paper collected for recycling has increased continuously for decades (see Figure 1 on page 30).[10]

In principle, all non fibrous/non paper components should be removed as far as possible from the product stream at the time of raw material collection (recovery and sorting).

Figure 13 shows graphical view of the balance between marginal costs and benefits, where the marginal costs consists of sorting, cleaning and transporting the respective fractions of the waste flow to collection centres, costs for administration of keeping the recycling policies in force, etc. The marginal benefits refer to the value of recycled materials in new production, excluding secondary benefits such reduced environmental impact and reduced depletion of primary resources caused by the use of secondary materials, etc. Recycling policy with a goal of maximizing social welfare must aim at maximizing the net benefits to society, i.e. bring equality between the marginal costs and marginal benefits of recycling.

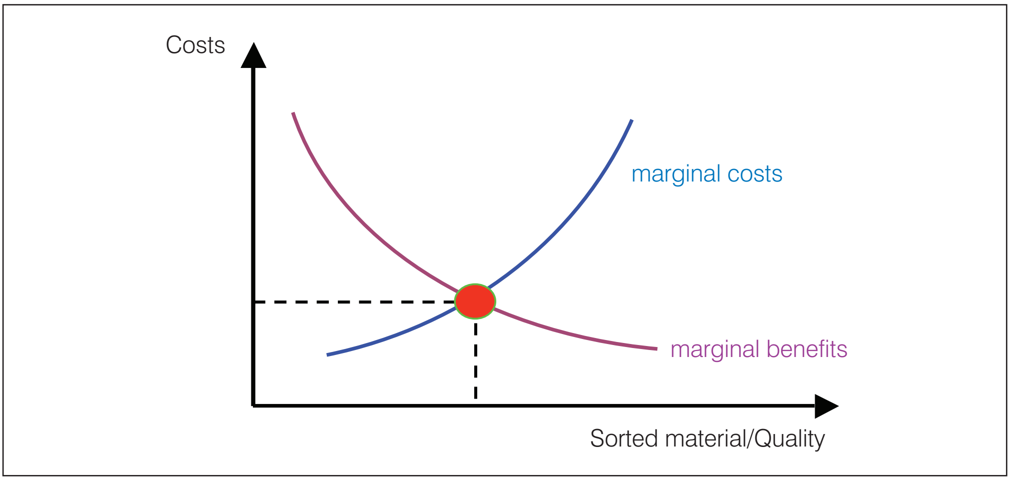


Figure 13: The economical equilibrium of recovered paper sorting [11]

The criteria, for determining the percentage of unusable materials for grades, defined in the European paper industry's EN 643 document, is subject to individual mills' specifications defined in contracts between mill and supplier. In the case of a high concentration of unusable materials (e.g., more than 3%), customers most often refuse delivery of the recovered paper shipment,[9, 12] or seek a financial discount to compensate for the additional work required.

Paper producers need a high and constant quality of recovered paper in significant volumes. Rising demands lead to increasing numbers of complaints as well as a greater demand for recovered paper grades with a controlled quality.[13, 14]

5.3. Quality Control Methods for Recovered Paper & Quality Monitoring

Foreword

The rising demand for recovered paper, in connection with improved collection from sources such as households and industry, has led to increased use of lower quality grades, often containing high amounts of contaminants or contraries. It follows that equipment and procedures have to be developed in order to improve the recovered paper quality control procedures currently used by the packaging paper mills.

For a better control of the raw material used in the recycling of packaging, it became imperative for recycler papermakers to obtain either monitoring tools/ sensors or to use checking procedures. Indeed, the variability of raw materials, in terms of unusable materials (form, origin, kind) or fibrous resources (type of pulps) is one of the major concerns of papermakers. This raw material heterogeneity constantly obliges to adapt the processes, to regulate the machines according to (not always advantageous) compromises between fibre losses and decontamination.

The comprehensive characterisation of the raw material source would make it possible to optimise the adjustments but also to direct it for the manufacture of the best adapted products (fluting, cover…)

Sampling & Sampling Devices

As, with current technology, it remains impossible to monitor the totality (100% sampling) of the delivery (either loose or in bales), only a sub set is checked after sampling. Sampling can be performed manually or using appropriate devices developed specifically for this task.

Manual sampling

Manual sampling can be performed on bale or loose delivery. For the former, the first step will consist in choosing one or two bales from the others in the delivery. The bales are then opened by dewiring and a slice of 30 to 100 kg is separated from the bale, followed by manual sorting into various components (paper, plastic, wood, glass, etc.). Each category of components is weighed to allow quantification of the amount of impurities. At the same time it is usual to determine the moisture content, typically performed by gravimetric method (sampling, weighting, drying and weighting again).

For the loose delivery, a procedure might consist of spreading the load on the floor and to sample on a 2 metre length on the full width of the delivery vehicle and to sort manually the various components as previously described. Moisture content has also to be determined. One additional point for the deinking furnishes, is the age of the newsprint has to be assessed (reading the date) because of difficulties in deinking aged newspapers.

Whatever the type of deliveries (loose or bales), the manual procedure is time-consuming and particularly boring for operators (and therefore prone to errors).

Sampling devices

Core-drilling devices are often referred to as monitoring devices but are, in reality, sampling devices. The goal of these devices is to take from within bales of recovered papers and boards, sample (which can vary from a hundred to thousand grams) on which characterisations have to be carried out. These characterisations are most of the time moisture content and sometimes quantification of unusable materials, principally determined by the operator in charge of the core-drilling system. Even the procedure can be efficient, is still relatively time-consuming and the main consequence is that papermakers do not obtain an immediate characterisation of their raw materials.

Portable or fixed core-drilling exist equipped or not with conveyor. The principle remains always the same: a steel pipe fitted with a calyx. It is mounted in a rigid saddle and held in position by a bushing. The extracted core has between 20 to 40 mm diameter and the length is adjustable.

Several core-drilling systems are available on the market but whatever their characteristics, they remain "only" sampling devices and papermakers have to retrieve the cored samples for further time consuming analysis. The analysis is performed after collection of the sample, it is time-consuming to monitor the cored sample.

Example of core-drilling systems:

- Lam'Bale Sampler developed by CTP commercialised by Kādant (France);
- Recycled Fibre Tester commercialised by SMS (Finland);
- Double core-drill commercialised by Verborg (the Netherlands).

Pulping-Screening Devices

A decade ago, before the emergence of modern non-contact sensor technology (particularly the Near Infra-Red one), CTP developed an automatic compact device which allowed a quick determination of the rate of impurities (non-usable matters to the paper manufacture) and to produce clean pulp. This "pulping – screening" device is marketed under the name of Lam' RCF Tester by the Kādant establishments.

This laboratory device can perform pulping and subsequent screening of about 1 kg of paper samples, usually cored specimens taken from recovered paper bales.

The equipment automatically delivers two types of washed rejects from hole and slot screening to be inspected visually, and a clean pulp to be used for further analysis such as physical properties and cleanliness measured on handsheets.

The weight of coarse rejects from hole screening gives the amount of contraries or non-pulpable material contained in the sample while the analysis of the slot screening rejects enables the amount and nature of fine contraries which may affect product quality or cause problems during the recycling process to be assessed.

In the standard version, the operating conditions of the pulping and screening units were defined to simulate usual brown paper grade recycling conditions

Quality Sensors

For a fast and complete monitoring of the raw materials, papermakers have asked for several measurements. The most often quoted were:

- moisture content;
- unusable materials content;
- qualification of grade (according to EN643).

These additional ones are also of importance but are rarely asked:

- ash content;
- volatile compounds (VOC) qualification and quantification;
- lignin content (to obtain information about the mechanical pulp content);
- ink content (absolutely / flexo ink);
- chemicals (REACH Legislation);
- stickies;
- additives (wet strength paper).

Various technologies are used for the development of sensors:

- image analysis;
- near infra-red technique;
- mass spectrometry;

The Near Infra-Red (NIR) spectrometry has been in use for several years in different sectors like food processing, chemical or drugs in order to study precisely and quickly a sample's chemical composition. For the papermaking sector, it has really been an "emerging" technique for a few years, and is definitely a very "promising" technology for the future.

This technique is based on the measurement of reflected light given by a sample. The sample to be analysed must be illuminated by a light source with a wavelength (λ) range between 800 and 2500 nm (NIR wavelength area). Then, the light reflected by the sample is collected by a detector and transformed into a spectrum by a NIR spectrometer.

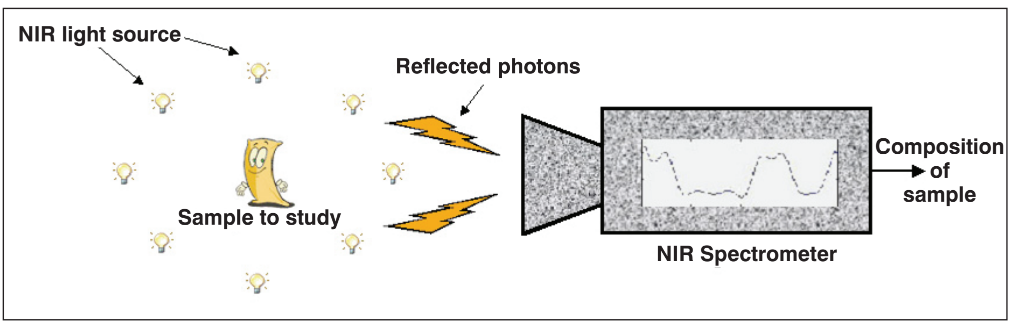


Figure 14: General principle of NIR spectrometry

A particularity of the NIR spectrometry (compared to other spectrographic techniques) concerns the exploitation of the spectra (inlet data). Indeed, it is very difficult to use them directly and often we need complex data analysis methods in order to develop multi-linear statistics models to predict the desired outlet data (for example in our case, the moisture content or the percentages of contaminants or raw materials). As a consequence, these methods need to do a very important step of calibration (or "learning") in order to build the prediction models.

Finally, the main advantages of the NIR spectrometry are:

- it gives data of the composition of samples
- there is no need of sample preparation
- non destructive technique and, above all for our project, very rapid measurements

The NIR technology is a very powerful technique, but it is sensitive to the measurement environment; optics (and mechanical components) and statistical models used, have to be fine-tuned in order to optimise the discrimination and ensure accurate results.

Fibre Analysis

Most of the time fibre analysis sensors are based on image analysis.

In response to the papermakers' request about the fibrous potential of the recovered papers and boards, CTP has developed a fibre analyser which can be implemented of the pulping-screening device. Indeed, the latter produces clean pulp after removal of the unusable materials.

This fibre analyser is marketed by TechPap (commercial subsidiary company of the CTP) under the name MorFi. It is a research and quality control tool to completely characterise fibre morphology. The image analysis is performed on the fibre network in liquid phase, so that the measurement occurs in the fibre natural unrestrained environment.

This apparatus gives the dimensional specifications of fibres and the shives as well as the distribution by size class. This sensor could be placed on the accepted fraction of pulp obtained with the pulping-screening device in order to determine the principal fibre characteristics resulting from recycling from papers and boards.

This device is available as an on-line version for the monitoring of the recycling process or laboratory version for quality laboratories in mills and for institutes or schools.

One key issue for the appropriate consideration of raw material properties with regard to pulp and paper quality is the characterisation of the widely distributed fibre morphology parameters. Modern optical fibre measuring techniques provide detailed information on several thousands of single fibres. Even after condensing the measuring result to size classes (e.g. 100 or more discrete groups of fibre length) it is still a challenge to handle the huge amount of data and consequently for practical use often only average values (e.g. mean fibre length) are evaluated.

To overcome this dissatisfying situation PTS developed a new Softsensor for virtual fibre fractionation which provides data reduction without such drastic loss of information. The fractions determined by the algorithm are similar to those resulting from the well established and accepted laboratory fractionation in Bauer-McNett or other devices. The Softsensor has proven to be a very effective tool to assess raw material variation and separation or refining processes. Further advantages result from the high reproducibility of calculation results and the availability of the method for online applications in principle.

Moisture Content

Several technologies can be used to determine the moisture content of recovered paper and board deliveries:

- Near Infra Red technology: Moisture content of samples is determined with the NIR;
- technology by the two wavelength bands at 1440 and 1940 nm which correspond to water absorption bands (example: Monitor developed by CTP and commercialised by TechPap, PaperBaleSensor developed and commercialised by PTS);
- Dielectric: an electrode passes a harmless, low-power electronic field through the sample. Moisture is measured thanks to an electrode through which a field radio frequency passes. In the case of recovered papers and boards, the unsuitable plastics, adhesives… can disturb measurement and give a false value of moisture (example Forte 8000);
- Capacitive gauge: example AP500 commercialised by Emco.

Unusable Material Content

Several possibilities exist to quantify the unusable materials content:

- Screening and gravimetric method: The quantification of impurities can be performed using the pulping-screening device (see previously) coupled with a core-drilling system. Other laboratory screening devices can be used (Hainld, Somerville…);
- Near Infra Red technology: By spectra acquisitions the metal and plastic compounds can de detected. (examples of sensors: Monitor developed by CTP and commercialised by TechPap, PBS (Paper Bale Sensor) developed and commercialised by PTS, and a NIR system developed by PTS for loose recovered paper.

Grade Qualification

Presently grades are qualified in mill by visual inspection. This inspection is only performed on the visible part of the delivery which can induce mistakes in the classification of raw materials.

Attempts of grade determination were performed mainly using the NIR technology but the technique is limited by imprecision in the definition of grade.

Volatile Compounds

The organic material residues can be a significant source of bacteria likely to generate a microbiological contamination. The consequence of this bacterial proliferation, related either on the presence of organic materials or poor storage conditions (external storage) can result in an odour of the bale. Other types of chemical contamination can also generate odours or volatile compounds, prohibited in paper recycling. Quantifying volatile compounds of recovered paper bales would make it possible to refuse raw materials heavily contaminated by micro-organisms or prohibited products and thus to limit the risk of contaminating the papermachine. All of this requires a reliable means of detection.

Thus, a detection system must be developed in order to identify the bales likely to be contaminated by prohibited or forbidden products. Electronic noses (sniffers) are measurement devices for the analysis of volatile compounds arising from a sample.

Electronic noses based on gas sensors have been developed during the last decade to analyse volatile compounds and have found applications in many areas such as the analysis of beverages, foods and polymers. However these systems offer significant improvement over existing methods, they present some drawbacks in terms of selectivity and reproducibility. Now, a new generation of artificial noses, based on mass spectrometry, opens new opportunities in the analysis of odours and volatile compounds.

Although the technique is still in development, particularly the adaptation of this device to the papermaking conditions, the results gained thus far are very encouraging.

Presently with the use of the electronic nose, we have seen that it is possible to distinguish raw materials (4.02 and 1.05 from two collection systems: industrial and commercial) by classifying the bale by their olfactory signature and to define a standard of acceptance for one type of raw material (to define criteria to refuse contaminated bales).

Monitoring Procedures

Monitoring procedures are often time-consuming, tiring and repetitive for operators. Most of the time, they consist of sampling the delivery and performing various tests on the sample: laboratory classification to determine unusable material content, drying sample to quantify the moisture content (gravimetric method). This both limits the amount of data that can be gathered and can lead to errors.

The following procedures are applied on recovered paper delivered in bales.

CTP procedure 1: moisture content and unusable material content

This monitoring procedure was based on the results of a statistical study. The application of this procedure calls for the core-drilling system and pulping-screening device commercialised by Kādant.

To determine the moisture content in bales of recovered papers, the recommendation is to take 4 measurements (cored samples) in order to have an accuracy of 2%. For loads (batches) known to be homogeneous, this same accuracy can be obtained with only two samples.

The results of many tests have shown that the use of a micro-wave oven allows the determination of the moisture content (accurate value) in 10 or 15 minutes instead of 24 hours in a conventional oven at 105°C.

For the determination of the rate of contaminants, the recommendation is to carry out two operations with the pulping-screening device to have an accuracy of 1.5%.

A visual observation of the slotted rejects will give a qualitative information on the types of impurities present in pulp.

TAPPI procedure: OCC load inspection

A "Control Card", "Load Inspection Form" has been introduced in American mills recycling Old Corrugated Cardboards. This card allows gathering information on the quality of recovered papers in order to make a database characterising the various suppliers. The essential points of control relate to:

- The load quality: evaluation of the load condition;
- The bale tagging: OCC bales must have tags with the supplier name;
- The moisture content: moisture content of the OCC loads must be determined when coming into the plant;
- The visual quality: evaluation of the OCC material quality.

The OCC load inspections are done by the OCC truckers who unload the rail cars and trucks delivering OCC. These inspections look at how the bales were shipped, the bale moisture, contaminants shipped with the OCC, and the gross quality of the OCC. Information for moisture deductions, quality deductions are often generated here. Any load rejections will also take place during these inspections.

REVIPAP: specification for "ordinary grades" (France)

REVIPAP is the French organisation for papermakers using recycled papers and boards.

REVIPAP (in collaboration with the French papermakers) defines a specification for the "ordinary grades" with the following objectives:

- to improve the quality of raw materials;
- to define requirements;
- to inform on the origin of the products;
- harmonisation of practices for delivery and control of entering products;
- procedure to solve discrepancies.

The content of the specification is:

- definition of the product;
- list of undesirable matters;
- strictly prohibited materials;
- moisture ratio;
- conditioning;
- transport;
- information on the raw materials;

- monitoring and assessment of discrepancy;
- non-conformity.

In addition several conditions must be also required for transport:

- the deliveries will be of a minimum of 23 tons;
- trucks have to be covered;
- transports of bale mixture and bulk in same loadings are strictly forbidden;
- for bulk deliveries, mixtures of various qualities of paper and board are strictly forbidden.

Monitoring procedure used in Spanish mills

SAICA uses the following procedures for the control of the raw materials. The monitoring controls are not performed at delivery but on the waste yard before using the bales when using the horizontal "Recycled Fibre Tester" or in another site on lorry directly with the vertical "Recycled Fibre Tester".

Each truck load delivered is controlled by randomly choosing two bales per load. These bales are then placed on a conveyor and are cored by the "Fibre-Tester" device (see previous description). One or two corings are carried out (automatically) on the diagonal of the bale and constitute one sample. There are thus two samples per loading. On each sample the determination of moisture (conventional condition: drying 3 hours in a drying oven at 105°C) is performed and randomly a measurement of the contaminants rate by manual sorting of the cored samples (drying and weighing).

The objective of SAICA is to make a database of their suppliers in order to be able to negotiate with them in case the conditions of sale or specification have not been adhered to.

Visual consignment evaluation

Counting of the visual unusable materials: the externally visible unusable materials of the 8 chosen bales are counted. This counting takes place at a distance of approximately 2 m from the truck (e.g. of the materials to be counted: big parts out of foil and plastics, metallic part, rubber, glass, wood, packaging of building materials…)

Definition of the bale condition: in order to define the bale condition the chosen bales are evaluated regarding the following criteria:

- correct and careful wires (no loose wires…);
- press quality (sufficient and regular press density);
- cleanliness of the recovered paper bales (soiling, mould…);
- the individual criteria is evaluated as follows: Good =1; Normal =3; Bad= 5.

Evaluation of the control results and determination of the quality index: the determined results for the moisture content, the amount of visible unusable materials and the bale condition have to be evaluated with the help of a matrix.

CTP procedure 2: moisture content and unusable material content

The procedure proposed consists in implementing the NIR sensor developed to quantify the moisture content and the unusable material content on a manual or automatic core-drilling system to avoid hand-man operation. Results can be obtained immediately after drilling.

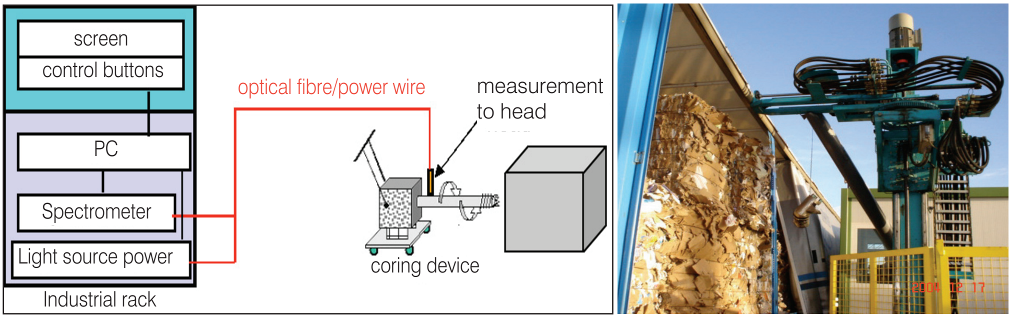


Figure 15: Schematic of the CTP procedure 2 with manual and automatic core drilling system

The complete system developed (hardware for acquisitions & software for data treatment) is very efficient for moisture and unusable materials measurements.

CTP and PTS procedure: moisture content and unusable material content

For papermakers not equipped with a core-drilling system, portable versions of NIR sensor exist. It is based on the same principle as the version previously described and equipped the core-drilling system. However the conditions of use are slightly different. A hole is made in the bale (with a manual drilling machine) and the probe is introduced in the hole.

CTP and PTS propose portable sensors:

- MONITOR portable for CTP;
- PBS (Paper Bale Sensor) for PTS.

The PaperBaleSensor (PBS) is a measuring system permitting simultaneous and highly accurate measurements of the moisture, polymer, fibre and ash contents of recovered paper bales within just a few minutes. The only prerequisite is a simple drill hole of any depth which – unlike the previously required core drillings – can be made automatically within seconds, using simple equipment. The actual measuring is done by a lancehead-shaped sensor. The sensor scans the bore in the near-infrared wavelength range and calculates the shares of the components present according to a fixed routine. Moisture contents of up to 10% can be measured at an accuracy of ± 0.5%, synthetic materials are determined at the same accuracy. The two main components – fibres and ash – are measured to an accuracy of 10 and 5%, respectively.

Recovered paper delivered loose

INGEDE has developed a standardised method to enable mills to inspect their recovered paper quality visually but rather detailed. The advantage is a result of contamination and composition of recovered paper which is achieved quickly. Thus the frequency of inspection can be much higher than by using a gravimetric inspection method.

The method describes the inspection of unbaled deliveries of recovered paper with visual counting of unwanted material and subsequent conversion to their content by weight. The portion of accepted papers is visually assessed by estimation. Both conversion and estimation need verification by a gravimetric inspection on a regular basis[95].

Recently NIR measuring procedures for the quality control of loose recovered paper were developed. They can determine the content of unwanted material in recovered paper for deinking (1.11) in a random sample (50 to 100 kg) of a 10 t lorry load.

In a joint project of INGEDE, CTR AG (Villach, Austria) and PTS (Heidenau, Germany) a prototype of a quality control device on the basis of a new NIR Imaging System has been developed. PTS has also developed a NIR quality control system on the basis of a diode array spectrometer. Both devices can detect and quantify non-paper components (plastics, textiles, wood), unwanted papers, flexo printed newspapers and the deinking papers. The PTS system can also determine the ash and moisture content of the sample.

Conclusions & Trends

With the developed tools and the proposed monitoring procedures, it is possible to characterize the raw material at reception of the loads. With automation, measurements can be performed quickly and reliably. The advantage of these fast measurements is the acceptance or the refusal of a load and the pressure this exerts on the suppliers to comply with the technical specifications of the types of raw materials (1.02, 1.04, 3.02, etc.).

For the majority of the papermakers, the development of tools for raw material monitoring is of considerable economic interest; most paper mills are ‘blind’ in this crucial area and they work without objective measurements.

NIR can also be used at the beginning of the recovered paper treatment process to check and homogenise quality as long as the recovered paper is still dry. There is one installation at the pulper conveyor of a deinking plant. The ash measurement provided by the NIR system enables the loader drivers to keep the ratio of newspapers and magazines as constant as possible[92].

5.4. Trends in Recovered Paper Quality

This chapter deals with the quality or recovered paper as far as it is influenced by collection, handling and storage.

One of the decisive criteria for the future utilisation of recovered p&b is its quality. However, quality is a complex function of:

- The composition of the recovered p&b available;
- Reduction in fibre length;
- The amount of undesirable components in the recovered paper;

- Ash content;
- The state of the art of recovered paper treatment technologies;
- The accepted level of impurities in the finished pulp;
- The accepted level of residues produced during recycling.

For most deinking mills the decisive criteria are the optical properties of the deinked pulp. The selection of the recovered paper grades is determined by the quality requirements for the deinked pulp as well as the available treatment process.

The increasing volumes of recovered paper transported around the world mean that collectors will have to be more aware of quality issues. As a result, encouraging separate collection streams and harmonizing standards and definitions for recovered paper have both become major issues in Europe and further afield; though not in the UK.

CEPI is lobbying hard to encourage legislators to promote the separate collection of recovered paper, as well as trying to educate the authorities at all levels that recovered paper is not a "waste" product at all, but should be treated as a "valuable raw material".

The increased demand for recovered paper coupled with a global push to increase recovery rates has meant that quality is declining. It has always been known that the quality of the individual recovered fibres deteriorates with time and the number of times they have been recycled. However, quality is also being affected by the drive to collect from ever smaller sources, thus driving the move towards more efficient collection systems, which are by the nature mixed; and further also by increased collection rates which inevitably mean that the sources will become smaller and are likely to be more contaminated.

These quality issues are coinciding with the requirement for many papermakers to develop and manufacture lower basis weight products which gave the same or better functionality than higher basis weight grades.

Trends Observed in Recovered Paper Quality: Deinking Grades

INGEDE is the "International Association of the Deinking Industry" and is dedicated to improving recyclability of recovered graphic papers and recovered paper quality. INGEDE's members are 32 paper mills, mostly European, utilising more than 10 million tons of recovered paper per year. INGEDE has been running a statistical evaluation of recovered paper utilisation and quality in its member mills since 2002.

The majority of recovered paper for deinking mills is old newspapers (ONP) and magazines (OMG) – mostly "Sorted graphic paper for deinking" (grade 1.11) according to the EN 643, but also recovered office papers. The production consists of newsprint, SC, LWC, office papers as well as hygiene papers.

The INGEDE member mills using predominantly ONP and OMG purchase 80% of their recovered paper as 1.11 or similar, 7% as pure ONP, 12% as pure OMG and 1% as higher grades. The overall composition of this mix is about 47% newspapers, 50% magazines and 3% higher qualities. There is no significant trend over the years.

EN 643 states that "recovered paper and board should in principle be supplied free of unusable materials", therefore no limit is given in the current version of this standard. Most INGEDE members set their individual limits for unwanted material as an overall figure (non paper plus unusable papers). Some also split this into two limits for non-paper components and for unusable papers.

The current content of total unwanted material is about 2.5%. It climbed from a level of 2.4% in the year 2002 to a peak of 2.8% in 2005. In the past years the number improved slightly dropping to about 2.5% in 2007.

The mills' limits for non-paper components range from 0.2 to 3%. The average content of non-paper components is about 0.5 to 0.6% without showing a significant change in the last years.

The deinking process is designed to remove inks but not to whiten unbleached brown fibres. The content of brown packaging papers and boards is therefore part of the entry inspection of recovered paper deliveries. For "non-deinkable papers", meaning brown packaging and other unusable papers, EN 643 states a long-term target of 1.5% maximum content in grade 1.11. Until this target will be fixed, the standard recommends an agreement between supplier and mill. These agreements result in limits from 1 to 3% amongst INGEDE members.

The average content of unusable papers is, however, not yet below the EN 643 long-term target. It is around 2%, with brown paper and board at about 1.6%. Also here a peak in 2005 was observed; the content of brown paper and board was above 2.5%! The peak was noticed predominantly in Western and Southern Europe. The quality level in terms of total unwanted material is generally better in Central Europe. However, there a steady increase in the content of total unwanted material can be observed (Figure 16).

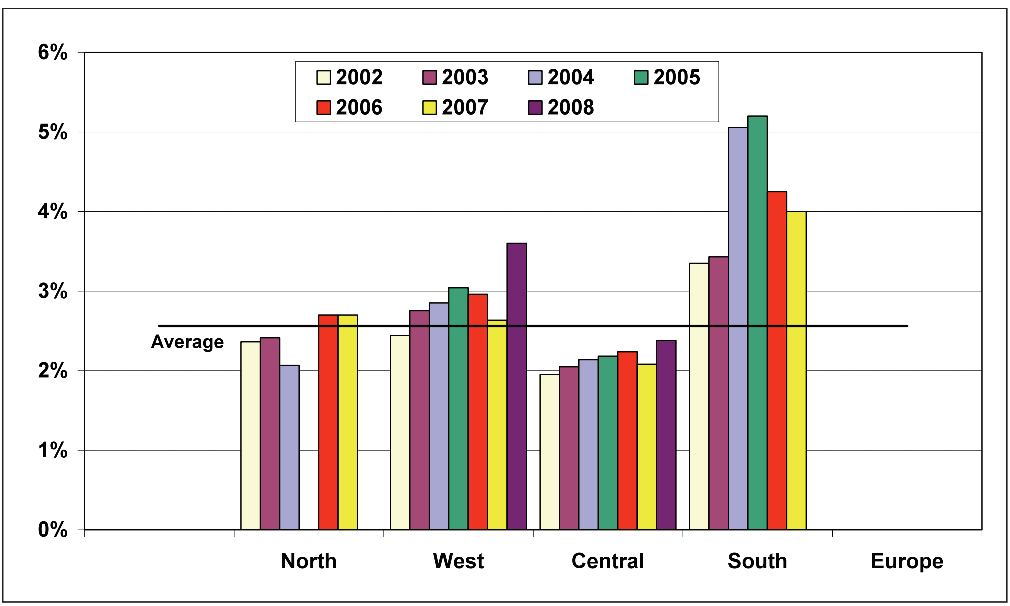


Figure 16: Total unwanted material at INGEDE member mills 2002 to 2007

The moisture limit is defined at 10% in EN 643 for all recovered paper grades, this being also the limit at most of the mills. Although there are some regional differences, most mills record values safely below that limit. The average is between 8.6 and 9.0% with the lowest value in the year 2004 and slightly rising since then.

A high age of printed products affects their deinkability, mainly in the case of offset prints due to the post-printing curing of the inks. Most INGEDE members set the limit for the age of recovered paper at 4 to 12 months; the most common limit is 6 months. Although single deliveries of high age occur, the average is normally between 1 and 2 months.

If the recovered paper delivery fails to meet these quality limits the mills react commercially or even refuse the paper. The most important reason for refusal is unwanted material – total unwanted material, unusable paper and/or non-paper components. This is followed by moisture and bale quality, the latter often being a safety hazard. The composition of the graphic papers is dependent upon the reading habits in the region where the paper is collected. Since the mills have to adapt their processes to that indigenous mix, there are only claims if the composition is largely deviating from the normal mixture of news, magazines or other desired papers. It is noteworthy that there are refusals due to high content of newspaper printed with waterbased flexographic inks, since deinking of conventional flexo inks is incompatible with flotation that has been developed for hydrophobic offset and rotogravure inks. Since the targets for the age of the paper are usually met, there are not many claims because of this parameter.

Trends Observed in Recovered Paper Quality: Brown Grades (Packaging)

At the time of the COST Action, the Brown Recovered Paper appeared to be going through a number of changes:

- The natural moisture content of recovered paper is limited to 10%.
- The content of non-paper components and paper detrimental to production is increasing over the last few years. Incoming recovered paper needs to be checked more frequently and thoroughly to make sure that the production process will not be disturbed.
- Recovered paper has been re-used / repulped for a long time period and many times. The average fibre length is getting shorter and the fibre can shown signs of multiple use (debris and hornification). To balance this, process paper mills are forced to use more process chemicals and introduce either virgin pulp or carefully selected sources of Recovered Paper to rejuvenate the fibre properties.

To fully understand this market, a good understanding of what is collected, how it is collected and what kind of factors influence the recovered paper market, especially the brown grades, is required.

What do we collect?

The grades we do collect and consume are mainly 1.04 and 1.05 (OCC). The length of these fibres is longer that it's for instance of mixed paper grades like 1.02. Not all European countries have sufficient OCC available. Mixed paper is a good alternative. Also within the OCC grades, the quality differs. This is partly depending on the amount of virgin fibres. In Scandanavian countries like Sweden paper mills are producing a lot of kraftliner which contains much virgin fibre. This is no problem at all in these countries because of the huge amount of forests. So the packaging which ends up as recovered paper is of much better quality than the packaging which is mostly based on recycled paper.

How do we collect?

Another factor which influences the quality of recovered paper is the way in which it is collected. In each European country the collection systems are different from each other. This is less significant for the brown grades as long as they are collected separately from glass, metal and plastics. Unfortunately, this is not always the case in each country. When a bale contains a lot of non-paper components or paper detrimental to production, the production process will be disturbed. Since the end of 2008 the Waste Directive is supporting this separate collection and all European countries need to implement this into national law. As a result of this it is hoped that the quality of the brown grades will be (slightly) better.

One of the more common collection systems are the so called "blue bins". This is a collection system in some countries in Europe and is an initiative from our supplier to fulfil the requirements of separate collection and recovery. Collecting paper with these "blue bins" has given some indications that the system produces paper of a better quality than other methods of collection.

Due to some increasing and new production capacities around Europe, even more recovered paper will be needed. One of the markets which has the opportunity to generate and to export more recovered paper is eastern Europe. This could mean that recovered paper needs to travel significant distances before it reaches its final mill destination. Quality will become an even more important issue due to this factor and its important that all sources are following the European standards of recovered paper which are referring to quality.

Market developments

The market for brown grades is extremely volatile driven by a complex system of supply and demand. For instance when people are consuming less products, less packaging is needed (also paper packaging), less paper ends up in the recycle chain and less paper can be collected. Prices can go up because a shortage of brown grades might exit or prices stay low because paper mills don't consume that much brown grades any more because less paper packaging is needed.

Another significant factor is the export market. Recovered paper is now a worldwide commodity and in the Far East the paper mills need much more brown grades than is collected in the internal market. So the recovered paper users are also buying brown grades in the USA and Europe to get sufficient recovered paper.

Requirements of customers are the third main factor. Customers are requiring more and more from producers of container and boxboard. One of the most important requirements of GMP and food contact is traceability. To fulfil this requirement, the paper industry of brown grades is focussing on bale identification which makes it possible to demonstrate a visible link between recovered paper and the last owner of it. Other customers are asking for FSC and PEFC certification which makes sure that producer of packaging and their customers are doing a good job for the environment.

Due to the current economic recession, most paper mills in Europe and in the USA which closed during the last few months predominantly utilised pulp as a raw material rather than recovered paper. In China where a number of small paper mills which used straw (which produces shorter fibres) as their raw material are closed by the government, the new, big paper mills are importing recovered paper. This all will have an influence on the length of the fibre circulating in the recovered paper streams and the processing requirements at the mill.

5.5. Recyclability of Paper Products

Deinking Grades

There are two key aspects of recovered paper quality for deinking: One is the characteristics of the delivery in terms of contamination, moisture and composition (see pages 49 onwards), and the other is the recyclability of the paper products in that delivery. The first aspect is in close connection with the collection system, handling and storage of the recovered paper. It was addressed already on page 48 that co-mingled collection is detrimental to quality. Therefore it is essential for the paper industry that paper and board are collected separately from other recyclables. The deinking industry favours a separate collection of graphic papers in order to reduce the contamination with non-deinkable paper and board.

The aspect in this chapter deals with the recyclability of paper products, a feature which is a function of the product itself. It can basically be subdivided into two sections, the ease with which inks may be removed (Deinkability) and any adhesive applications. The first one – the deinkability – is mainly dependent on the printing process used.

Deinkability

Deinking by flotation is the predominant technology used in Europe, Asia and North America. Washing is and will remain limited to special products such as hygiene papers. For both processes the detachment of ink from the paper surface is a prerequisite for a good deinking result. Cross-linked and vegetable oil based inks are harder to detach than mineral oil, solvent or water based inks. An efficient flotation process needs additional certain characteristics of printing inks. They have to be hydrophobic and need to be in a certain particle size range in order to be floatable (Figure 17).

From the chemical and physical nature of the inks, offset and rotogravure inks should not represent a challenge for flotation. The inks are hydrophobic and fragment into a proper particle size during repulping. Flexographic and inkjet ink particles are too hydrophilic and too small for an efficient flotation. Cured systems and some toners, particularly liquid toners form agglomerates that are too big for effective flotation. Examples of deinked pulps produced by flotation deinking of various inks are presented in Figure 18.

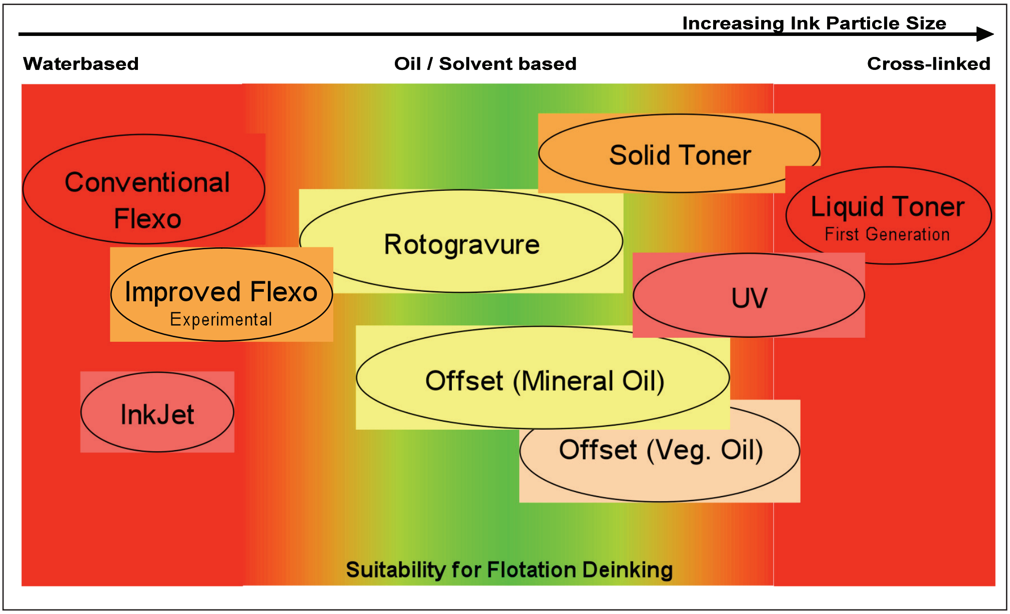


Figure 17: Compatibility of different printing technologies with flotation deinking (green area = good deinkability / red area = poor deinkability)

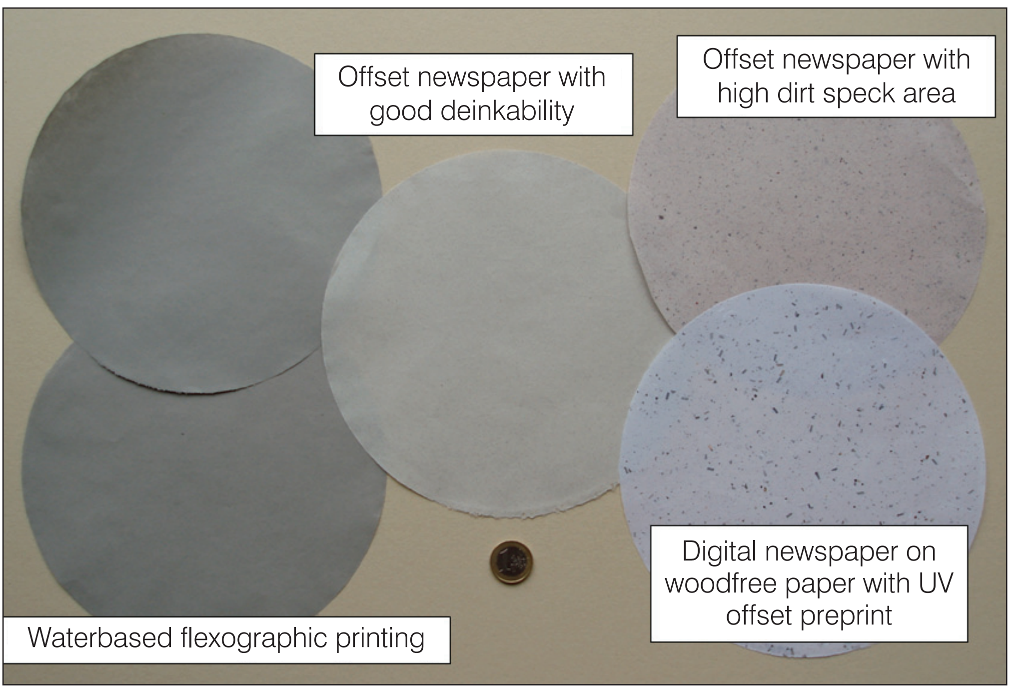


Figure 18: Handsheets of deinked pulp

A proper assessment of the deinkability of several printed products has been on the agenda of INGEDE's research activities for the last few years. For this assessment, deinkability tests carried out according to INGEDE Method 11[76] serve as the basis for comparing deinkability of prints. In March 2008 the European Recovered Paper Council (ERPC) adopted the Deinkability Scores as assessment scheme[77]. The ERPC is the committee of the signatories and supporters of the European Declaration on Paper Recycling.

Assessment of deinkability

The deinkability test according to INGEDE Method 11 simulates at laboratory scale pulping and flotation, the two major process operations for ink removal. Before pulping all samples undergo a three days artificial ageing which is equivalent to about a three month natural ageing for typical offset prints. Pulping, storage and flotation are exactly defined in equipment and operating parameters.[78, 79]

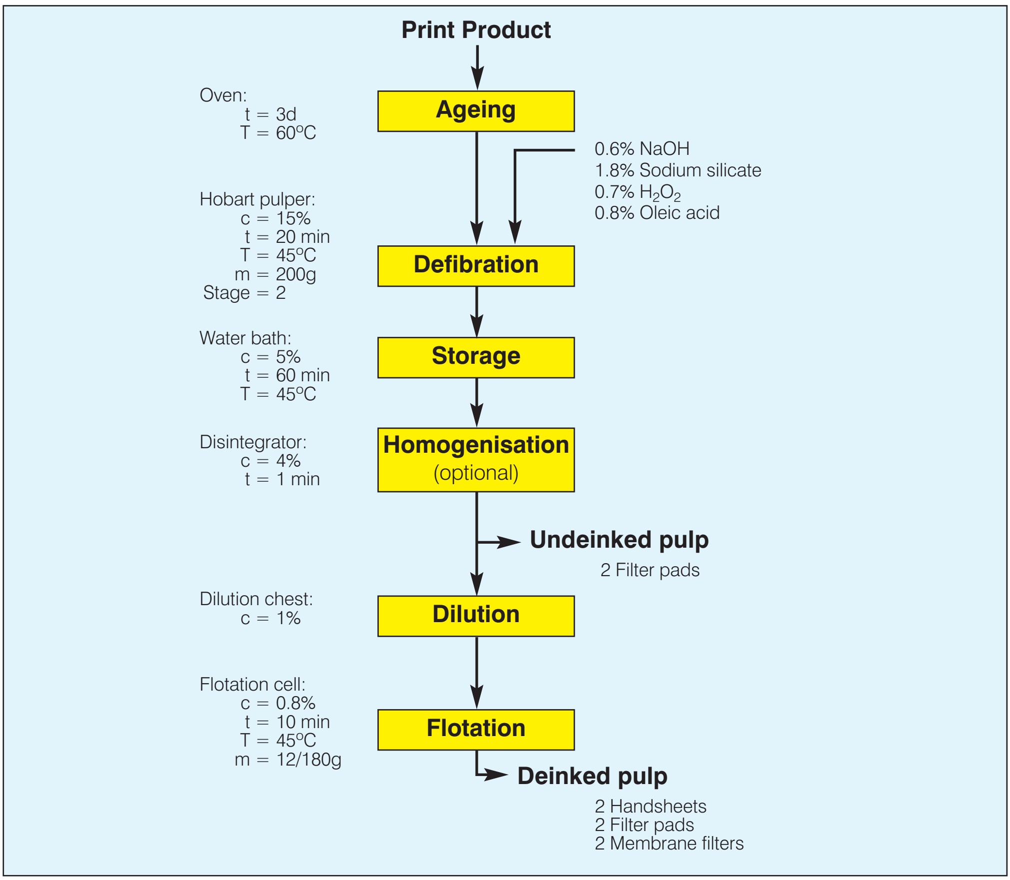


Figure 19: Flow chart of INGEDE Method 11

INGEDE Method 11 comprises the five parameters listed in Figure 19. The first three are quality parameters characterizing the deinked pulp in brightness and cleanliness (luminosity Y, dirt particle area A). The dirt particle area is subdivided in two results – the dirt particle area larger than 50 μm particle diameter, which are all particles visible with the naked eye, and the area of particles above 250 μm diameter. This is very close to the TAPPI assessment of dirt specks which counts all spots above 225 μm. Additionally, the colour shade on the red-green-axis of the deinked pulp is determined by the a*-value due to the fact that the red discoloration is more critical than a discoloration on the yellow-blue-axis (b*). The two last are process parameters (ink elimination IE, discoloration of the filtrate ΔY) giving information on possible effects of ink carry-over on the deinking process. In the assessment, they complement the information provided by the three quality parameters.

Objectives	Evaluated Parameters
High Reflection	Luminosity Y of Deinked Pulp
High Optical Cleanliness	Dirt Area A* of Deinked Pulp
No Colour Shade	A* Value of Deinked Pulp
High Ink Removal	Ink Elimination IE
No Discolouration of White Water	Filtrate Darkening DY

Quality Parameters

Quality Parameters

Figure 20: Test criteria for deinkability

The test results are converted to a score system, which in turn allows the deinkability assessment in one figure by weighing the parameters according to their importance. Additionally, the Deinkability Scores provide the opportunity for cross comparisons between different product categories. The maximum score is 100 points in all product categories.

To achieve a common point system, threshold as well as target values are defined. Depending of the type of threshold values either a lower threshold, an upper threshold or a threshold corridor is fixed which have to be exceeded, undercut or met respectively. These threshold values which are independent of the print product categories are listed in the following Table 4. For a given print product, threshold values have to be fulfilled for each parameter. If one or more threshold levels are not reached, a print product is judged as “not suitable for deinking”.

Parameter	**Y** [Points]	**a*** [–]	**A_{50}** [mm²/m²]	**A_{250}** [mm²/m²]	**IE** [%]	**DY** [Points]
Lower Threshold	47	–3.0			40	
Upper Threshold		2.0	2 000	600		18

Table 4: Threshold Values of Deinkability Scores

According to Table 5 target values are set for each group of print products and for each parameter. The target values of the parameters colour (a*-value; green-red axis), dirt particle area (A50 and A250) and filtrate darkening (ΔY) are equal for each print product category. The target values of the luminosity of the deinked pulp (Y) and the ink elimination (IE) have variable levels depending on the print product category.

Category of print product	[Points]	[–]	[mm²/m²]	[mm²/m²]	[%]	[Points]
Newspapers	≥ 60	≥ -2.0 to ≤ +1.0	≤ 600	≤ 180	≥ 70	≤ 6
Magazines, uncoated	≥ 65	≥ -2.0 to ≤ +1.0	≤ 600	≤ 180	≥ 70	≤ 6
Magazines, coated	≥ 75	≥ -2.0 to ≤ +1.0	≤ 600	≤ 180	≥ 75	≤ 6
Stationery (Y of base paper ≤75)	≥ 70	≥ -2.0 to ≤ +1.0	≤ 600	≤ 180	≥ 70	≤ 6
Stationery (Y of base paper >75)	≥ 90	≥ -2.0 to ≤ +1.0	≤ 600	≤ 180	≥ 80	≤ 6

Table 5: Target Values of Deinkability Scores

If the target value of a parameter is met, the full score is given for this parameter. The scores of the six parameters in Table 6 have different values in order to reflect their importance. The parameter luminosity of the deinked pulp has, with a proportion of 35%, the most significant effect on the total Deinkability Score, followed by dirt particle areas (25% as total of A50 and A250) and colour (20%) of the deinked pulp and the two process parameters ink elimination and filtrate darkening (10% each).

Parameter	**Y**	**a***	**A_{50}**	**A_{250}**	**IE**	**DY**	**Total**
Maximum Score	35	20	15	10	10	10	100

Table 6: Maximum score per parameter of the Deinkability Score

Between the threshold and the target value of each parameter, the score is linearly subdivided, resulting in a constant increment per parameter. Finally, the score of all five parameters is added up to provide a single number that corresponds to the total score for a particular print. This allows a simple overall assessment on the deinkability of a print product with one numerical value between 0 and 100 points comparable to test results of consumer goods (Figure 21). If one or more threshold value fails, the print product is considered unsuitable for deinking. Anyhow, the product may be well recyclable without deinking – for example in a board mill. If all thresholds are reached the product is judged to be deinkable with three various gradations: poor, fair and good.

Score	**Assessment of deinkability**
71 to 100 Points	Good deinkability
51 to 70 Points	Fair deinkability
0 to 50 Points	Poor deinkability
negative (failed to meet at least one threshold)	Not suitable for deinking*
* The product may well be recyclable without deinking	

Figure 21: Evaluation According to the Deinkability Scores

The research institutes have performed nearly 300 tests on behalf of INGEDE. One way of displaying the results is according to product category is described in Table 5 (on facing page).

The assessment scheme is still too young in order to deliver reliable trends in deinkability. However, from the work with this system it is now known which printing technologies are obstacles for deinking[96]:

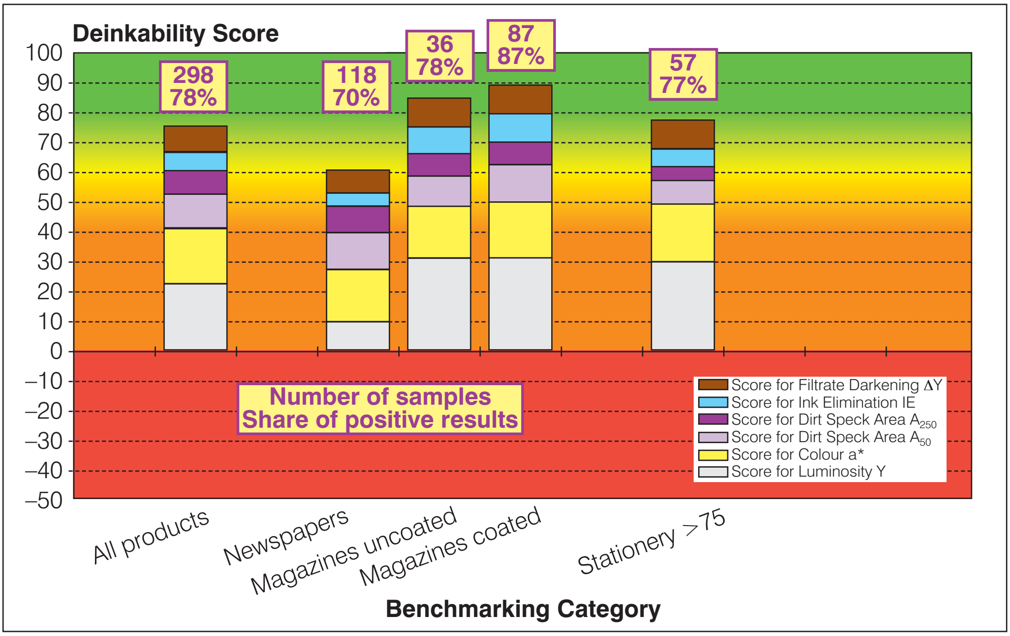


Figure 22: Deinkability test results by benchmarking category

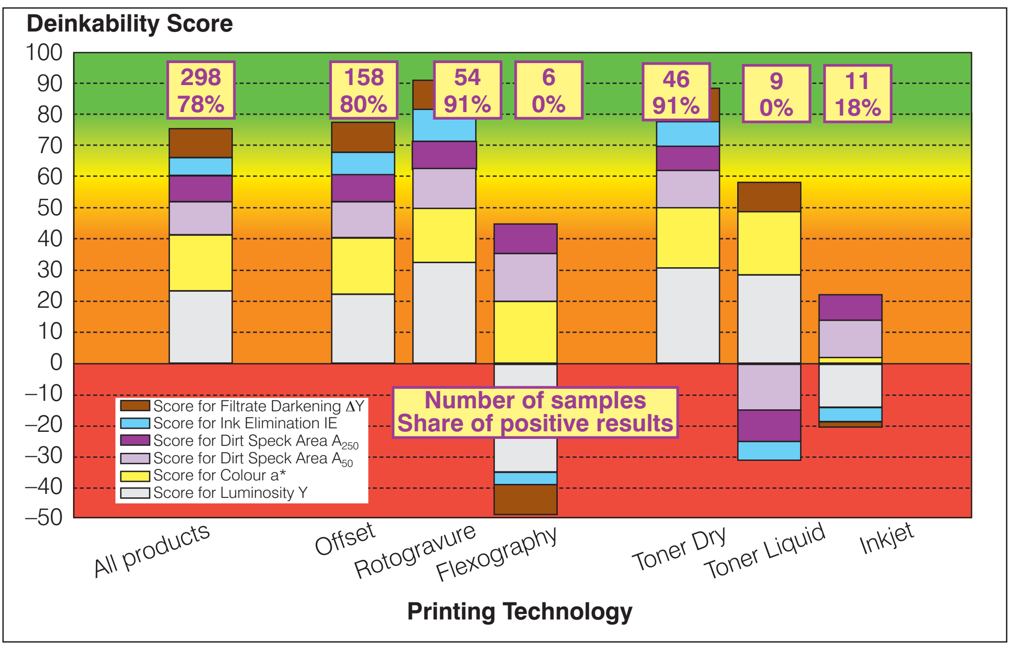


Figure 23: Deinkability scores of tests with different printing technologies

Each column in Figure 23 shows the average Deinkability Scores grouped by printing technology. The elements of the stacked columns represent the scores for the individual assessment parameters.

A total of 80 per cent of the offset prints – mainly newspapers and magazines – achieved a positive assessment of their deinkability. If they fail, it is usually due to luminosity or dirt particle area. The latter often occurs in case of UV cured prints. Luminosity deficits are in connection with a high amount of inks on low weight paper, (as is the current trend in newspaper manufacture and promotional flyers). Waterless offset was found to be rather trouble free[97].

Rotogravure prints generally have good deinkability. The few ones which failed were due to dirt particles. Red discolouration is sometimes visible but in no case lead to a negative assessment. This is an improvement compared to older historical results.

Flexographic printing in graphic products is done for some newspapers in Italy and the United Kingdom. All tests fail in luminosity, ink elimination and filtrate darkening due to the hydrophilic nature of the ink particles.

Toner prints are usually well deinkable if they are made with a dry toner process. All samples of liquid toner prints fail a positive judgement because of a very high content of dirt particles in the deinked pulp. The toner films are very cohesive and flexible; they do not fragment well enough during pulping.

Inkjet prints in most cases fail to achieve a positive deinkability result. Most of the samples investigated were inkjet printed newspapers which are nowadays promoted for small volumes and remote locations, e. g. foreign newspapers at international airports. Similar to flexographic prints, inkjet fail due to luminosity, ink elimination and filtrate darkening.

In the conventional printing technologies, the variations in the deinkability are more pronounced with uncoated papers. the worst results were obtained for waterbased flexographic newspapers. Research has shown that newly developed inks can perform better results in the deinking plants but these new iks are not yet established commercially. In a few cases the deinking process can be tuned a little to cope better with flexo inks, but usually at the expense of a lower efficiency in the removal of other ink types present in the papers blend. Inkjet and liquid toner prints represent real threats for deinking mills. Much work is still needed to ensure that these two printing technologies produce deinkable prints.

Removal ability of adhesive applications

The second product related quality aspect is the removal ability of adhesive applied to the sheet. These adhesive applications form tacky particles in the paper recycling process, referred to as "stickies". These "stickies" are classified according to their sources as primary and secondary stickies[98]. The first group of stickies is introduced by the recovered paper. Secondary stickies originate from physico-chemical effects during recovered paper processing. Depending on their size, stickies are classified in macro-, micro- and disco (dissolved and colloidal) stickies. There is a clear definition to distinguish between macro- and microstickies using a mechanical screening process in laboratory scale[99]. The definitions of disco stickies are not as clear and generally acknowledged.

Research work proved that mechanical screening is the most efficient tool for sticky separation in the industrial process. This means that stickies have to be as large as possible in order to be screenable. A particle size of the macrostickies above 2.000 µm as determined by means of INGEDE Method 4 is favourable in order to guarantee complete removal in a state-of-the-art recycling process[100].

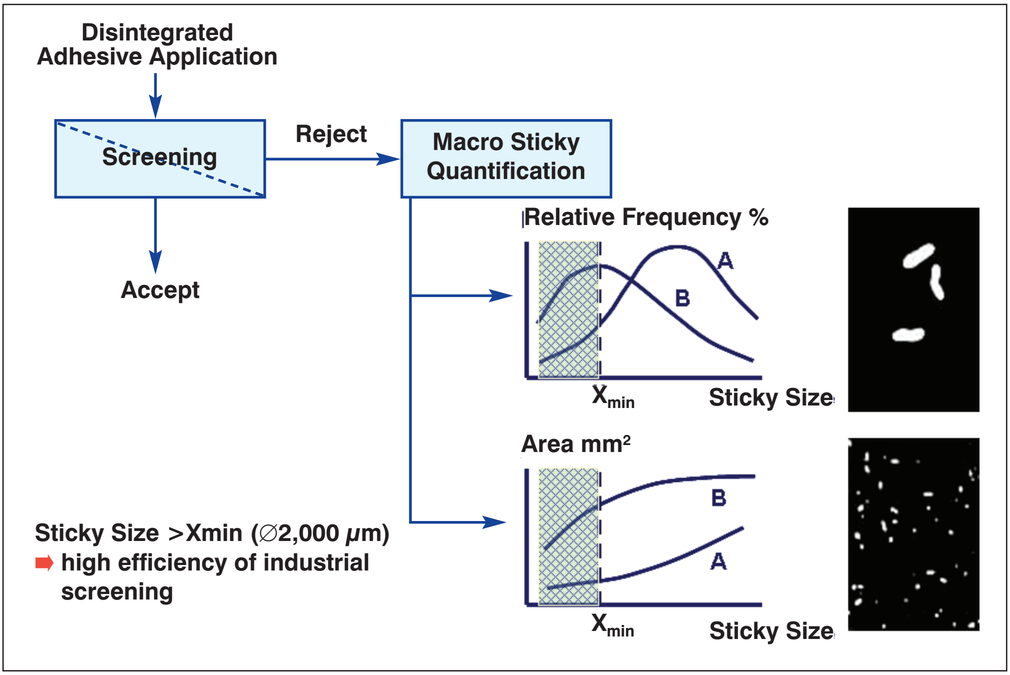


Figure 24: Assessment of the sticky potential of adhesive applications in graphic papers[101]

For an assessment method under laboratory conditions not only the screening but also the pulping process has to be defined because it is essential for the fragmentation of the stickies. For this, INGEDE Method 12 was developed[102]. In this method, adhesive applications are pulped together with deinking chemicals and woodfree copy paper, which is free of stickies.

An assessment system similar to the Deinkability Scores is currently under discussion among the stakeholders of the paper value chain. The proposed system follows the findings which were already described in this chapter. If a printed paper product contains one or more adhesive applications, they have to be detectable as macrostickies. If this not the case, it means that the adhesive application only forms microstickies respectively disco stickies. Here an adequate removal ability of adhesive applications is not given in any case. Results of macro sticky measurements achieved by means of INGEDE Method 12 will be converted into scores. For the two parameters area and share of the macrostickies below 2 000 µm particle size, threshold and target values will be defined. The target values will depend on the product category – magazines, catalogues & paperbacks, mailings, envelopes. A survey of the recycling behaviour of a sufficient number of these products is necessary to achieve a sound database which can be used to define future target values.

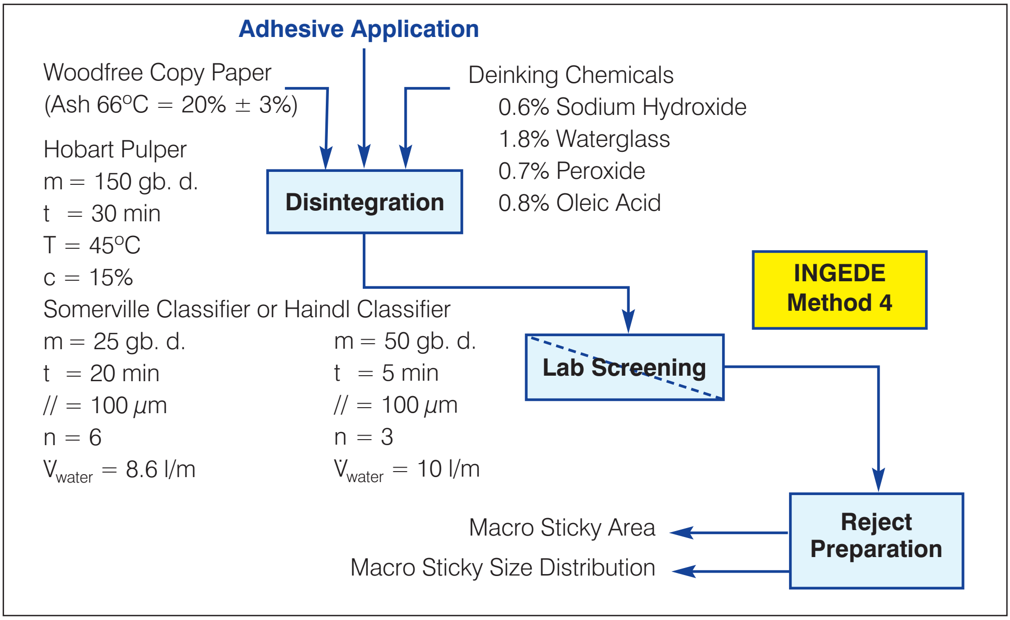


Figure 25: Flow chart of INGEDE Method 12

From earlier surveys[67] it is known that glued spines are normally not critical for recycling if they are made with hot melt glues. Among those, polyurethane hot melt glues perform even better. Hardly any label products fulfil the recycling criteria. The thin films and the chemical nature of the used dispersion glues provide a big challenge for recycling. There is an indication that UV cured dispersions behave much more recycling benign.

Packaging Grades

The ash content of paper/raw material has a significant influence on the paper properties. The experience of the industry (in the brown, packaging grades sector) shows that the ash content in recovered paper has discrete periods in which there is a significant increase and decrease. These fluctuations are due to the changes in the flow around the recycled paper loop.

Fillers are next to fibrous raw material as an important material in paper production (especially graphic grades). Therefore they play also an important role in the recycling processes. In packaging grades production fillers are detrimental matter, as they cause decrease in the strength properties of final product. Constant control of ash content in the secondary raw material is an important step in the production processes. The graph presented in Figure 26 represents the changes in the ash content in raw material of grades 1.04 and 4.01 CEPI EN 643 analysed in the years 1975-2005 in one of Dutch corrugated manufacturers.

Especially the first part, years 1975-2000 represent an constant increase in ash content, while the following few years 2000-2004 show and intensive decrease of ash content in recovered paper. The increase of ash content in the first named period is the result of the increasing use of recovered paper as alternative fibrous raw material. In the second period, the explanation for the decrease is the fact, that the increasing popularity of using recovered paper graphic grades production, therefore more intensive sorting and separation of the fillers containing recovered paper grades. From 2004 the ash content appears to be more or less stable, and at that moment the precise situation has not yet established.

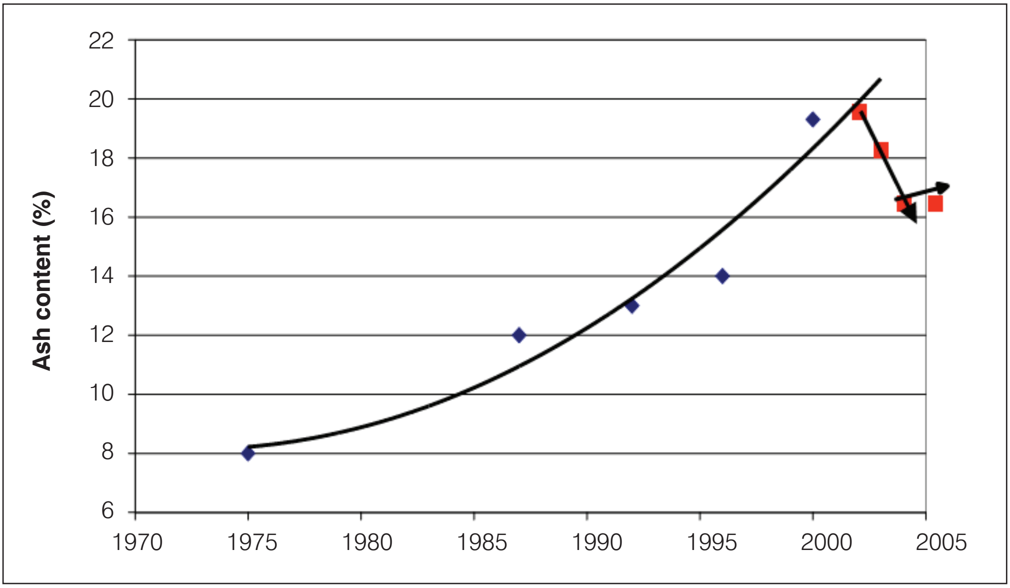


Figure 26: Ash content in recovered paper (grades 1.04 and 4.01 CEPI EN 643)

6. State-of-the-art in Treatment Technologies

6.1. Introduction

Recycling is an old tradition of the paper industry. Recovered material has always been a source of fibres for the paper industry and nowadays the European paper industry uses the same amount of virgin fibres as recovered papers. Most of them are used to produce brown grades paper and board but for the past 20 years there has been a strong increase of the use of recovered papers to produce, through deinking, white grades such as newsprint, tissue, market pulp and also more recently magazine papers.

Deinking is a sophisticated way of (up)recycling, high grade papers can be produced by using this technique. By using the deinking technology, white grade papers can be produced. This means that the components which cause a reduction of brightness, i.e. the inks, must be removed, but also that all the additives used during printing, converting and using the paper must also be removed. From the recycling point of view these additives are contaminants. They include various types of adhesives (binding materials, labels and tapes, etc.) staples, plastic films, inks, varnishes, and all the components of the pulp which cannot be used to produce paper. In some cases fillers must also be removed.

Extended reviews on the state of the art of recycling technologies, from process unit operations to the complete process design and special issues like stickies, deinking chemistry and deinkability, are available in different formats[30,31] and from different sources. The summary below focuses on the description of process steps of recycling and deinking lines.

6.2. Process Steps

The deinking process is a combination of the various treatments needed to produce pulp from recovered papers and to clean it for the production of paper. The deinking technology includes all the main steps of conventional recycling technology, but special treatments are added in order to remove the ink.

Pulping

Pulping is always the first step. During pulping, fibres are separated and all the additives added to the paper during printing and converting process are (or should be) separated from the fibres. Various kinds of devices are used: low consistency pulpers, medium consistency pulpers and drum pulpers are all offered by machinery suppliers. The choice of the type of pulper depends on various parameters including efficiency and energy consumption with respect to:

- defibring kinetic in order to minimise residual paper flakes;
- minimising the breaking up of contaminants in order to improve their removal efficiency. Due to this requirement deflakers are no longer in used;
- efficient ink detachment (however this objective is sometime contradictory to the previous one).

For deinking application, chemicals (caustic soda, sodium silicate and soap) are most often used in the pulping stage in order to facilitate ink release from the fibres even if there is a recent trend to move to neutral repulping conditions. Bleaching chemicals (typically hydrogen peroxide) are also often used. Several studies describing these unit operations have been reported recently.

Removal of Contaminants

The removal of contaminants is based on their different properties, compared with fibres, fines and fillers:

- differences in size: particles smaller than fibres can be removed by washing and contaminants larger than fibres, if stiff enough, can be removed by screening;
- differences in density: if sufficiently large, particles having a density from that of the water phase can be removed by centrifugal cleaning;
- differences in surface properties: flotation can remove hydrophobic particles, additives (synthetic surfactants or soaps) are generally used to collect ink particles which improves the flotation efficiency.

Each technique is efficient for the removal of contaminants in a defined size range. The Figure 27 can be considered as a good approach to washing and screening efficiency. For cleaning efficiency, the combination of size and density must also be considered and flotation efficiency depends mainly on surface properties.

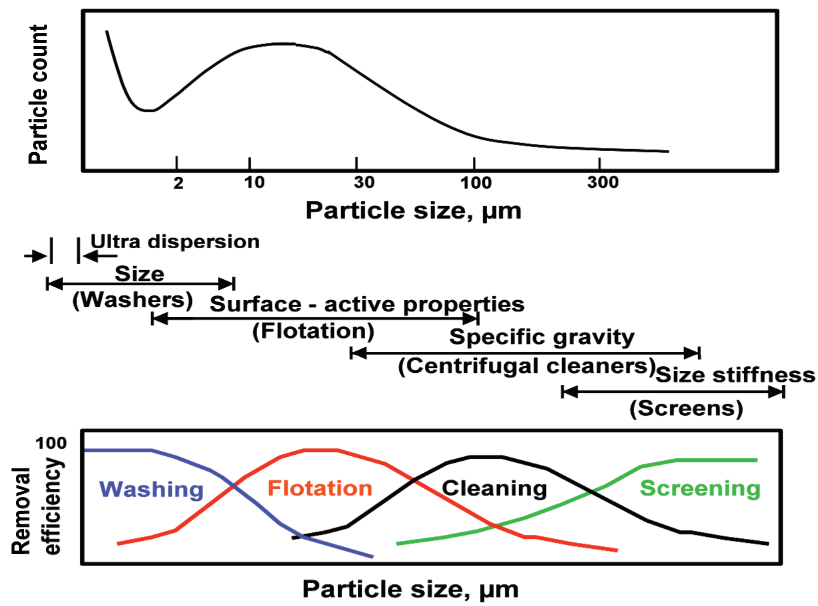


Figure 27: Particle size distribution and unit operation removal efficiency

Screening

Screening consists in removing contaminants by retaining them on a screen while fibres go through the openings (holes or slots down to 0.10 mm width) of the screen. At the beginning, the screening devices were open vibrating screens, Today they are closed and pressurised disc or basket screens to increase capacity. A rotor creates pressure pulses to avoid plugging of the screen cylinder (Figure 28). The tangential

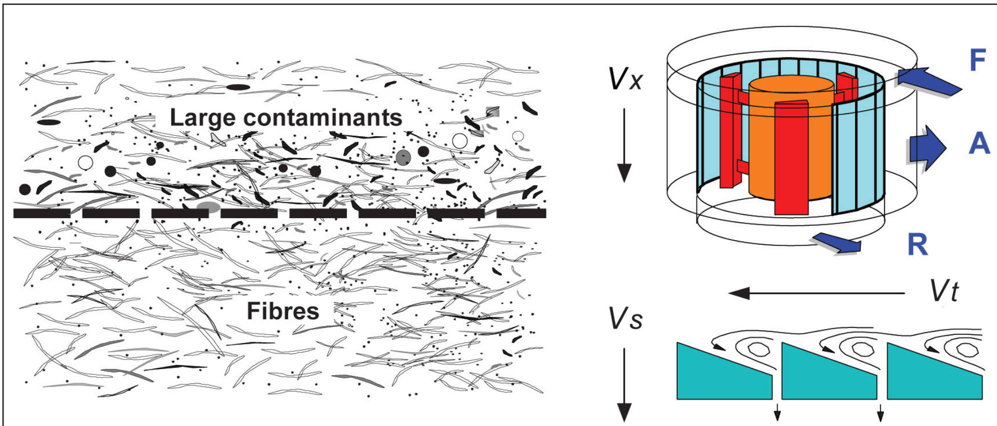


Figure 28: Principle of screening – Basket screen and slotted screen plate

flow velocity (Vt) produced by the rotor and the shape of the contours at the slot inlet induce hydrodynamic phenomena, i.e. some probability screening, which contributes to the contaminant removal efficiency in addition to barrier screening. Screens remove large and stiff contaminants including plastic films, shives, paper flakes and macro-stickies. A too large velocity through the slots (Vs) reduces the efficiency of screening, namely in the case of soft stickies, which can be extruded through the slots.

Cleaning

Cleaning is based on particle separation in a centrifugal flow field. A swirling motion is created by the tangential inlet flow. The vortex motion creates centrifugal forces which causes the particles heavier than the stock to migrate to the outside of the cleaner, while lightweight particles migrate toward the vortex core (Figure 29).

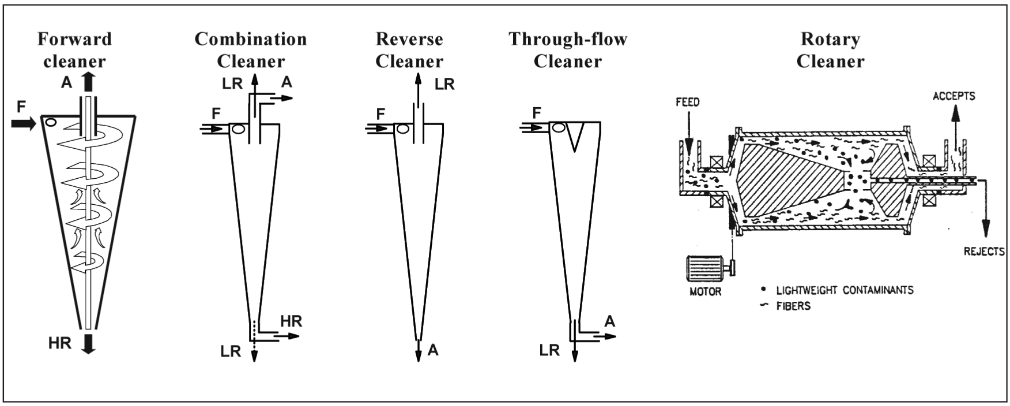


Figure 29: Principles of cleaning - High-density and low-density cleaners
(F: feed, A: accepts, HR: heavy rejects, LR: light rejects).

Large size cleaners are generally used (5%) to remove coarse heavy contraries, while multistage systems of smaller cleaners are used at low consistency (1%) for fine cleaning. Cleaners can be designed to remove high and/or low-density contaminants. Forward or high-density cleaners remove metals, sand, coat flakes, and some inks and stickies. Reverse or low-density cleaners of various types (Figure 29) remove hot melt adhesives and various plastic particles. The main parameters affecting cleaning efficiency are radial acceleration, residence time and diameter of the cleaner.

Fractionation

Fractionation is a unit operation for separating a fibre stream into two or more flows (fractions) on the basis of fibre properties. Fractionation makes selective purification, treatment and utilisation of fractions possible, which can be useful where multiple or stratified products are an issue or where contamination is predominantly associated with a particular size phenomena. This process provides papermakers with the capability of selectively processing fibres suspension by separating short and long fibre stock. As result each stock quality can be selectively adjusted to suit the production requirements.

The basic equipment in fractionation processes are cylindrical or disc screens, very similar to those used for screening. Fractionation screens run under different conditions and have relatively smaller holes or narrower slots than similar screening equipment. Basket holes/aperture size, flow split, and stock freeness are the dominant factors of a fractionator's performance.

Fractionation technology is proved to be an effective means in recycling applications and it not only provides the flexibility of treating pulp streams selectively, but also provides economic incentives, such as reducing operating costs. As a result it significantly broadens the spectrum of papermaking processes.

Flotation

Flotation consists in removing hydrophobic particles (particularly ink particles), by encouraging the ink particles to coalesce with air bubbles and floating them up to the surface for removal. Flotation aids are used to improve the attachment of ink particles to air bubbles.

The first deinking cells were developed from and similar to those used in the mining industry for mineral ore flotation. Today, various designs are proposed by the machinery suppliers to improve air mixing, ink collection and foam removal (Figure 30).

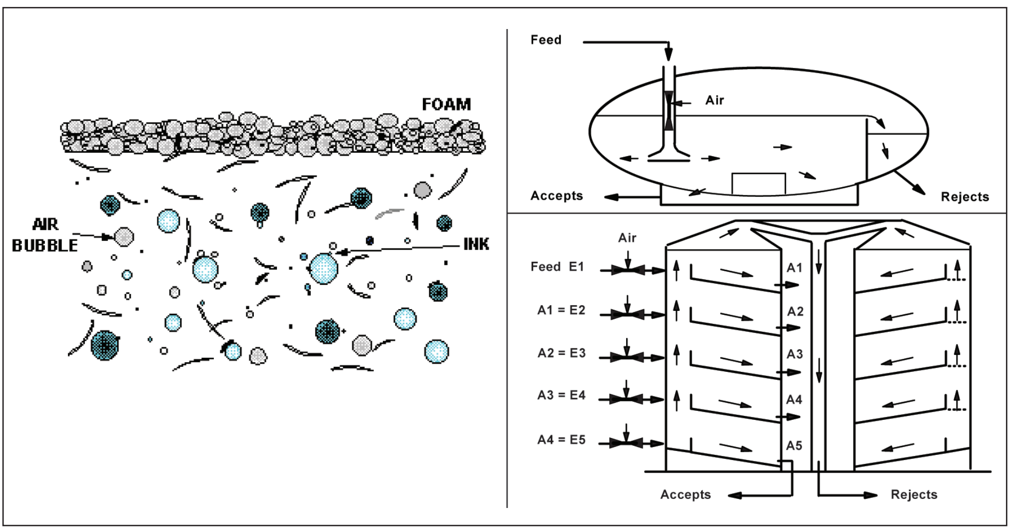


Figure 30: Principle of flotation and example of flotation cell designs - Flotation cells in series, - Multistage aeration cell

Injector cells, where the air is drawn in through a venturi, have become the standard in deinking with some 50% air mixed to the pulp at each aeration step. Several steps, using cells implemented in series or in a single cell, are necessary to reach the required pulp brightness, and, depending on the technology and the deinking line structure (Figure 30), a secondary stage is generally used to minimise the flotation losses. Flotation can remove ink (oil based ink with hydrophobic characteristics), varnishes and some adhesive particles.

Washing

Washing consists in removing small particles with water through a screen, larger particles including fibres being retained on the screen. The washing process always corresponds to that of a thickening stage and is derived from the same technology. Various types of washers operating in different consistency ranges are used for wash-deinking: typically drum and disk washers or high-speed belt washers (Figure 31) at low consistency and screw-press devices at high consistency.

The washing efficiency depends on the pulp consistency and on the technology used to avoid fibre mat formation and maintain turbulence in order to minimise the retention of fine particles by the build up of a fibre network. The maximum theoretical ink or ash removal efficiency is given by the thickening factor as far as the fine particles tend to follow the flow split with the filtrate. Washing can remove fillers and finely divided ink particles, as well as dispersed colloidal materials.

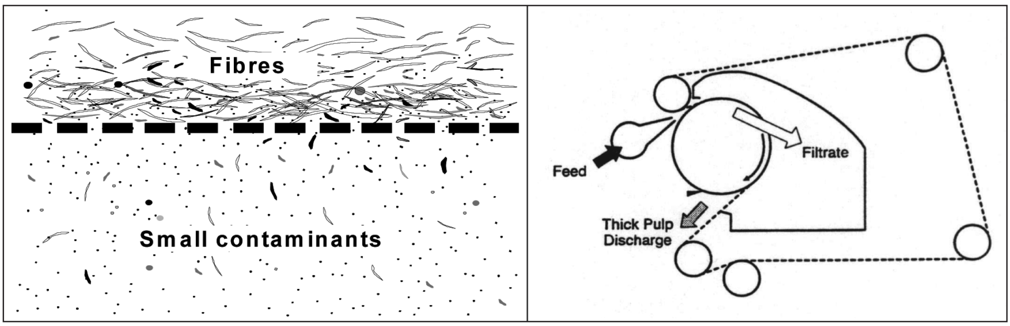


Figure 31: Principle of washing and example of high-speed belt washer

Dissolved Air Flotation

Dissolved air of micro-flotation is normally used to treat the deinking process waters in order to remove fillers and inks from washing waters and small dispersed colloidal contaminants in thickening waters. Micro-bubbles are formed by releasing part of the process water stream where air has been dissolved under pressure. Solids are flocculated and driven to the surface with the micro-bubbles (Figure 32). Compared to deinking froth flotation bubble size and air content are much lower and the process is not selective as the suspended particles are flocculated together.

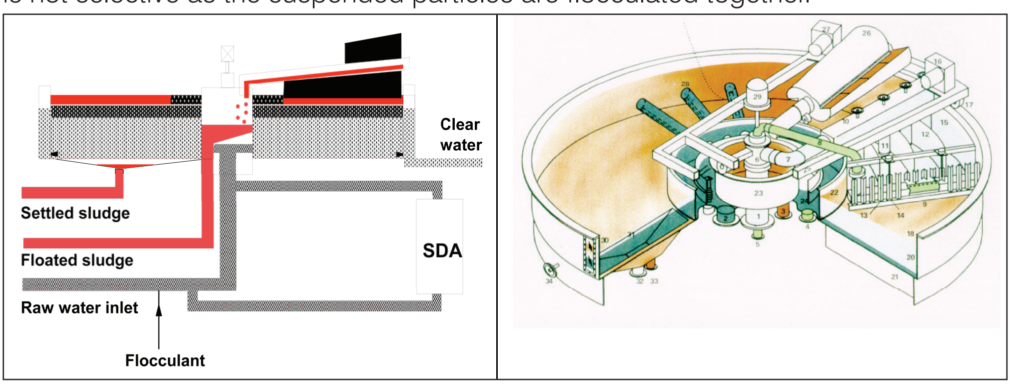


Figure 32: Principle of dissolved air flotation and example of technology Dispersion of residual contaminants

Dispersing & Kneading

This thermo-mechanical process, which does not remove any contaminant, was first used for the recycling of packaging papers to disperse wax and bitumen and is now widely used in deinking lines. Hot dispersing is performed after thickening the pulp at high consistency (25-30%) in low-speed kneaders or high-speed dispersers (Figure 33) in order to disperse residual contaminants such as hot-melt adhesives or specks from varnish particles and toner inks.

Some contaminants such as adhesive particles from labels or tapes show little dispersion ability. Hot-dispersing can be associated with peroxide bleaching. In a multi-loop deinking process, this treatment has been recognised as very efficient for detaching residual ink before post-deinking, as well as to disperse residual specks.

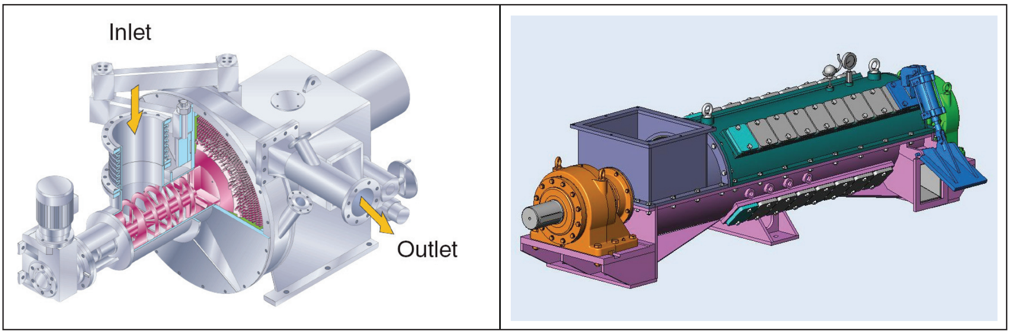


Figure 33: Principle of dispersing (left) and kneading equipment(right)

Bleaching

Various bleaching processes are used as brightness is often the main concern for DIP. Hydrogen peroxide (oxidative) bleaching and sodium hydrosulfite or FAS (reductive) bleaching are the most common. Peroxide is generally added to the pulper, to avoid yellowing of wood-containing pulp, and/or at the inlet of dispersing and kneading. Peroxide under oxygen pressure and ozone can also be applied for high brightness woodfree deinked pulp.

Bleaching is frequently used to ‘trim bleach’ the fibre; to ensure a consistent product.

6.3. Recycling & Deinking Lines

The complete process to be applied on recovered paper to meet the recycled pulp quality requirements is determined by the RP grade and demands of the final paper product. Almost half of the total recovered papers are recycled for the production of case materials, i.e. fluting and liner, mainly from Old Corrugated Carton (OCC), as reported in chapter 7 (see Figure 37on page 88). Besides these brown RP grades, white RP grades, i.e. mainly Old Newspapers (ONP) & Magazines (OMG) and some high quality grades, are reused in newsprint, tissue and other graphic paper grades as well as in whip top layers of packaging papers, and have thus to be deinked. Mixed RP grades are used together with OCC and for grey solid board layers and are thus not deinked. Some examples of typical recycling and deinking lines for different applications are presented below.

Recycling Lines

The recycling of corrugated board started with clean post-consumer carton boxes and converting rejects. Most of the recycling process was devoted to re-pulping, deflaking and refining of the kraft fibre rich raw material. The contaminant removal process steps gained importance as the recycling rate increased and with the development of hot melt glues and plastics in packaging. The hot-dispersing process has been developed to enable the recycling of bitumized and waxed cartons. The fractionation process was also developed for the recycling of packaging papers in order to limit the refining and hot-dispersing action to the long fibre rich fraction, reducing damage to the already shorter fibre fraction, which also contained the contaminants and residual flakes to disperse. Today, with a recycling rate of more than 90% in the case material sector (Figure 37 on page 88) there is much less need to refine the multi-recycled fibres. The need to preserve fibres and to save energy also led to shut down many hot-dispersing treatments, thanks to progress in fine screening as it is more effective, in a recycling perspective, to remove the contaminants, like hot-melt glues, instead of keeping them dispersed in the paper.

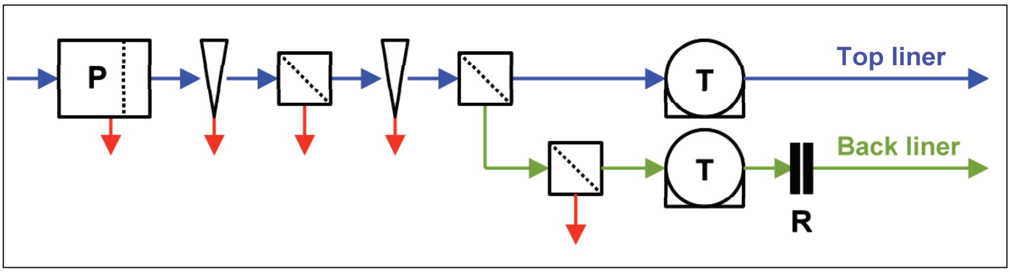


Figure 34: Recycling line for the production of test liner

Figure 34 shows a typical OCC recycling line for test liner. Pulping is performed in a low consistency pulper, followed by coarse screening (typically plate screens with holes) and fractionation (typically basket screens with 0.15 mm slots), both screening steps being protected by cleaners to remove sand and metals which could damage the equipment. The short-fibre fraction is particularly clean due to the use of fine slots and can be used directly for top liner or top layers. The long-fibre fraction has to be screened (typically with 0.25 mm slots) and the refining treatment is optional depending on the quality of the raw material. The long-fibre fraction can also be used in top layers if pulp cleanliness is improved, e.g. using screens with finer slots (0.15-0.20 mm), additional low-density cleaning and dispersing[32]. The stock preparation and fractionation process can be adapted to produce 3 fractions for different paper layers and grades, i.e. test liner and fluting[33].

The yield of packaging paper recycling lines depends essentially on the amount of non-paper components in the raw material, i.e. a few percent, and to a lesser extent on the recycling process, as fibre and paper flake losses are normally limited to 1 or 2%. Most of the RP soluble fraction (mainly starch) is removed with the process water and treated at the biological water treatment plant. The typical yield of OCC recycling lines is in the range of 90-95% and the energy consumption around 150 kWh/t recycled pulp.

Deinking Lines

Deinking lines are more complex than OCC recycling lines, since, in addition to the re-pulping and contaminant removal process steps, the pulp has to be deinked, i.e. inks have to be detached from the fibres and removed, and optionally bleached in order to reach the increasing brightness requirements. Removing inks difficult to deink, like flexo prints and some digital prints, and "stickies" from pressure sensitive adhesives (PSA) are currently the main challenges in the field of deinking.

The basic single-loop deinking line typically used some 20 years ago for newsprint included alkaline pulping (with hydrogen peroxide in order to avoid wood-containing pulp yellowing), coarse and fine screening and cleaning, flotation and final thickening for the recirculation of process water in this single loop. In the conventional single-loop wash-deinking process for tissue, the final flotation and thickening was replaced by washing and dispersing followed by a final second washing stage.

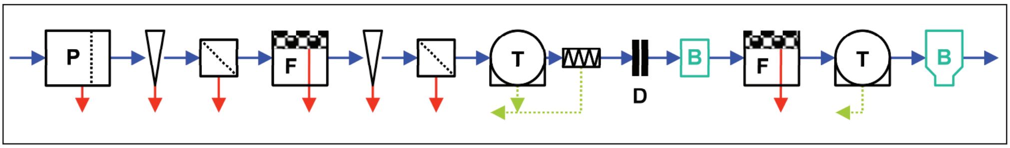


Figure 35: Deinking line for the production of newsprint (with optional bleaching steps)

Modern deinking lines are based on two-loop processes, as illustrated in Figure 35 showing a typical newsprint DIP line[34].The first (alkaline) deinking loop includes high-consistency pulping (drum or batch pulper and screen), coarse cleaning and screening (with holes), flotation, fine cleaning and fine screening (0.15 mm slots), thickening and pressing, and finally hot-dispersing or kneading, optionally combined with peroxide bleaching, to complete the ink detachment from the fibres. The second loop with post-flotation (to remove the residual free inks and specks) and thickening can be followed by reductive bleaching. A single fine slot screening step has been proposed before flotation, together with the use of smaller holes at the batch pulper to reduce the need for the coarse screening step in order to simplify the deinking lines[35].There is a trend to reduce the alkalinity in the first loop in order to produce less colloids during pulping step. Increasingly neutral conditions are required to accommodate flexo prints[36].

The current trend to increase the use of recycled fibres in higher quality graphic paper grades (SC and LWC) has led to the development of more sophisticated DIP lines[36] as illustrated in Figure 36. An additional medium consistency slot screening step implemented after coarse screening improves the removal of stickies to reach the final pulp cleanliness requirements, essential when the sheet is to be coated. The first bleaching step performed at the hot-dispersing step can be extended in a bleaching tower to increase the final pulp brightness.

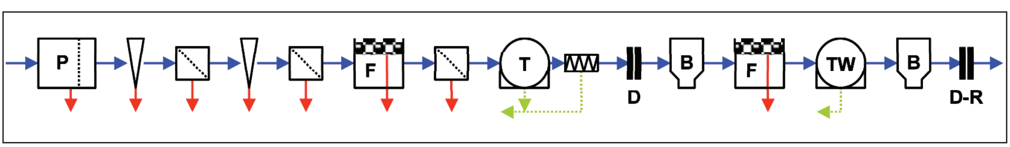


Figure 36: Deinking line for the production of SC and LWC papers

For LWC DIP lines, a washing step replaces the final thickening in the second loop in order to achieve the required de-ashing[37] and refining is then recommended to further increase the base paper strengths, especially with 100% DIP based LWC. Washing can also be implemented in a third loop after a second dispersing step[38]. Three-loop deinking processes are mainly used for the production of market DIP from wood-free mixed office waste.

Dissolved air flotation (DAF) is implemented on part of the thickening or washing waters to remove inks, ash and colloids. The process water management is based on counter current design, with typically a first DAF on the paper machine water loop, a second in the second deinking loop and a third on flotation reject thickening water. The use of screw presses at the end of the deinking line helps maintain separate process water loops in order to reduce the carryover of colloids to the paper machine.

The tissue DIP lines are based on two-loops wash-deinking processes replacing the thickening steps in the layout shown in Figure 35 (previous page). Depending on the raw material (wood-free or wood-containing RP) and final product quality, the flotation steps are kept or not in one or two deinking loops, the highest quality (deashing and brightness) being obtained at the lowest deinking yield (down to 60% or less) and consequently at the highest energy consumption with respect to the DIP production.

DIP application	Newsprint	SC / LWC	Tissue	Market DIP
Energy: Electricity [kWh/t]	300-380	400-500	400-500	650-750
Energy: Heating [MJ/t (t steam /t)]	450-950 (0.2-0.4)	650-1100 (0.3-0.5)	650-1100 (0.3-0.5)	900-1300 (0.4-0.6)
DIP line yield [%]	78-85	65-70	60-70	60-65

Table 7: Energy consumption and yield figures for different deinking processes

The specific energy consumption for the production of deinked pulp depends on the deinking process and to a large extent on the deinking yield, as shown in Table 7[30]. A typical figure for newsprint is 350 kWh electrical power and 0.3 t steam per t DIP. When adding thermal energy (steam for hot-dispersing) and electrical energy demand, the total energy figures are about 500 kWh/t for newsprint DIP and 700 kWh/t for SC, LWC and tissue DIP, compared to about 150 kWh/t for recycled fibres from OCC.

6.4. Reject & Reject Treatment

Solid Waste from Recovered Paper Processing

Whilst considering the non–paper and non–recyclable fractions of recovered paper the whole value chain of paper and board products needs to be taken into account.

The majority of paper and board products, after their use, become waste or secondary raw material within relatively short periods. Reuse or recycling of those products contributes to sustainable development by reduction of the volume of waste. However, recycling processes generate new waste. This is mostly due to the contamination of the secondary raw material, which has to be removed during re-processing. Disposal of this waste is becoming an important issue for paper mills.[3]

There is a certain level of impurities that cannot be exceeded because the lower the quality is, the more limited the application for the raw material becomes, until such time as it cannot be used for the manufacture of paper. The level (and type) of contamination has direct influence on the amounts of residues produced during recycling.

The accepted level of residues produced during recycling is an area largely dominated by laws, ordinances, regulations etc. but also economics to those who generate the residues. The regulations governing the disposal of waste will however undoubtedly become even more restrictive.[12, 15]

In the past, the paper industry always managed the problems associated with paper recycling very effectively, at times when there was the limited environmental enlightenment. The menace of water based inks, the problems of sludge disposal, the increasing problems caused by stickies and the increasing amount of solid waste are becoming critical issues in paper recycling. But all this happened at recycling rates, at least in Europe, which were significantly lower than those we would possibly have to contend with in the foreseeable future.

Various solid wastes, different in the composition are generated (removed from the fibre) in different stages of stock preparation process.

Table 8 below represents the most commonly occuring solid waste streams from recovered paper processing.

Source of waste	Composition of waste
pulper	Wires, plastic bags, textiles, bottles, strings, wood pieces, wet strength papers and other larger objects
high–density cleaning	Glass, nails, paper clips, textiles, pins
pre–screening	Long, thin and wide contaminants, plastics, polystyrene, stickies
flotation – deinking	Fillers, fibres, fines, printing ink, stickies
forward cleaning	Small compact particles with high density such as sand, shives, hard particles from UV–colours, coating colours, varnish
fine screening	Plastic fragments, light weight contaminants, hot melts, stickies, fibres
process water clarification	Colloidal material, fillers, fibres, fines, ink particles

Table 8: Solid waste from different stages in recovered paper processing with non–hazardous characteristics[3, 24, 25]

It is essential to pay attention to the waste, to learn more about the waste and to be conscious of what is needed for its removal, especially since these materials can become very attractive and valuable material for further processing in other industry sectors. And through further processing it the impact of the paper industry on the natural environment can be reduced through the lowering of emissions, while at the same time extending the Limits of Paper and Board Recycling.

Reject Treatment

A consequence of processing recovered paper in paper and board production is the number of unwanted material produced, but unwanted doesn't have to mean unusable, nor have a value. The nature and quantities of such materials will vary in line with the grade of raw materials used. Such material can add up to 15% of the total production. In addition those mills that deink recovered paper will also produce sludge, in the amounts up to 40% of the total production capacity.

Not so long ago there was no problem with handling the rejects: collection, dewatering, loading onto trucks and transport to a landfill. The costs were low and perhaps in some European countries they still are, but the situation is going to change and much more work needs to be done with the reuse option for rejects. The option of landfilling rejects has to disappear, the new purpose is to make the unusable useful. Development of the use of recycled fibres in the paper industry is the success story of the second half of the 20th Century. It was a development that was unseen in the 1950s. At the threshold of the century, recycled fibres are an indispensable raw material in the global paper industry to satisfy the need for fibres in industrialized and developing countries

Management of residues from production processes is a sustainability challenge for the industry and society as a whole. That is to say, residues, as by-products from production, are also part of the eco-cycle scheme. This is because of the real value of waste materials. Still in paper industry, the solid wastes are considered as detrimental for production by-streams with negative value (to the papermaker). First of all, balance has to be found between the costs and quality of the raw material (recovered paper). As it is known that, production of 100% recyclable fibres containing recovered paper is possible but very often are economically unattractive (Figure 13. on page 51).[22]

Environmentally, the disposal of great amounts of problematic, detrimental matter to be disposed can be problematic and for papermakers this can incur extra costs that can in some situations can be as much as 5% of total annual paper mill operating costs. Very high waste disposal fees are paid for solid waste from paper recycling. In some European countries waste disposal fees have already reached the level of 150 €/ton.

It is obvious that the composition and amount of the rejects depends on the grade of processed raw material (see page 51) as well as on the efficiency of the stock preparation line equipment employed. The treatment technology to be applied to the reject stream, depends to a large extent on the quality of those materials. However the solid waste have to be pre-handled at the mill's site. The pre-handling consists mainly from dewatering and drying of the wastes, in some cases certain solid waste streams should also be sorted in order to separate their valuable components (i.e. fibres with high papermaking potential). There is thus a wide variety of different reject's treatment technologies available:

- Production of secondary fuels (especially with reject with high caloric value);
- Direct incineration and energy recovery (external and internal facilities);
- Production of cement-like components - non-organic components/ingredients used as an alternative raw material for other applications (e.g. cement substitutes);
- Certain rejects streams with high fibres content can still be used for papermaking processes for lower quality products;
- Applied as raw material for construction industry - building panels or insulation;
- Composite semi-finished products;
- Conversion of plastic containing wastes into kerosene and petroleum products;
- Fillers/pigments recovery.

7. Use of Recovered Paper in Different Paper Grades

In the ideal case recovered paper would primarily be used for the manufacturing of the same grade of paper, i.e. newspapers for new newsprint, brown packaging papers for new packaging grades etc. depending on the availability of recovered paper and the collection systems used. This principle can however not always be fully applied; a certain mixing of recovered paper always takes place during the collection process.

In recovered paper utilisation downgrading is always an option. This means that high quality recovered paper grades can be used in the production of "lower paper grades". On the other hand, it is difficult to use low grade recovered papers in the production of high quality end products; e.g. mixed grades cannot be utilized in printing & writing paper manufacturing. Clean recovered paper is, however, always a good raw material for the paper industry.

With suitable collection and treatment technologies recovered paper can be utilized in nearly all paper grades. This is illustrated in Figure 37 (overleaf), which indicates the utilisation rate of recovered paper in different major paper grades in Europe in 2005. This figure and the corresponding Table 9 on page 89 clearly show the following:

- The utilisation of recovered paper for different new paper grades varies largely, up to 100%, the overall European utilisation being 48%;
- The world of recovered paper is clearly divided into two large groups:
  - printed products which after deinking are used for manufacturing of new printing papers, mainly newsprint and similar grades;
  - packaging papers and board which without deinking are used for new packaging materials, brown grades for case materials;
- These two major groups are relatively equal in size, covering c. 50 and 40%, respectively, of the total paper and board production;
- Household and sanitary products are important applications as well, but much smaller than printing grades or packaging materials.

Figure 37 indicates that in the printing paper sector, newsprint is the dominant product using recovered paper as a raw material, its utilisation rate being as high as 82%. Even though it represents only c. 22% the overall printing & writing paper production it still absorbs c. 71% of the total amount of recovered paper used in the sector.

At the same time this indicates that printing & writing grades, other than newsprint, form the product area with the greatest potential for an increase in the use of recovered paper. Increasing the utilisation rate of recovered paper in these grades from the present level of c. 10% to, for instance, 30% would increase the need for clean and bright recovered fibres by as much as c. 7 million tons annually in Europe.

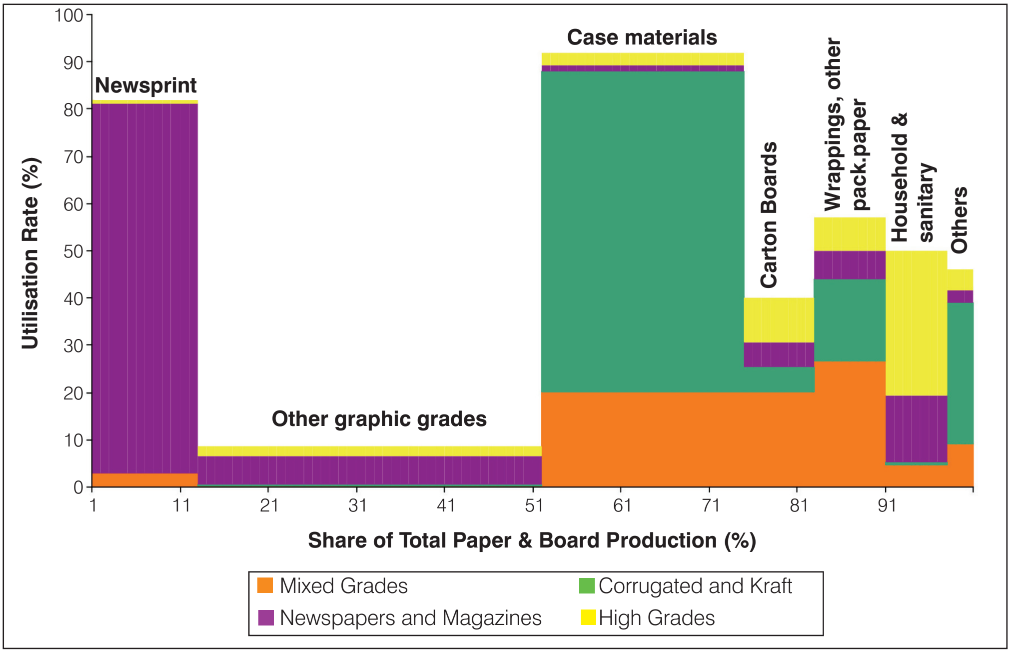


Figure 37: Utilisation of Recovered Paper (RP) in CEPI Countries *(Source: CEPI 2005)*

Utilisation of this new potential depends, however, on the availability of suitable recovered paper and technical possibilities to produce a deinked furnish clean and bright enough for these paper grades. This in turn would require a collection and sorting system that could collect, sort and deliver recovered woodfree paper grades in large enough volumes.

The best recovered paper sources such as printing houses, converting facilities, over issues and stores are already well covered. The share of white grades of the RP volume collected from households varies between 3-7%. Optical sorting systems are available which can sort out white grades from the recovered paper stream but they are not used to any large extent. Much also depends on the quality and degree of pre-sorting of the input recovered paper.

The lack of an unused collection capacity for high quality recovered printing paper and therefore available corresponding sorting systems thus form a clear limitation to an increase of the utilisation of recycled paper in the printing and writing sector.

In the area of packaging grades liner and fluting are the main grades utilizing recovered paper, the utilisation rate in these being c. 91%. These grades are thus already "filled up" with recovered paper. Their share of the production of packaging materials is c. 60% but their share of the sectors total use of recovered paper is c. 74%. Of the total use of OCC almost 90% goes into the production of case materials liner and fluting.

Fluting and liner together with newsprint in the graphic papers sector use about two thirds of the recovered paper collected in Europe.

Household and sanitary products are often regarded as big users of recovered paper. This is not the case neither in absolute nor relative terms. With an utilisation rate of c. 50% this sector uses only about 7% of the total amount of paper recovered. The main raw material is white recovered paper grades from printing industry and offices. The technical possibilities to increase the amount of deinked furnish going into these grades obviously exist; an increased use is perhaps more a question of the attitudes of the end consumers to the use of recycled material in hygienic products.

To summarise, different paper grades are being mixed with each other during the collection process and upgrading of a recovered paper furnish is much more difficult than downgrading. It is evident that as the total overall collection rate is increased, so the overall quality of the additional recovered paper furnish will decrease due to an increasing mixing of different paper grades. It is also evident that the paper grades, that can absorb very large amounts of low quality recovered fibres, i.e. newsprint in the graphic paper sector and fluting & liner in the packaging sector are already very well "saturated" with recovered paper furnish. Therefore, the development of collection systems that minimize the degree of mixing of different paper grades during the collection process as well as enabling an efficient utilisation of the best collection sources and removes a bottleneck for an increased utilisation of recovered paper in printing & writing grades and thus also a clear limitation for a further increase in paper recycling in Europe.

	Mixed Grades [kton]	Corruga. and Kraft [kton]	News. and Magazines [kton]	High Grades [kton]	Total Usage of RP [kton]	Usage by Sector [%]	Total Paper Production [kton]	Utilisation Rate [%]
Newsprint	319	0	8670	98	9087	19.0	11026	82.4
Other Graphic Papers	144	83	2433	952	3612	7.6	38093	9.5
Total Newsprint + O.G.P.	463	83	11103	1050	12699	26.6	49119	25.9
Case Materials	4777	16171	310	676	21934	46.0	23978	91.5
Carton Board	1663	443	420	763	3289	6.9	8082	40.7
Wrapping upto 150g/m²	346	640	220	314	1520	3.2	3843	39.6
Other P&P for Pack	1814	747	255	250	3066	6.4	4281	71.6
Total Packaging Papers	8600	18001	1205	2003	29809	62.5	40184	74.2
Household & Sanitary	333	49	912	1915	3209	6.7	6376	50.3
Other	402	1290	113	185	1990	4.2	4298	46.3
Total	**9798**	**19423**	**13333**	**5153**	**47707**	**100.0**	**99977**	**47.7**

Table 9: The utilisation of Recovered Paper for different paper grades in 2005 CEPI countries

8. End uses of Recovered Paper other than Papermaking

8.1. General Aspects

There is no reliable coherent data available about Recovered Paper utilisation outside the paper industry in Europe.

In the USA, according to AF&PA (American Forest & Paper Association) statistics, the utilisation of recovered paper in paper and board manufacturing was 30.2 million (metric) tons. Additionally, 0.8 million tons was used for construction purposes (including moulded products) and 1.6 million tons for other uses (including insulation, mailing bags and other end uses). These figures indicate that between 4.8% and 7.4% of all recovered paper is utilised outside the paper industry.

It is difficult to estimate the recovered paper utilisation for other purposes outside the paper industry in Europe, because reliable statistics simply do not exist. According to CEPI estimates, in addition to the paper industry use, over 8% of collected paper is used in other recovery applications (e.g. construction material, animal beddings, composting, composting and energy). Because this figure includes energy use (which according to current European definitions is not recycling) the recovered paper recycling for other end uses must be considerably lower than 8%.

If we assume that, for example, 4-5% of recovered paper in Europe is utilised for other end uses, outside the paper industry, the actual recycling rate would be about 4% above the level which the official statistics show (61% in 2005 for COST E48 members countries, *according to CEPI Key Statistics*). The reason for this is that, so far, the recycling figures have included only the paper industry end uses.

It is a frequently asked question; is it more profitable to recycle paper for papermaking purposes or to compost it? Modern printing inks are mostly vegetable based, non-toxic and not damaging to the environment. Therefore, it seems recovered paper is a suitable material for a good compost.

However, there are good reasons why recycling is located higher than composting in the materials management hierarchy. Namely, the majority of energy in the paper lifecycle is spent to manufacture paper from virgin pulp (as opposed to growing trees, transporting the paper to retailer, collection and processing). Thus, recycling for papermaking purposes saves most of the manufacturing energy. It has to be kept in mind that, most of it will be lost when the recovered paper will be composted. Furthermore, the avoided costs of other raw materials will be lost (water, bleaching chemicals, minerals etc.).

Paper is a non-renewable resource and should be recycled, not composted. However, the recent changes in the energy market proved that the above mentioned statement depends on the market needs. Neither is better than the other. Recycling or composting occur where it is economically feasible and the advantages or disadvantages of each must be considered on a site specific basis.

From a papermaking standpoint, promotion of recycling should take priority over composting activities (or any other use which removes the material from the Paper Recycling Loop). For example, old corrugated cardboard is a great material to be recycled and utilised within the paper industry as it is a secondary raw material of high quality, and should not be collected amongst the food scraps for composting.

Finally, nearly all types of paper industry related waste are suitable for composting (fibre containing sludges, deinking sludge, as well as biological sludges from waste water treatment plants). Solid wastes from recovered paper processing (pulping, screening and cleaning) are usually available for composting to a limited degree. In this type of solid waste, the content of materials like plastics, glass, stones and other non paper components has a detrimental influence on composting, and therefore efforts should be made in order to separate those materials.

8.2. Biorefinery

The Principles

The basic principle of the traditional oil refinery and the biorefinery are schematically represented in Figure 38. An oil refinery mainly supplies transport fuels and energy, and only a relatively small fraction is used for chemistry. At a biorefinery a relatively large amount is used for chemistry and material utilisation.[39]

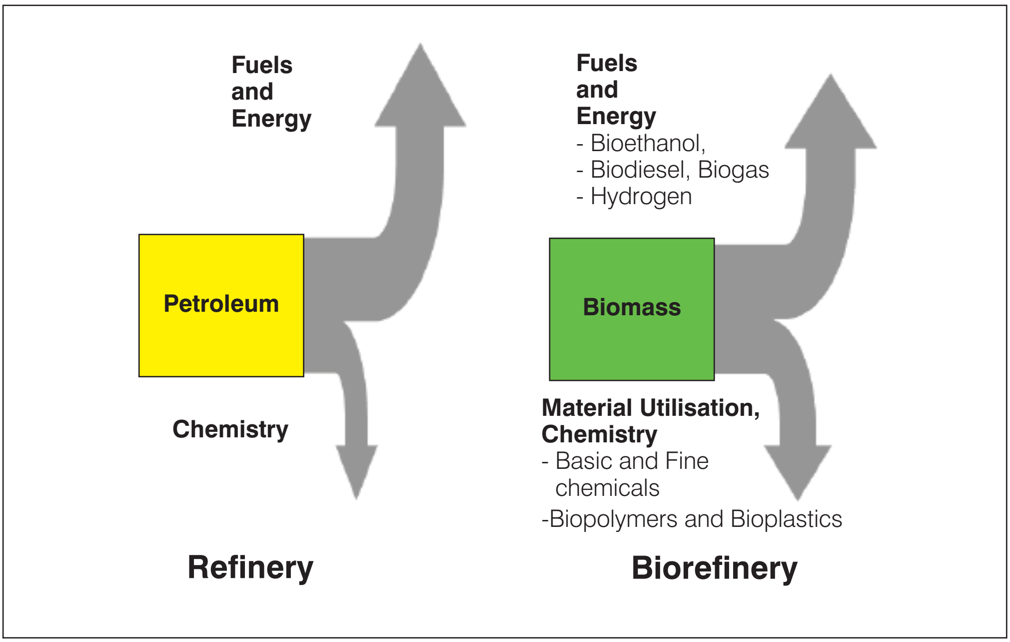


Figure 38: Oil refinery versus biorefinery (Kamm *et al.,* 2006 [39])

The sentence, "Biorefining is the sustainable processing of biomass into a spectrum of value-added products (chemicals, materials, food and feed) and energy (biofuels, power and heat)" can be used as a definition covering various sectors.[40]

A primary concern in the biorefinery approach for the production of fuels and chemicals to replace the current petrochemical products, is the availability of biomass, namely regarding the competition with food. Biomass sources can be categorised in different ways (Biofuels Technology Platform, WG1 Biomass availability & supply) including:

- Agricultural residues and energy crops;
- Forest biomass;
- Biowaste streams, which includes municipal solid waste, construction, demolition, packaging and household wood waste, market and garden waste, food processing waste and sewage sludge;
- Marine biomass, keeping in mind that it is generally accepted that of the global primary biomass production half is terrestrial and half aquatic.

In these categories, recycled fibres are generally considered as a component of municipal solid waste, and not in the forest biomass where they primarily belong to.

Many existing industries, including the agro-food and the pulp and paper industries are in fact already a type of basic biorefinery:

- Chemical pulp mills are among the largest producers of bio-energy as about half of the raw material is reused on site, which enable energy neutral production of chemical pulps. Some specialty chemicals are also produced in some mills.
- Paper recycling and deinking mills also produce bio-energy from solid rejects and deinking sludge (incineration, combustion & heat plants). “Biofuels” in different forms (like fuels pellets from coarse rejects using the Rofire process, methane from the water treatment plant) and other by-products (like cement products produced from deinking sludge incineration processes) are also produced in some mills.

The implementation of real biorefinery concepts in the pulp and paper industry sector, means that, besides the main products (pulp and paper), the mill sites would produce significant biofuels and chemicals measured in terms of quantities, added-value and CO_2 impact regarding the replacement of fossil oil derived products.

In this respect, various “biorefinery processes” will have to be implemented on pulp and paper mils sites to produce such bio-fuels and chemicals from basically wood or recovered paper biomass raw material. Typical “biorefinery processes” include:

- Chemical processes: extraction, fractionation, synthesis, etc.;
- Thermo-chemical processes: gasification, pyrolysis, etc.;
- Bio-chemical processes: fermentation, digestion, etc.

Main driver in the biorefinery approach is that forest biomass should first be used for products. Biorefinery aims to create more value from the bio-based raw material provided by the forest-based sector. Compared to direct use of wood or recovered paper for energy production, the production of pulp and paper creates (or safeguards) several times more added value and employment (CEPI report).

Wood-based Biorefinery

Various biorefinery concepts around the chemical pulp mills have been extensively investigated and will become reality: with the implementation of new processes and the collection of additional forest residues, the pulp mills will produce bio-fuels and chemicals while remaining energy neutral. An example of such a wood-based or forest product based biorefinery concept[41] is shown in Figure 39.

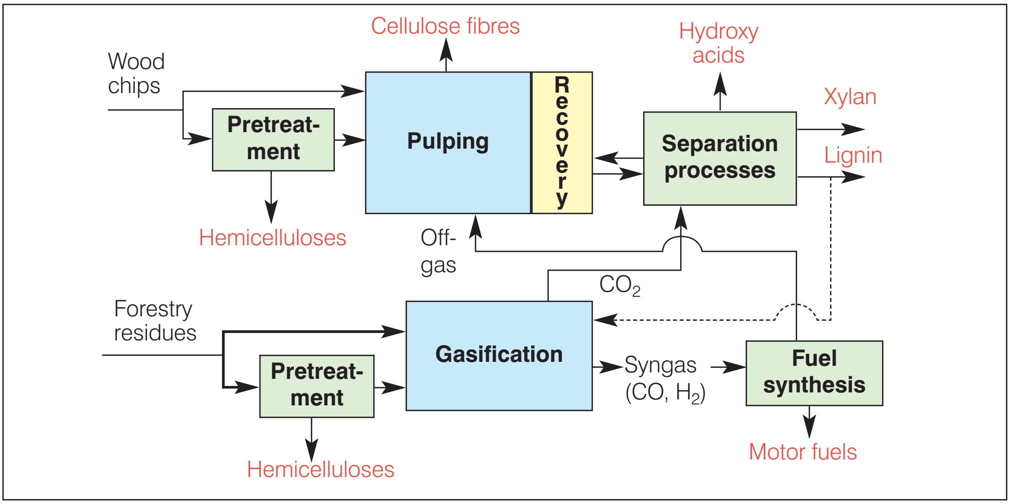


Figure 39: FORCE-concept of STFI and VTT *(Axeguard, 2007).*

Recycled Fibre Based Biorefinery

Concepts of recycled fibre biorefineries have not yet been fully investigated. Obviously, the development of such new strategies where recycled fibres are reused for paper first and for energy last would retain jobs and add value, compared to the scenarios where biorefineries are developed on municipal waste, including recovered paper. Figure 40 shows the recycled fibre biorefinery concept in the wood-fibre value chain compared to the wood-based biorefinery. In the recycled fibre biorefinery concept, the biomass raw material is essentially fibres from recovered paper (instead of wood in Figure 39), with some other biomass like starch (mainly from corrugated board) as well as some non-renewable organic materials like plastics entering the paper recycling chain with the collection of packaging paper & board.

Most of the large paper recycling and deinking mills already produce some bio-energy and other bio-products, but not yet liquid biofuels or bio-chemicals, from their rejects:

- Coarse rejects can be incinerated to produce energy on-site or secondary solid fuel, for example with the Rofire and FoxFire processes[42] used in Dutch mills. Coarse rejects can also be used to produce various composite materials[43];
- Deinking sludge incineration produces, despite the high ash content, some excess heat used on site. Deinking sludge is commonly used in the production of bricks and cement[44]. A special incineration process[42] treating sludge from different mills to produce cement has been reported in The Netherlands. Sludge can also be used to produce panel board for the building industry[45];

- Biogas is generated at the anaerobic effluent treatment plant, from the RP soluble biomass fraction. The bio-methane produced in packaging paper recycling mills can lead to significant savings on the gas consumption[46].

In addition to recycling and deinking rejects, RP sorting rejects should be included in the recycled fibre (or RP) biorefinery domain considered in Figure 40.

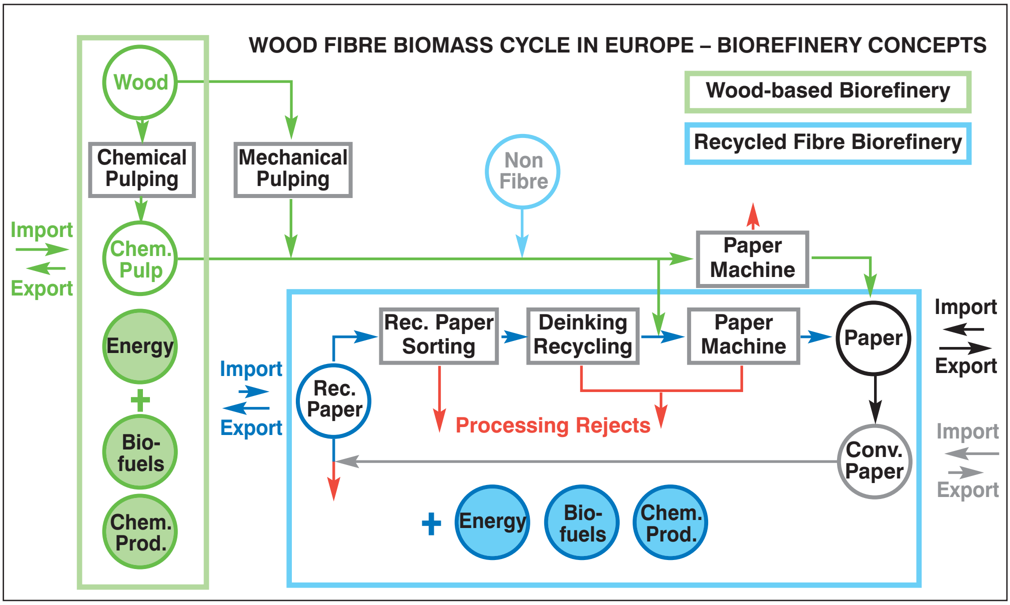


Figure 40: Wood based and recycled fibre biorefinery concepts in the fibre value chain

8.3. Recovered Paper for Insulation in Constructions

The insulation is made from a composite of recycled paper such as cardboard, newspaper and telephone directories. Fibrous insulation can be used for building, renovation and re-insulation projects. In addition to being more environmentally friendly than conventional fibreglass insulation, it is also denser and good for both sound reduction and increased airflow.

There appears to be significant potential to develop the cellulose based insulation technology, although further research is needed to develop appropriate technologies, and investigate costs.

The proven methods of application ensure the insulation provides a complete seal to minimise heat loss, eliminating gaps, cracks or other cold bridges. It has extremely low embodied energy, requiring far less energy to produce than any other mainstream insulation material.

Its fire resistance is improved through the addition of simple inorganic salts, enabling it to comfortably meet the fire protection standards required for timber-frame construction and conventional lofts. After additional treatment it is also resistant to biological and fungal attack, treated against insects and is unattractive to vermin. Further it is also harmless to other common building components such as copper pipes, electric cabling and metal nail-plate fasteners.

The traditional process involves grinding the paper in a hammermill to produce a fibre fluff, which is treated with fire retardant chemicals (boric acid or ammonium sulphate), then bagged and sold. The finished product usually consists of about 80% post-consumer waste, with the remaining 20% consisting of fire retardants and in some cases acrylic binding.

When, eventually, insulation is removed from a building, it can be recycled again or incinerated safely without creating toxic waste or biodegradability problems.

8.4. Moulded Papers

Moulded fibre is a classic packaging medium that continues to be used in new and innovative ways and has enjoyed a renaissance due to the excellent environmental credentials of paper. Moulded pulp is manufactured from 100% recovered paper, with the process being tolerant of some contamination, typically more than a conventional sheet or board product.

Figure 41: The most common moulded paper product – an egg box

The term ‘moulded fibre’ describes the production method where up to 100% recovered paper is dispersed in water to form a homogeneous fibre suspension. This mixture of water and fibres is pumped into a vat containing a large revolving drum. Packaging moulds are mounted onto the surface of the drum. The liquid pulp is sucked into the moulds by means of a vacuum and water is simultaneously extracted. The wet packaging is then pressed and dried. The final product is subsequently post-pressed and printed or labelled. Machines used for this process work very often with a closed water system, in which the water is cleaned and used again within the process.

Moulded pulp packaging is versatile packaging material and can be moulded to suit a variety of applications, almost any three-dimensional shape with many favourable characteristics. With the fibres being relatively soft and able to cushion items by absorbing any impacts, it has the ability to protect products and to promote their integrity, freshness and appearance. Small-scale, batch production of moulded pulp products for use in packaging has become technically and economically feasible with the advent of new moulded pulp technology. Over the years the product range has been considerably expanded. Today moulded pulp packaging is increasingly being used in electronic and consumer applications, from egg, meat, fruit and bottle packaging to disposable tableware, custom-made protective packaging and hospital disposables. Moulded pulp technology can also be used to manufacture high end technical products (such as filter media) from material blends using virgin pulp fibres and synthetic fibres.

Moulded fibre products are recyclable, biodegradable/compostable, easy to dispose of; they can be manufactured in different colours or special fibre mixes.

Quality of recovered paper is very often not seen as an issue, although large solid contamination such as compact discs in newspapers/magazines causes problems (environmental loads caused by decreased processing efficiency and higher waste generation, expensive waste disposal fees).

An increase in the number of companies manufacturing moulded pulp could be advantageous,(and the market could be grown to accommodate their output) particularly as the process can utilise the lower grades that currently have little market value. There may in particular be an opportunity in the regions, where a proportion of paper collected for recycling is currently landfilled. A niche market may also exist in the regions where there is an existing concentration of other (non-paper) manufacturing activities that could consume the moulded pulp packaging, such as electronics.

8.5. Recovered Paper for Art & Handicraft

Many museums all over the world collect paper. In most cases not only for the material itself but for the image depicted on it, such as a drawing or a print, but it happens more often nowadays, that also three-dimensional objects made out of paper or recovered paper represent high artistic value.

In the last two centuries, paper has been used to an increasing degree as the basic ingredient for other forms of creative expression, in which the material aspect plays an important role. Recently, more and more artists have discovered the creative potential of paper as well as raw materials used for paper production, among those also recovered paper.

Although this kind of activity will never provide a significant commercial outlet for Recovered Paper, it does have an important role to play in improving the consumer’s perception of Recovered Paper as a valuable raw material and not as a waste product of society.

Figure 42: Use of Recovered Paper in art

8.6. Recovered Paper as Biomass for Energy Production

Research shows that, under the correct conditions, recovered paper burns cleaner than coal. It produces less nitrous oxides and sulphur dioxide that contribute to acid rain. To produce an alternative 'solid fuel' pelletisation equipment shreds waste paper and other combustibles, softens them with steam, then compresses and extrudes them into pellets. When burned, the pellets, mixed with coal and other fuels, produce process heat, steam, and in some cases, both process steam and electricity.

Segregated recovered paper can be recycled a number of times into new products, but once the fibres have lost their papermaking abilities they can then be incinerated for heat recovery, allowing two 'bites' at the environmental cherry. Similarly, those paper products unsuitable for recycling, for example hospital wipes, can also be incinerated for heat recovery.

When choosing the best environmental option individual elements of the waste management cycle should not be viewed or compared in isolation. A full LCA should be used, where possible, to determine the impacts on a number of areas.

Recycling and incineration with heat recovery can co-exist. A prime example is Denmark, which has a positive recycling record but also incinerates, with heat recovery.

The paper industry's view is that incineration with heat recovery should be used in preference to landfill, but only after recycling requirements have been met; ensuring that the maximum possible benefit is derived from the fibre before it is used for energy production.

Dilemma: raw material vs. energy use?

Energy contents:

1 ton of oils is equal to 2.5 tons of paper (if oil price USD 100/barrel = USD 764/ton). The same equivalent of paper = USD 305/ton

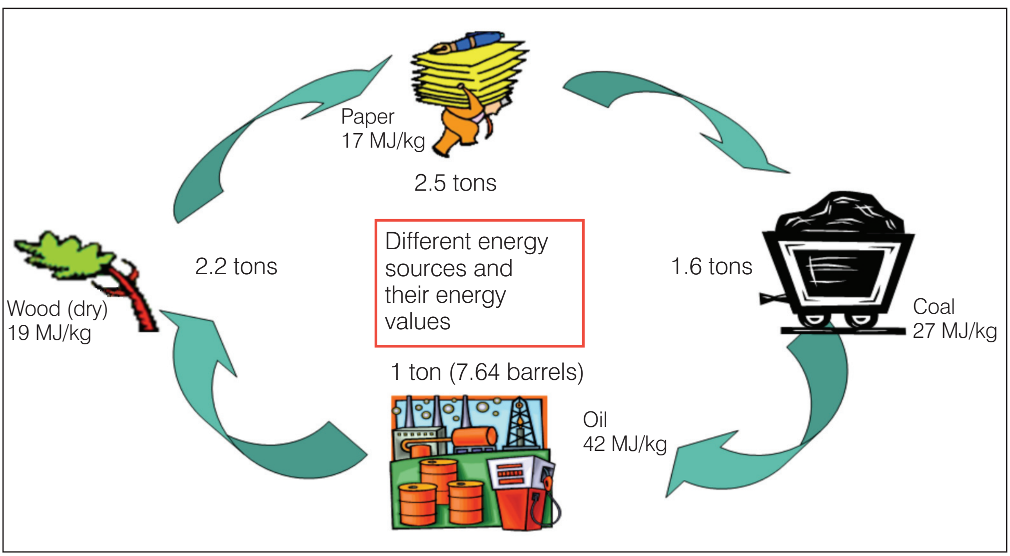


Figure 43: Different energy sources and their energy values *(Source: Pöyry)*

9. Recovered Paper Market & Trade Issues

9.1. Global Trade Flow

About 196 million tons of recovered paper was collected and utilised globally in 2006. About 23% of this volume (45 million tons) was not utilised in the country of collection but traded and exported to another country.

There is significant trade between countries and regions. Regions which collect more recovered paper than they can utilise are net exporters of their surplus material; to regions where collections fall short of the demands of local paper producers.

Globally trade has to maintain a balance. Recovered paper imported to one region is not possible if there is no excess material in other regions. China and other parts of Asia (excl. China & Japan) are the biggest net importers of recovered paper. On the other hand, North America, Europe and Japan are the main recovered paper exporters.

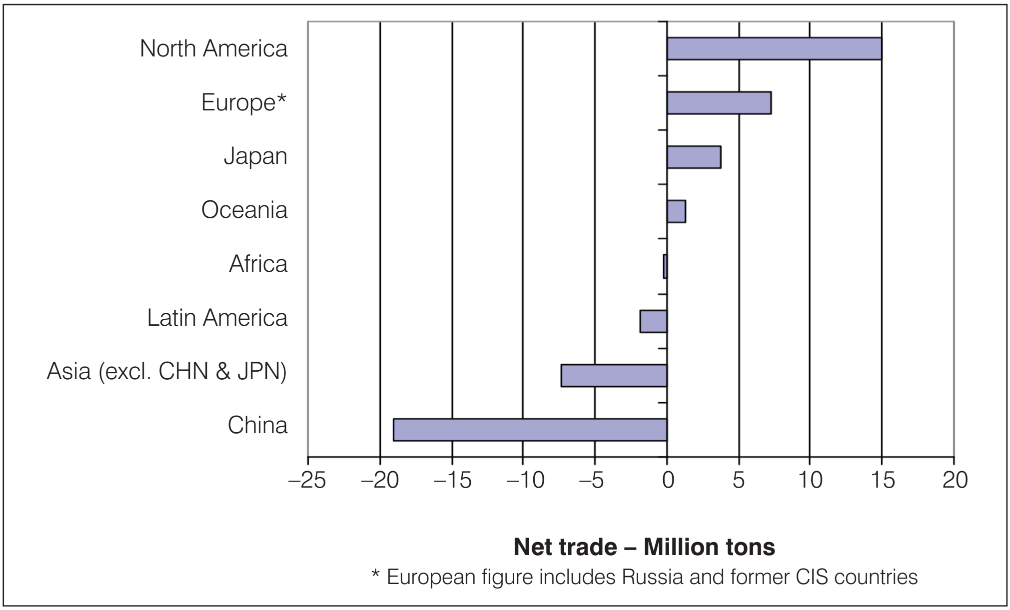


Figure 44: Global recovered paper trade balance by region in 2006 *(Source: Pöyry)*

The biggest recovered paper trade flows are from the USA to Asia, between European countries and from Europe to Asia. Great volumes also move from Japan to other Asian countries, from the USA to Canada and Latin America, between Asian countries and from Oceania to Asia. At present, China is, by far, the most important recovered paper importer in world markets. China with its current unprecedented appetite for Recovered Paper also has a great effect on the price level.

Taking into account the limited availability of virgin fibre raw materials in Asia and, in particular, in China and the very fast economic development in this region it can be expected that the flow of recovered paper from USA and Europe to this region will continue in the future and be limited only by the availability of recovered paper in these regions.

Eventually, China's internal market for Recovered Paper will develop and the region will satisfy more of it's needs from local material. The decline of this 'export market' could have a profound effect on the global recovered paper market and current 'exporters' should be looking to develop new markets / consumers to utilise current collections when this happens.

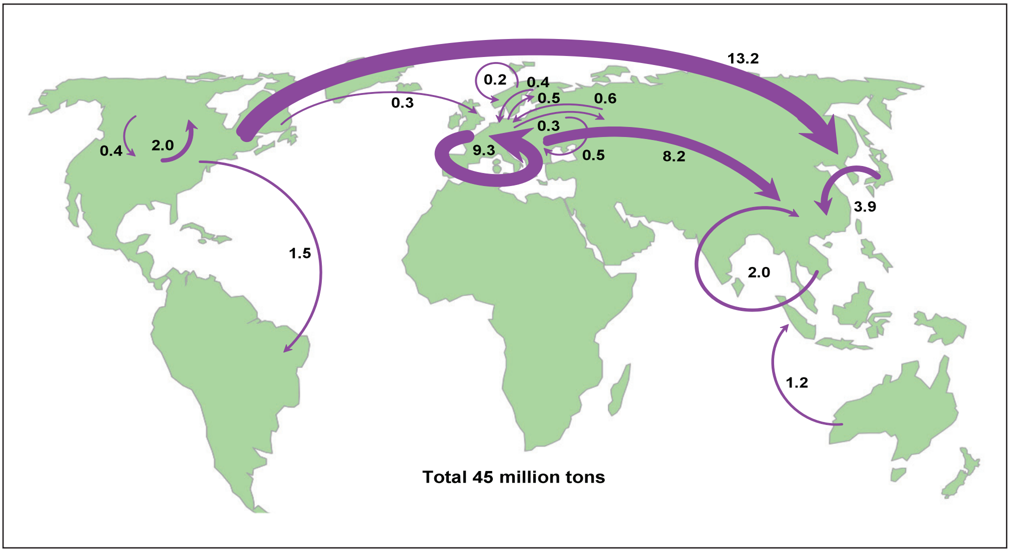


Figure 45: World recovered paper flows in 2006, million tons *(Source: Poyry)*

9.2. Trade Flow in Europe

The total recovered paper collection in Europe (Table 2 on page 34) was 56.7 million tons in 2006. During the same year the recovered paper utilisation was 50.3 million tons. Thus European collection exceeded the utilisation by 6.4 million tons which volume was exported to outside the region.

There are also great structural variations inside Europe from one country to another. The biggest net exporters (in 2006) were the UK, Belgium, France, the Netherlands, Italy, Poland, Switzerland and Germany. The leading country, in this respect, was the UK.

On the other end of the scale are the net importers namely Austria, Spain, Sweden and Slovenia.

It has to be noted that this analysis shows the net trade for the total recovered paper. If the trade balances were analysed by different recovered paper grades, the outcome would be different for each specific recovered paper grade.

According to the recent forecasts (see page 37) the European recovered paper net export is expected to stay at present level or even to grow to some extent by 2015. This means that even though the utilisation will grow, the collection is expected to grow even faster. This puts great pressure on developing the collection, sorting and logistical issues, because the best sources as well as the easiest and densely populated areas are already being exploited.

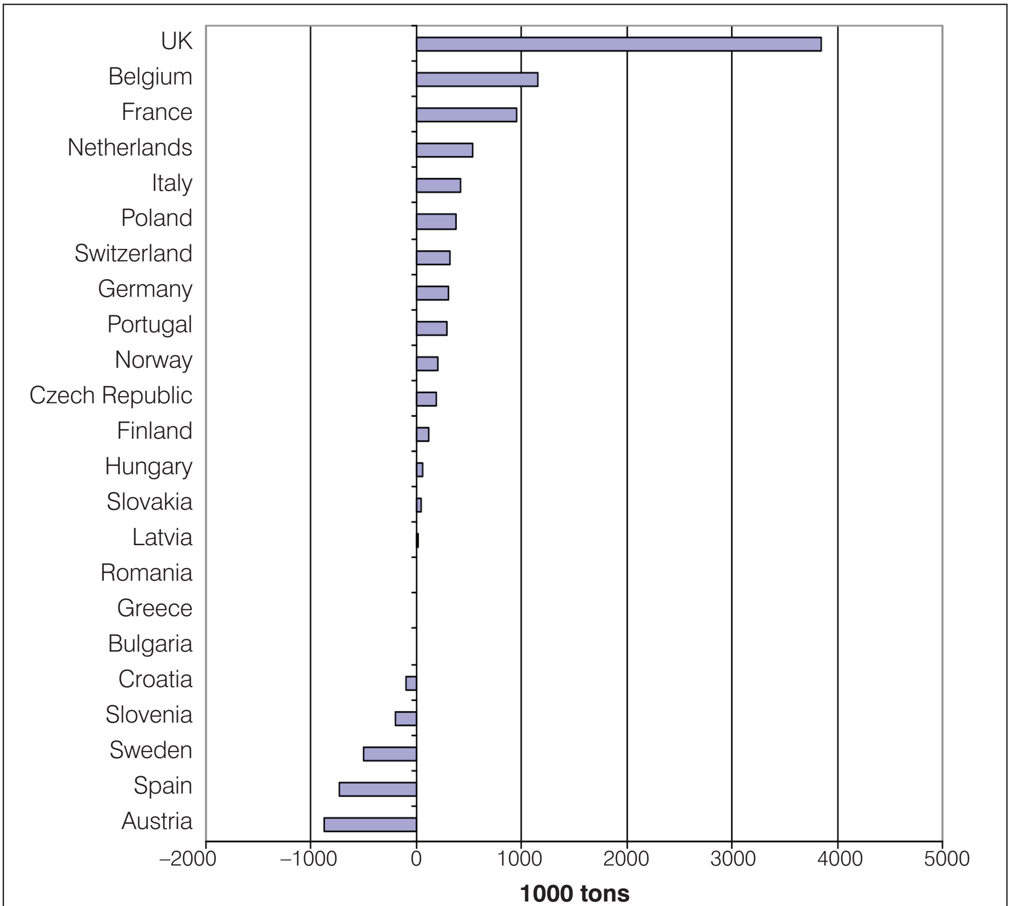


Figure 46: European Recovered Paper net trade by country in 2006 *(Source: Pöyry)*

10. Legislation & Regulations

10.1. Introduction

Legal provisions on waste, regulating recovery and recycling of paper, have become an essential framework for the paper industry. Whereas the legal framework, as it is set up by the European Waste Framework Directive[54], was old and outdated, some other more recent pieces of legislation and policy had, sometimes inadvertently, a consequence for recycling too. While now the Waste Directive has been recently revised and other mechanisms such as Better Regulation project has been put in place, most of the implementation of the legislation at the national level is still based on the over 30-year-old Directive on waste.

In particular the industry has felt being under served by the Waste Framework Directive as it implies that recovered paper merely as waste to be disposed of, and not a valuable raw material. It also did not support the industry's efforts to implement quality management which has become more and more vital with increasing paper collections on one hand, and tapping into poorer quality sources of recovered paper on the other hand. In particular, increasing volumes of co-mingled collections (collections of multi-materials where several dry recyclables are collected in a single stream) were spreading to more countries, causing serious problems in material efficiency.

In addition to Waste Directive much other legislation have an impact on paper recycling such as Landfill Directive, Waste Shipment Regulation and Packaging and Packaging Waste Directive, or policies such as those on Climate Change and energy. Without clear guidance on waste hierarchy but with a strong focus on energy policies related to climate change, a concern of recovered paper being used as a renewable energy source by other industries has been growing.

More recycling has meant more recovered paper and more direct costs in waste permits and waste transportation, as well as more costs arising from quality management to something that was perceived as waste. Therefore industry was burdened with increased amount of impurities, non-paper elements and cross-contamination and cost related to managing them.

At the same time paper products contain more non-fibre elements (composite materials) and have become more complex, without having legal framework allowing for a cost efficient – if any – outlet for residues from recycling. Permitting practices clearly are another issue defining the limits of paper recycling; as legislation says what is and is not possible, the local permitting authorities decide what is and is not accepted and implemented.

All this has been contrasting the target EU has set itself to become a “Recycling Society”. This target was announced in a thematic strategy on prevention and recycling of waste[55]: This long-term strategy aims to help Europe become a responsible recycling society that seeks to avoid waste and uses waste as a resource. The waste and resources strategies are two of the seven ‘thematic’ strategies required under the 6th Environment Action Programme (2002-2012)[56].

10.2. Secondary Material Contra “Waste” Definition

Paper recycling in Europe has been faced with an identity crisis for the industry recovered paper has become an essential raw material – whereas for policy makers used paper has simply been a waste problem. This has been culminated in the classification of recovered paper as waste as opposed to secondary material. The very rigid legislation defined waste as “any substance or object …which the holder discards or intends or is required to discard”.

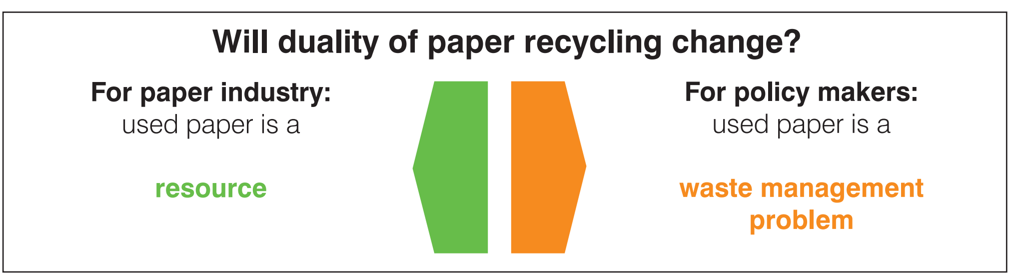


Figure 47: European waste legislation does not accommodate for the needs to use waste materials as a resource. *(Source CEPI 2008)*

Once a substance or an object became waste, there was no mechanism for it, despite any recovery operation, to cease to be waste and to become non-waste again. Therefore recovered paper was waste, with all legal and bureaucratic requirements and red tape that follow from that status. With the increased volumes of recycling, this became a significant burden for the industry, with very little if any value added to the environmental protection as paper recycling operations are in addition already covered by environmental permits based on the Directive on Integrated Pollution Prevention and Control[57].

Quantifying the cost of the waste classification is difficult as the current implementation of the waste legislation is not uniform throughout Europe. A case study from one large paper recycling mill concluded some years ago an extra cost of 12.50 €/tonne of recovered paper only from the waste permit conditions at the mill site. A study on the German metal industry quoted a cost of 5 to 10% of the annual turnover due to the waste legislation requirements, which could be comparable to paper industry. Yet, in some other countries there are no additional requirements at the mill site on top of the IPPC permit. In all countries, however, transporting "waste" requires a specific permit and the pool of such transporters to choose from is smaller than when transporting secondary materials.

Most importantly, perhaps, handling secondary raw materials allows for creating more solid quality management rules than for those handling waste, simply due to the fact that the supply chain does not take very seriously the risk of making "waste" any worse.

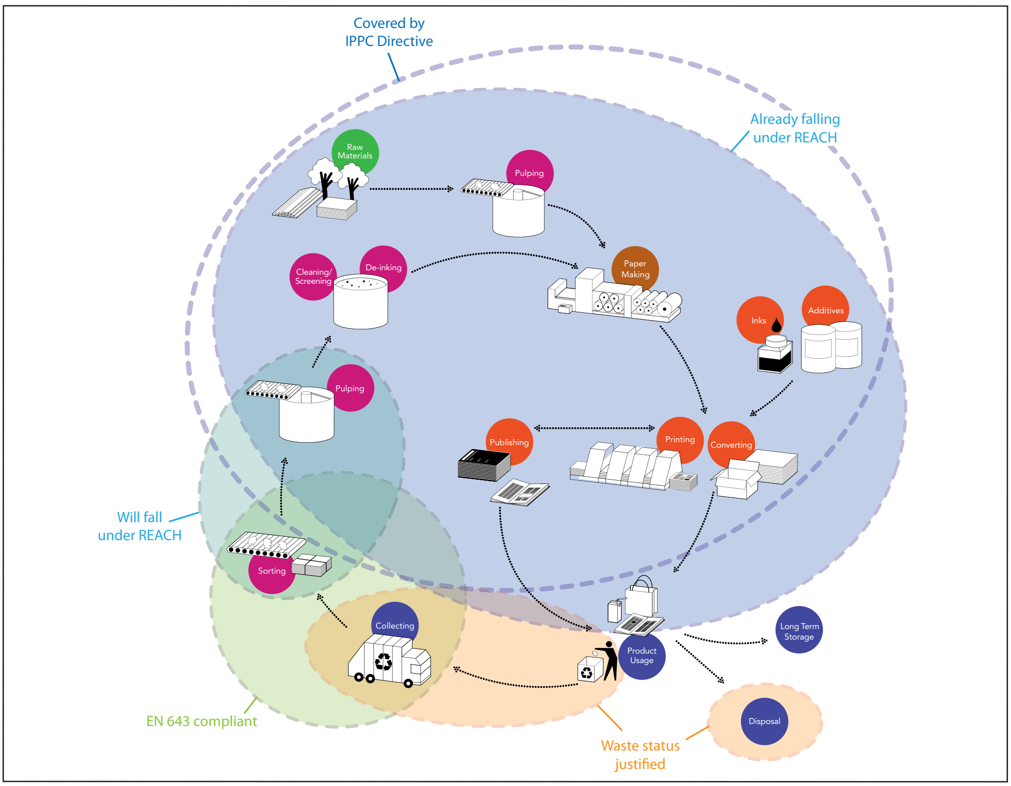


Figure 48: Paper recycling loop fully covered with several pieces of legislation *(Source CEPI 2008)*

The industry feels the Waste Directive does not create any added value for the environment where the operation is already covered with more stringent legislation. This situation may change with the revised Waste Directive which for the first time introduces a mechanism, for a handful of specific material streams including paper, to cease to be waste. This would take place in a case-by-case assessment for each of the candidate materials and could still take a long time before it was legally enforceable. (See p127; Future Legislation for details.) Until that day, European legislation has not succeeded in what the industry has done: closing the loop. Were that situation changed, Industry would then benefit from having more usable materials, better yield and less cost for managing residues.

10.3. Lack of Proper Legislations – Obstacle for Recycling

"By and large, waste is being better managed than it was. The industry that deals with it is becoming more efficient, the technologies are getting more effective and the pollution it causes is being controlled more tightly. In some places less waste is being created in the first place. But progress is slow because the politicians who are trying to influence what we discard and what we keep often make a mess of it."[58] This quote from the editiorial in *The Economist* shows that paper is not alone with the problem, and Europe is not the only region in need of better legislation. However, with the high volumes of paper recycling in Europe, the problem here is probably more pronounced than elsewhere.

In particular this has been demonstrated in the rules for good quality collection systems which are by and large lacking, confused and ambiguous rules on rights and obligations throughout the recovery chain, and sluggish if not impossible permitting procedures. This has meant, in short, lack of understanding that waste is a starting point of another cycle of industrial production process. The first steps by the industry to have this better understood by its stakeholders, has included the development of a European Standard on recovered paper grades[59], and indeed the convention within the industry to use words "recovered paper" instead of "waste paper", both actions dating back to 1990's.

Many other tools from research to technological development have been used to overcome the obstacles the lack of proper legislation has created. Notably the industry has developed voluntary measures to fill the gaps in the legislation. Guidelines on responsible sourcing and quality management of recovered paper by Confederation of European Paper Industries (CEPI), or CEPI's initiative to invite the whole paper value chain to join the European Declaration on Paper Recycling are industry own initiatives that have proven vital to allow for increased recycling despite the lacking support from the legislation. Similar positive impact is expected from the launch of the Industry Guidelines on paper and board in contact with food, as that would clarify, in the absence of a specific legal measure, how paper and board can comply with the Framework regulation on materials in contact with food[60].

European Declaration on Paper Recycling (2000 – 2005, 2006 – 2010) was noted as a success story in an assessment of voluntary agreements by the European University Institute (EUI) in Ispra. Proactively responding to the industry's own strategies, without push from specific NGO campaign or public criticism, "ambitious targets and organisational effort" have made European Declaration on Paper Recycling a 'gold standard' in the EUI evaluation[61].

10.4. Residues from Paper Recycling – Prevention – Landfill Directive

Waste legislation hits recycling in other ways other than directly impacting the collection and quality of recovered paper. It also regulates the management options for by-products, residues and rejects from paper recycling mills.

1990	2002	2006
76.70	27.80	19.17

Table 10: Specific amount of paper industry residues landfilled (kg/t of product)[62]

While landfilling has become uneconomic option in most of the European countries, in some, the permitting authorities have failed to provide any other option for managing residues from recycling operations, effectively forming a bottle neck for increasing paper recycling. More importantly, it seems to prohibit industry initiatives to improve environmental / ecological performance.

New Waste Directive may provide sorely needed clarity in taking at least by-products out of the waste operations, defining them as non-waste, but yet they then have to comply with the strict European chemicals legislation set in REACH Regulation[63].

The Landfill Directive[64] on the other hand could help the industry by encouraging the diversion of more paper from disposal to recycling. The Directive came into force on 16 July 1999; with targets on diversion increasing stepwise up to 2016. Whereas it is the local authorities who usually have the monopoly in deciding on the management option for any waste material, paper industry can only advocate recycling as a preferred option and would welcome all paper to be separately collected; Landfill Directive is therefore potentially a powerful tool.

Landfill Directive targets include reduction of biodegradable municipal waste going to landfills to 75% by 16 June 2006; to 50% by 16 June 2009; and to 35% by 16 June 2016. EU member states depending highly on landfill, have a four year extension to each date.

By 16/6/2006	16/6/2009	16/6/2016
To 75%	50%	35%

Table 11: EU targets for reduction of biodegradable municipal waste to landfills
(Source Landfill Directive)

The potential of paper diversion from landfills to recycling was still up to 20 million tonnes in Europe in 2007[65]; compared to the total paper consumption (100 million tonnes), it seems that paper has already met and exceeded the target of max 35% landfill, but further diversion would improve availability of recovered paper and help achieving the overall target of the Directive as other waste streams may have it harder to advance in diversion. In a certain number of countries, a very high number of landfills for non-hazardous waste and for inert waste will have to be re-equipped or closed by 2009 to conform to the Directive.

The Directive does not apply to the spreading on the soil of sludges, the use of inert waste for redevelopment or restoration work in landfills, neither does it apply to industrial waste.

A sustainable increase in paper recycling requires an increasing emphasis on eco-design and waste prevention, which the different sectors along the paper chain have pledged to support in the European Declaration on Paper Recycling[66]. By joining the Declaration they committed to qualitative actions, in particular by the eco-design of paper products, to improve the recycling rate by 2010.

As waste prevention is not just reduction of "generation of waste" but also reduction of the presence of hazardous substances in waste and technologies focussing on recyclable products, it seems that the paper industry has already many prevention measures in its everyday practices. If this is not correctly understood, waste prevention becomes a limiting factor for the industry.

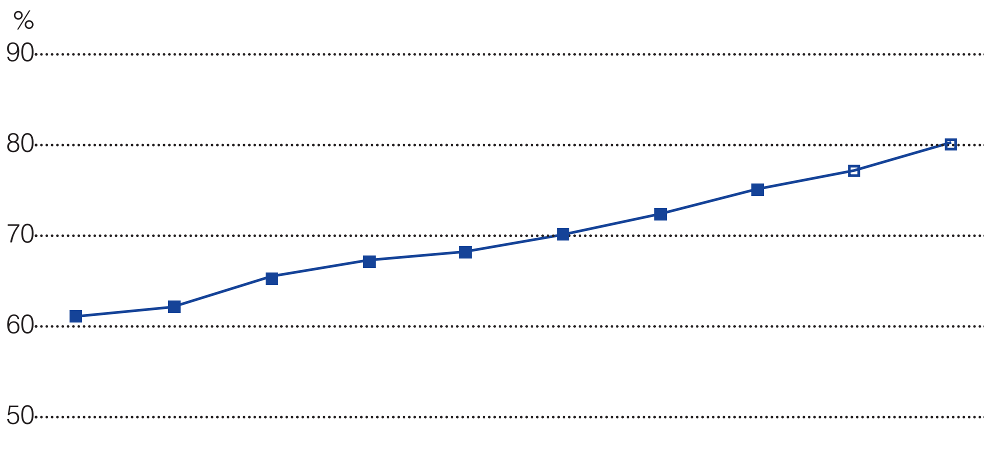
The new Waste Directive defines waste prevention in Article 3.12 as follows:

> 'prevention' means measures taken before a substance, material or product has become waste, that reduce:
>
> (a) the quantity of waste, including through the re-use of products or the extension of the life span of products;
>
> (b) the adverse impacts of the generated waste on the environment and human health;
>
> (c) the content of harmful substances in materials and products;

For example, lighter grammage and libraries could be considered for the letter a) above; recycling operation (as opposite to landfilling) and good quality collection schemes supporting resource efficiency could be considered for the letter b); and eco-design throughout the paper value chain to remove harmful substances from the auxiliary materials used on paper could be considered for the letter c). More examples can be easily thought of where necessary and depending on the actual context of discussions.

10.5. Packaging & Packaging Waste Directive

Packaging and Packaging Waste Directive (PPWD)[67] is the only EU legislation that sets recycling and recovery targets for paper and board. In many countries it has been driving recycling as it obliges setting up collection schemes.



	2000	2001	2002	2003	2004	2005	2006*	2007*
■ Recycling Rate	65%	67%	68%	70%	72%	75%	77%*	80%*

*estimates

Figure 49: Paper packaging recycling rate in EU 27: whereas EU publishes the figures with a lag of two years, CEPI publishes an estimate for the two most recent years. *(Source CEPI, 2008)*

In reaching those targets, paper based products have been excelling for years – the target of 60% recycling rate, to be met by 31 December 2008 was met already in 1997[68] and was in 2007 estimated to be at 80%[69]. These targets are different for each packaging material and are e.g. only 22.5% for plastics. This inequality between targets for competing packaging materials has sometimes lead to discussions on eventual market bias the Directive may cause between materials; this is somewhat ironic as the Directive itself was originally set up to ensure the functioning of the Internal Market (of recyclables) – in addition to prevention and reduction of the impact of packaging and packaging waste on the environment.

The Directive has also been important in defining “essential requirements” for packaging manufacturing and design, and the CEN standards on packaging, including on packaging recycling[70].

It seems to also have succeeded in the delinking of environmental impact from the economic growth: Data released from the European Union contradicts widely held perceptions packaging waste problems. Despite 40% growth in GDP in the nine year period from 1998 to 2006, the amount of packaging placed on the EU market only increased 11% while packaging going to landfills actually fell by 33%[71].

With very few exceptions, the 27 Member States of the European Union have realised impressive results that have dramatically reduced landfill waste. Despite various timetables to achieve a 60% waste recovery rate, the EU-27 average is already at 69% with the EU-15 registering a remarkable 72% average; this success can be attributed to successful recycling of paper based products, performing significantly better than the set targets.

The data also shows the average recycling rate across the entire European community is just above the 55% target, even though the deadline to reach this goal ranges from 2008 to 2015. Moreover, disposal of waste in landfills has fallen significantly, as mentioned above, with only Greece and Portugal seeing marginal increases in packaging waste disposal.

Used packaging, like other products at the end of their life, is useful material for recycling. Recovered paper has become a commodity on global market and an essential part of the functioning of the global economy. Global shipments of used paper and board products are regulated under Waste Shipment Regulation[72] that came into force 12 July 2007.

Recovered paper is under the "list B of the Part 1 of the Annex V", usually (and understandably) referred to simply as "Green List". Recovered paper is thus not covered by an export prohibition (not covered by Article 1(1) (a) of the Basel Convention). Export of such "Green List" waste within the OECD countries, or other countries with an agreement with EU, is not subject to notification and consent procedure and is done under normal commercial transactions; however, the completion of an Annex VII form is required in order to increase traceability of cross-border waste shipments and to prevent illegal shipments of waste. This has increased somewhat the administrative costs of recovered paper trading but would improve transparency of the shipments as advocated by the paper industry.

10.6. Recycling & Food Contact Legislation

Materials intended to come into contact with food are regulated under Food Contact Regulation[73] and under Good Manufacturing Practice (GMP) Regulation[74] - none of which has paper and board specific rules. The general requirement that materials for (direct or indirect) food contact "must not transfer their constituents to the food in quantities that could endanger human health or change the composition or organoleptic characteristics of the food" applies to paper based products, but no specific measure exists on European level to guide how paper and board is to comply with this requirement.

Instead several national (e.g. German recommendation BfR XXXVI) or regional (Nordic or Council of Europe) standards are being used, sometimes unnecessarily restrictive or simply banning use of recovered paper. To fill this gap on the European level, and to update existing standards with most recent scientific knowledge, the paper packaging chain is preparing Industry Guideline[75] for paper and board in food contact to set a single European standard acceptable for consumers and policy makers.

The Industry Guideline is likely to set specific rules for managing recycling paper and board for food contact. Traces of non intentionally added substances (NIASs) will occur in all packaging materials and their complete identification and total elimination is not possible. The paper industry will select its raw materials to ensure NIASs in its products are present at extremely low levels.

The Industry Guideline requires that an operator must perform a risk analysis of the manufacturing to identify all operations which have the potential to influence the suitability of the final product for food contact purposes; this risk analysis may, for instance, lead to exclusion of unsuitable sources or grades of recovered paper.

A quality management system is required to manage the risk on an acceptable level. The continuing compliance with legislative and customer specifications has to be demonstrated and recorded.

The GMP Regulation, applicable as of August 2008, defines good manufacturing practice for all packaging to avoid food scares such as the ITX scandal in 2006. Food contact experts estimate paper and board packaging already complies with the regulation. However, the current paper industry GMP is under revision, to ensure consistency with the EU Regulation, and will be published in 2009.

These voluntary industry measures, building on the legislative EU framework, ensure safe recycling operations for food contact purposes based on several key elements:

- Selection of recovered paper of an appropriate quality;
- Cooperation within the value chain to ensure design for recyclability of auxiliary materials in paper products (inks, adhesives etc.);
- Selection of appropriate processing technologies;
- Operation of Good Manufacturing Practice, including Guidelines on responsible sourcing of recovered paper;
- Testing of finished products to ensure that a number of known potential contaminants are absent from the recycled paper and board.

The Pira Peer Review Report (March 2009) concluded on the Industry Guideline that "it is very easy to argue that it provides a more useful set of Guidelines for the safe use of recycled fibres than is currently in place under any of the National Regulations", and aligned with the requirements of the EU legislations. "A significantly more rigorous framework is offered for the approval of recycled fibres when compared to national legislation including fibre source, clean up processes and testing protocols, with the advantage over the Council of Europe Resolution that some of the associated complexity has been reduced" (Pira International 2009).

10.7. Energy (fossil/biomass, emissions of CO_2) & Carbon Footprint

Carbon Footprints

A global Life Cycle Analysis (LCA) study by the Waste and Resources Action Programme (WRAP) in UK looked in detail at the carbon balances between paper recycling and the disposal options of landfill and incineration. This report, Environmental Benefits of Recycling (WRAP 2006[91]), reviewed over 108 global life cycle assessments for paper, rejecting 99 for a number of issues including incomplete life cycle review, and studying 9 in detail.

The results, maybe reflecting rather the variable quality of the LCA s, showed enormous variation for paper recycling. A minority of situations existed where both incineration and landfill were found to be preferable to recycling but these typically involved extreme scenarios that are not typically found in practice. In the majority of studies recycling was the preferred option and for reduced greenhouse gas emissions, 73% of scenarios favoured recycling. Identical results were obtained by European Environment Agency EEA in a similar study.

Based on the study, WRAP considers that it is reasonable to say that recycling 1 tonne of paper and cardboard will avoid 1.4 tonnes of carbon dioxide equivalent compared to landfill, and 0.62 tonnes of carbon dioxide equivalent compared to incineration. This alone would have meant a saving of 38 to 85 million tonnes of CO_2 equivalent a year with current volumes of recycling in Europe compared to everything incinerated and everything landfilled respectively.

Whereas recycling usually has other climate change benefits in addition to avoided emissions from landfilling or incineration, such as the savings available from the substitution of primary raw materials with secondary materials plus the energy efficiency gains achieved through the reprocessing stage, calculating specific CO_2 savings from recycling is not straight forward. The difficulty in such calculations lies in the fact that paper manufacturing is extremely varied, much more than other industries, in terms of production processes, raw material inputs, energy sources, output products and locations.

Some estimates do exist, such as by International Energy Agency (IEA), which calculated recently that each ton of recycled pulp offers a net energy savings potential of 10.9 GJ/t (IEA 2007). IEA Energy Technology Perspectives (2008) notes that “between 10 and 20 GJ/t can be saved per metric ton of paper recycled, depending on type of pulp and the efficiency of the pulp production it replaces”.

Another WRAP study (2008) assessed the long distance haul of recovered paper (and plastics) to Asia: the study concluded that the benefits of recycling may outweigh emissions from shipping to the Asian market. The WRAP study found that emissions from shipping recovered paper from UK to China are less than 1/3 of savings from recycling, and less than 1/10 if the ship carrying the waste would otherwise have returned empty.

The Confederation of European Paper Industries has set out a framework for paper manufacturers to measure their carbon footprints (CEPI 2007). It will be up to the various paper industry sectors, and possibly individual companies, to determine this number based on their own unique circumstances. This work is in line with later developments in standardisation such as PAS 2050.

However, the methodology for quantifying all benefits from paper recycling is still not ready as one should be able to allocate CO_2 costs and savings between the phases of primary production and recycling, and as for example the method for calculating carbon storage in products (in fibre) is not fully developed yet.

EU Policy Impacts

In any case, it is clear that recycling contributes positively to mitigating climate change. In the light of that, it is surprising that the EU policy package on energy and climate change can potentially be a major threat to recycling. The reason for this is that EU has adopted a set of very ambitious targets for renewable energy which could lead to recovered paper, in addition to much bigger volumes of wood biomass, could be collected in a "mixed energy stream" and used to energy generation instead of material recycling. In a study for CEPI by McKinsey and Pöyry Consulting (2007) it was estimated that up to 25 million tonnes of recovered paper could be used for energy generation by 2020, leading to a gap comparable to almost half of the estimated utilisation of recovered paper in the paper recycling.

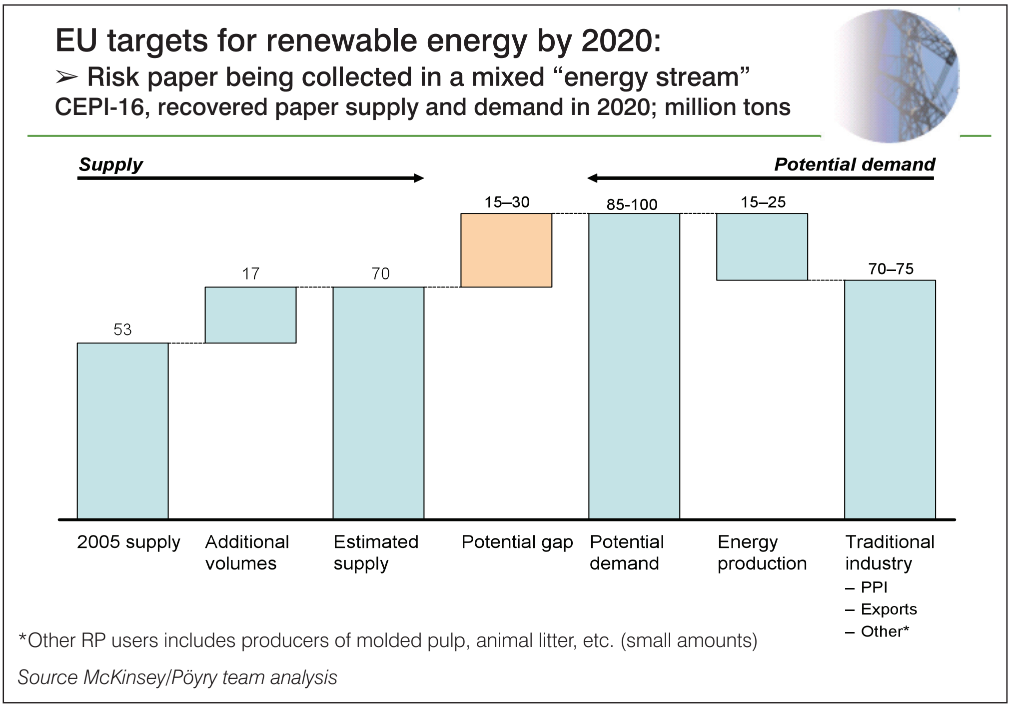


Figure 50: Threat of the RES targets for 2020 to fibre supply *(CEPI 2007, calculations by McKinsey and Pöyry Consulting)*

Whereas the climate change mitigation and more sustainable energy policy is essential for EU, it should not endanger the future of paper recycling, which as such is an action for climate itself, but short sighted policy hampering recycling would directly lead to even more pressure for sourcing forest based biomass, a resource that will be scarce.

When this article was written, many detailed elements of the EU climate policy were still being formed. It is already clear, however, that the eventual impact on fibre availability is not the only issue impacting paper recycling and, possibly, limiting its growth.

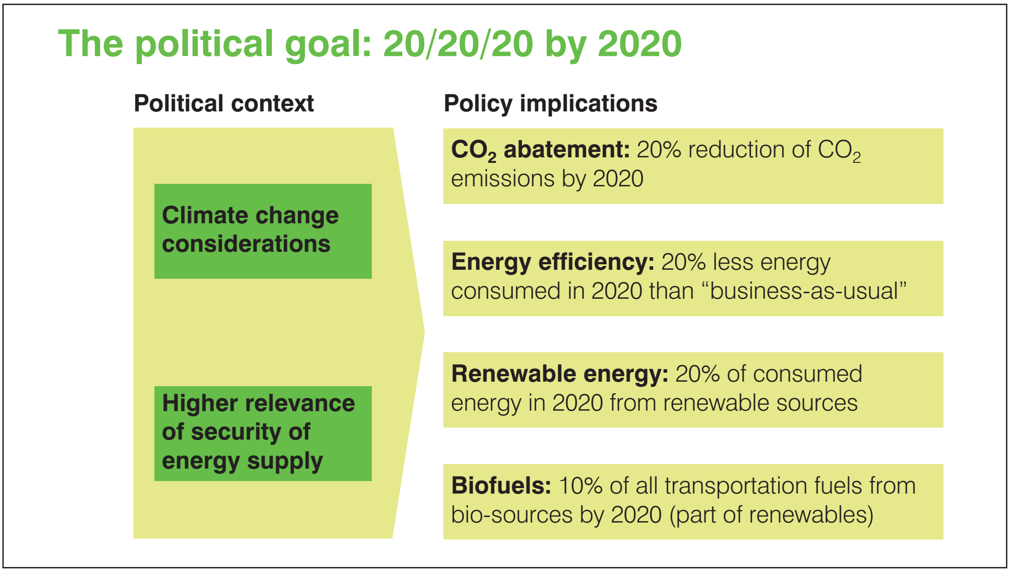


Figure 51: EU Energy and Climate Change policy 2020. With the possibility of a global climate agreement EU would assume a higher, 30% CO_2 abatement target by 2020. *(CEPI 2008)*

Despite the final EU target (20% or 30% abatement by 2020, or becoming 100% carbon free by 2050), already now it is clear that paper industry, including the recycling mills, meet the challenge set by the EU climate and energy policies in several ways: The energy (electricity and fuel) costs will go up, intentionally and considerably. Carbon emissions will be a cost. Energy taxes will rise in future and, for the promotion of renewable energies, the grid costs will increase as well. Raw material costs for wood, recovered paper and starch will increase as more (and more powerful) players enter the market. Also the costs of chemicals will rise.

This will, unavoidably, lead to new balances in the sector. Once the climate and energy package is being implemented fully, it will reset and readjust every known equilibrium in the paper industry between:

- forest-based biomass owners and buyers;
- mechanical and chemical pulps;
- virgin and recycled materials;
- integrated and non integrated producers;
- countries and electricity markets;
- energy consumers and producers;
- different materials – and technologies.

Most importantly, EU climate and energy policy will readjust the global equilibrium between EU and the rest of the world in case of no real international agreement on climate change mitigation, leaving EU to unilateral abatement measures. These new balances will come into the ongoing process of consolidation and restructuring.

The COST E48 action may screen out the sustainable strengths of paper recycling that may support the paper recycling industry through the painful change to the opportunities that no doubt wait in the future. However, paper recycling can only be sustainable if it is a part of the total paper loop where virgin production has an economic viability too. Both parts of the industry complement and depend on each other, and the impact of the energy and climate policy on any part of the sector will unavoidably limit the success of paper recycling.

11. Conclusions concerning the Current Status of Paper Recycling in Europe

Some current problems and bottlenecks concerning paper recycling in Europe can be summarised as follows:

Availability of recovered paper

The vast majority of paper & board currently collected in Europe is used for paper production either in Europe or elsewhere or for energy production. The amounts collected in Europe as well as import and export are currently in balance. Increasing demands for recovered papers as a result of e.g. increasing paper production volumes or growing wood prices can only be satisfied either by increased collection or imports. The globalization of the world economy has increased the recovered paper trade.

Collection activities

Potentials for increasing paper collection and utilization exist in several European countries but particularly in southern and eastern Europe as well as in UK.

Intensifying collection activities alone, however, is not sufficient. It has to be made sure that newly installed collection systems meet consumer's expectation in terms of accessibility, comfort and user-friendliness. Furthermore, an increase in collection activities may also need developments in local paper production capacity.

Society's awareness

The success of any efforts aiming at increasing collection rates and thereby increased collection volumes largely depends on individual's attitudes and environmental awareness. This is not, however, adequately developed in all parts of Europe.

Quality of recovered paper

In areas where already high collection rates are achieved, the exploitation of the remaining potential might result in inferior qualities which to some extent no longer meet the quality standards necessary for recycled paper. The same applies to paper & board collected via newly installed but inadequate collection systems. Separate collection of paper and board is a prerequisite for a good recovered paper quality.

Volume and structure of paper consumption

An overall decrease in the volume of paper consumption will of course influence upon the volume of paper collection. A decrease in the consumption of specific paper grades (e.g. newsprint) or generally any development leading to a change in the structure of paper consumption i.e. the division between the paper grades collected will influence the usability of the quantities collected.

Paper grades produced

The paper grades that can absorb large amounts of relatively low quality recovered paper, i.e. newsprint and case materials, are already quantatively satisfied with recovered fibres. Any significant increase in the overall utilization of recovered paper therefore will only be possible using higher quality printing & writing papers. They, however, require either recovered paper of a higher quality in terms of cleanliness (specks, ink residues and stickies) or more powerful and selective though economic treatment technologies. Neither of them is available at the moment.

Treatment technologies, energy costs and waste

The existing technologies for treating recovered paper and board are rather well developed and are able to produce an acceptable recycled pulp quality out of virtually any recovered paper – however on the expense of energy cost and the amount of waste generated. Not enough effort has been put on the development of energy saving, highly selective separation techniques and process lines. New ways have to be found for further utilizing waste from recycling plants.

Printing and paper converting

The industries in which paper & board is further processed traditionally did – and in some cases could - not sufficiently consider the consequences of their product developments on recycling. This was partially due to their own specific needs and constraints but to a not negligible extent also to a lack of mutual information. All corresponding attempts to improve this situation have yet not been successful.

Prices of recovered paper

Prices for recovered paper & board in Europe have been rather volatile in the last decade. They tend to be more sensitive to economical fluctuations than the price of wood. In the short term, the economical crisis ahead may therefore have a detrimental effect on the attractiveness of recovered paper & board as a raw material.

Alternative utilization of recovered paper & board

Competing utilization and, in particular, energy production may take over significant amounts of recovered paper. If used as a “renewable” fuel, i.e. if it is “thermally recycled”, recovered paper does not require costly sorting. From a societal waste handling point of view incineration is therefore just as acceptable as recycling. The overall added value related to recycling into new paper products is, however, not widely and sufficiently well understood and this aspect needs further promotion.

Carbon footprint

There are still no widely accepted methods to calculate the carbon footprint of products but some of the suggestions currently discussed might have very detrimental though unintended consequences for paper recycling. Moreover, CO_2 emissions entailed by transport may limit the transportation of recovered paper over long distances. This may create local limits to paper recycling.

CHAPTER THREE

THE FUTURE OF PAPER RECYCLING IN EUROPE

1. Future Trends relevant for Paper & Board Recycling

1.1. Trends in Paper & Board Production

Based on a series of interviews with leading industry experts (see page 37), during early 2008, paper & board production within the European study region is forecast to grow from 101 million tons in 2005 to 122 million tons by 2015. This equates to an average annual growth of 1.8% per annum for the ten year's period up to 2015. During the same period paper & board consumption is forecast to grow by 1.0% per annum from 91 million tons to 101 million tons.

At that time these interviews took place, the economic growth was still firm and general faith in industry development was not overshadowed by the global recession which occurred at the end of 2008.

The economic turmoil will have significant negative impact on future paper and paperboard consumption and production growth; at both global and European levels. However, without further detailed post-crisis studies it is not possible to estimate and forecast real effects of the recession on the future paper industry development.

The Action Task Force decided to adjust the quantitative forecasts based on the interviews and estimated that instead of 2015 the results would describe average situation in 2019 – 2021 (effectively introducing a four to five year delay). This forecast is based on the assumption that after the period of recession the paper industry indicators (paper & board production and consumption) would continue to follow the pattern described in the interviews.

Hypothetical forecasts are shown in Figure 52. After the recession (undefined period) the European paper & board production and consumption is forecast to continue growth according to the study findings.

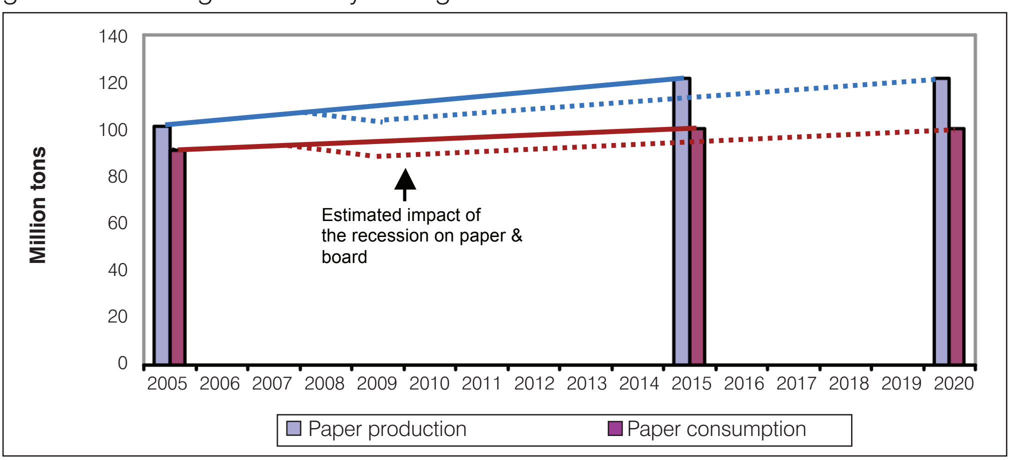


Figure 52: European paper & board production and consumption development during the period 2005 to 2015 (2019- 2021). The recession will postpone the target year with some years.

When carrying out the study, the forecast indicators related to the total paper and board production and consumption. No analysis concerning future development was made for individual paper and board grades. This would have been extremely difficult, especially for recovered paper & board consumption forecasts; as raw material furnishes vary greatly depending on paper & board grade being produced.

However, a general assumption can be made that production of packaging grades and tissue will grow faster than the average annual growth of 1.8% for the total paper and board indicates. On the other hand, production of communication papers (newsprint and printing & writing papers) is forecast to grow considerably less than the average paper and board production growth figure indicates.

Figure 53 gives an overall picture of the changes in the composition of the market, i.e. the changes of the shares of the main groups of paper & board grades produced in Europe during the period up to 2020. In 2005 the share of communication papers (newsprint and printing and writing papers) was about 49% of the total production. Based on general understanding of changes in the consumption patterns in the society, this share is expected to drop by some 4 to 5 percentage points by the end of the study period 2020. The share of tissue paper was 6.5% in 2005. This share is expected to increase to some extent. The share of packaging grades (corrugating materials, carton and wrapping) was 44.5% of the total production in 2005. This share is expected to grow by 3 to 4 percentage points by 2020.

It is important to remember that according to the study findings the total paper & board production is forecast to grow by about 20 million tons in Europe during the period concerned. This means that the production volumes of individual paper & board grades do not necessarily have to decrease though their share of the total production diminishes. It is also important to remember that paper & board production will develop at differing rates in different parts of Europe. Growth is forecast to be fastest in Eastern and Southern Europe. On the other hand, in Western and Northern Europe the production growth is forecast to stay below the average of 1.8% per annum.

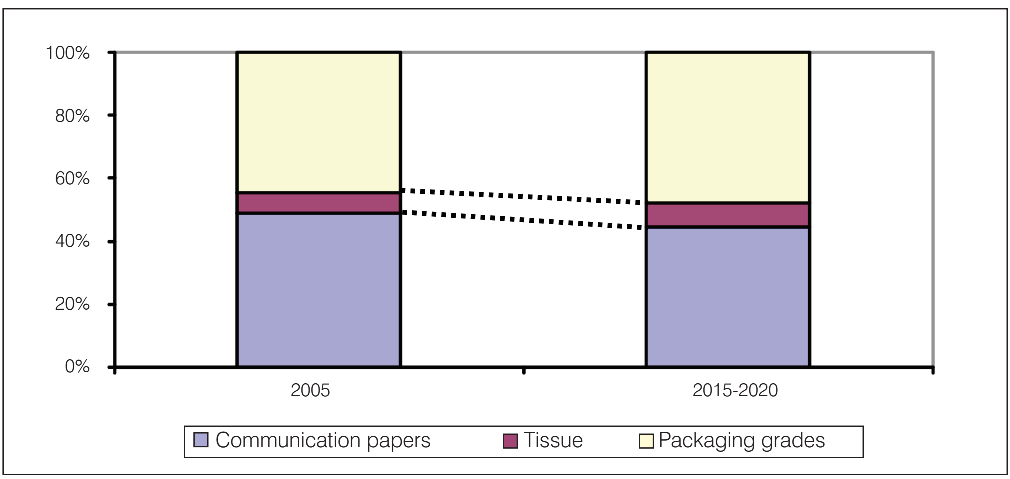


Figure 53: The share development of the main paper & board grades of total production in Europe during the study period.

In the light of the recent developments (i.e. the global recession) it might also be said that an estimated production growth of 20 million tons in Europe could be "somewhat optimistic".

When calculating average annual growth rates it is essential to define the length of the time period in question. In this study the original forecast period was 10 years (from 2005 to 2015). This together with the interview based growth volumes (for paper & board production and consumption) gave the average annual growth rates, mentioned above. However, if the time period is extended to e.g. 15 years (including the time lag caused by the economic turmoil), and volume forecasts are kept unchanged, the average growth rate for paper production for the whole extended period will be very low (between 1.1 to 1.4% per annum).

Europe is a heterogeneous region in the sense that there are separate regions with different paper industry structures, raw material base and growth potential. Eastern European countries will, according to the study interviews, experience a high percentage annual growth in the future. However, due to current low capacities the Eastern European growth volumes will not be large and will be insufficient to have a significant impact on overall European growth rates.

1.2. Fibrous Raw Materials availability for the European Paper Industry

The Paper industry's demand for raw materials is a function of paper production volume and the ability to develop differing characteristics from various raw material furnishes. This means that different paper grades use raw materials which are characteristic to individual paper grades.

In this chapter the raw material demand forecasts are based on the COST E-48 study forecasts which in turn are based on industry interviews carried out early 2008. The interviews suggest that during the 10 year period, the European paper and board production will grow by about 20 million tons. As mentioned in the previous chapter, due to the present recession, this growth may take 15 years, instead of 10 years.

One of the key findings from the interview round was that great share of the new production growth is based on recovered paper. During the period concerned the European utilisation of recovered paper is forecast to grow by about 14 million tons from 49 million tons in 2005 to 62 million tons. This means that the overall utilisation rate is predicted to grow from 48% in 2005 to over 51% by the end of the study period.

When combining the study forecasts (paper production & recovered paper utilisation) with general information on paper and board raw material furnishes we can foresee that an additional 6 to 7 million tons of virgin wood pulp will be needed to maintain the supply of fibre to the Paper Industry; not all new production growth cannot be based entirely on recovered paper.

Figure 54 (overleaf) shows clearly the situation described.

According to the interviews the paper & board production is expected to grow to 122 million tons by the end of the study period. The same experts expect that the utilisation of recovered paper will grow to 62 million tons. Using these forecasts as input data to a PÖYRY Fibre Balance Model (FBM - PÖYRY Fibre balance Model takes into account paper industry production volumes (present and future) and raw material furnishes to forecast future raw material volumes on country and regional basis), the result is that the forecast paper production is not possible without adding increasing volumes of virgin fibres into the process.

The shares of different types of virgin fibres will highly depend on the availability and price of wood raw material and energy. We have to keep in mind that also the demand for minerals and additives will increase, but this question is not analysed in this context.

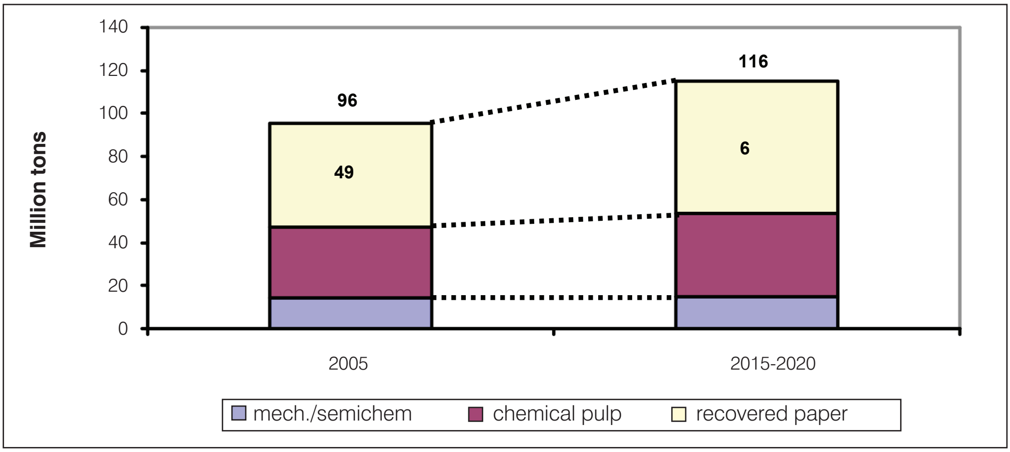


Figure 54: The European paper industry fibre raw material demand is forecast to grow from 96 million tons in 2005 to 116 million tons by the end of the study period. Main share of the additional raw material will be recovered paper.

It is forecast that the industry demand for mechanical and semi-chemical pulp does not change considerably from the current volumes. Thus the wood pulp demand growth is expected to concentrate mainly on chemical wood pulp.

The structure of increased recovered paper demand is based on the assumption which is explained in more detail on page 87. Each produced paper and board grade utilises today and in the future recovered paper grades which are most suitable and therefore characteristic to it. On the other hand the struggle between wood pulp and recovered papers continues; mechanical pulp competes mainly with old news and magazines in newsprint manufacture, bleached chemical pulps compete with white recovered paper grades in tissue production, OCC and mixed recovered paper grades contest with unbleached kraft and NSSC-fluting in corrugated material production etc.

The future trend is that recovered paper contents in paper production will be maximised. The rotation time for virgin pulp (from seedling to pulp) is counted in years; in Nordic countries in decades. By comparison, in the best circumstances the recycling time for recovered paper is only weeks or some months – this will give recovered paper a good cost advantage compared with wood as a raw material.

These issues, combined with environmental perception, give recovered paper a clear advantage compared with virgin wood pulp.

Ever increasing utilisation of recovered paper is, however, limited by quality and availability issues of highest quality recovered paper grades.

The best white grades are already effectively collected from printing and converting sources and good quality OCC sources like converting and retail waste (pre-consumer) are already fully exploited. A further challenge arises from the use of Recovered Paper as an energy source and it remains to be seen how much of the recovered paper potential will be used for Energy from Waste (EfW) despite the European Waste Hierarchy favouring material recycling.

According to study findings and interviews the paper and board consumption in the European study region is expected to grow only by 10 million tons during the forecast period. This is only half of the forecast paper and board production growth. This indicates an increasing overproduction of paper and board in Europe but it also means that considerable efforts must be made to intensify collection activity.

Both recovered papers and virgin fibres are needed in Europe; it is most important to solve the European long term virgin fibre sourcing issue. For example:

- In woodfree printing and writing paper production bleached chemical pulps will always play the vital role.
- In the packaging industry a virgin fibre injection is needed to replace fibres lost in circulation and to maintain the overall strength of the products

There is a dilemma: paper recycling has its limits!

Each time paper passes around the recycling loop a certain percentage of the post-consumer paper cannot be recycled due to contamination, inefficient collection systems, process losses, other uses and exports to outside Europe etc. This lost material must be replaced with either local virgin fibres or papers imported from distant producers. At a regional level, virgin fibre injected into the production sector is necessary to replace the occurring fibre gap. On the other hand, on a company level the overall target frequently is to minimize costs by maximizing recovered paper utilisation.

The optimum solution for the European market is to try to utilise the recovered paper recycling potential as much as is possible by intensifying collection activities, keeping different recovered paper grades separated during the collection process and improving sorting systems and utilisation techniques. The recycling of imported virgin fibre based papers produced in the Nordic countries and the Americas, combined with increasing virgin pulp imports from fast crop rotation regions (such as Latin America and Africa) will ensure the European paper industry maintains a long term, viable and sustainable supply of fibre.

1.3. Trends in Paper Coating, Printing & Converting

Coating

Graphic papers

In the first half of the 1990s film presses were established for paper coating. This triggered a substitution of uncoated papers by “FC papers” (film press coated papers). Nowadays the substitution takes place from classic LWC papers (which are coated off-line) to FC papers. That means that there is no significant increase in the share of coated graphic papers and also no major change in the composition of the papers.

In coated papers, high brightness and gloss have lost some of their importance when compared to cost considerations. The use of optical brightening agents has also been reduced and the mills are looking for lower cost pigment combinations.

The use of functional coatings, e. g. for enhancing the image quality of inkjet prints, will increase.

Packaging papers

Boxes, whilst predominately used to contain products, are increasingly used as advertising vehicle. There is an increase in coating of liners thus increasing the pigment content of recovered packaging paper.

Barrier coatings will play an increasing role in the development of future products.

Printing and converting

Graphic products

In general, digital printing technologies are advancing. The annual growth rate is predicted to be about 10%. Looking at the two main technologies of digital printing, electrophotography will grow more than inkjet. Inkjet needs a special paper to reach high print quality. That is obviously the reason for this difference.

Newspapers

It seems likely that Newspapers will continue to become more magazine like and will contain more sections, more supplements and more colour. Digitally printed on-demand newspapers will be available globally, possibly also personalised issues of newspapers. Even newspapers printed in conventional printing technologies will contain digitally printed sections. Niche publications can include special edition sections within the main newspaper publication or separate publications that target specific demographics or specific topics such as cars, houses, luxury goods etc. Micro-zone is the ability to target readers by their postal code. Typically, newspapers provide custom insert advertising to these areas with the use of intelligent newspaper inserting devices. Production digital printing technology can help enable more targeted printed pages for newspaper publications. This would allow publishers to increase the value of their newspaper and gain more local advertising revenue. In newspapers, inkjet will be ahead of electrophotography.

Magazines

Magazines will not change much in their printing technology. There will be only little customisation of content. Personalisation will be limited to addressing purposes only.

Promotional prints will be highly illustrated in colour and increasingly complex in design and component mix.

Non-paper insert or attachments to magazines are already common and will continue to grow. Examples for these are CDs in computer magazines and all kind of toys and gimmicks in children's magazines. This often requires wrapping the magazines in transparent foils.

Business and transactional prints

Business and transactional prints will use more special papers to provide exclusivity and also increase complexity. They will also incorporate electronics, magnetic stripes, RFID tags and the like. Transactional prints will be used for targeted promotional messages ("Transpromo"). The high quality transpromo prints will be the domain of electrophotography whereas inkjet will be used for less demanding applications.

Packaging products

Paper converters shift from pure manufacturers of packages to service providers for the whole supply chain. Trends are generated by main players of the supply chain, namely the brand holder. General trends can be addressed by terms as "convenience" and "wellness". Sustainability and recycling are terms often spoken about, but not clear visible or addressed in trendsetting packaging solutions.

Trends are attractive packages with more colour and more upgrading. This will lead to more multi-colour presses, to hybrid presses (combination of different print technologies), different lacquers and increased use of UV-technology. Combinations of different materials, compounds of paper and films will increase. New challenges will be products which are childproof or fulfil demands of elderly people.

Braille embossing

Added value can be achieved by adding more security elements like RFID, tamper evidence and security inks which are integrated in the packages. The "convenience" and "wellness" requirements will lead to codes for individualized packages using inkjet or laser technologies and photosensitive lacquers, integrated barrier coatings for water and grease resistance, introduction of nanotechnology (nano-pigments, nano-cellulose fibrils) as well as more communicative elements, e.g. coded product information readable via mobile phone.

1.4. Perspectives of Recycling Technologies

The processes considered when looking at the perspectives of recycling technologies normally start with the re-pulping of recovered paper and are all performed in water suspension at different consistencies or at least in a wet state.

The dry processes used for the sorting of recovered paper should however also be considered as both RP dry sorting and wet recycling technologies have a decisive impact on the technological limits of paper recycling. The decreasing RP quality in terms of unwanted components, like the increase of boards in ONP/OMG mixtures, will even more call for progress in sorting technology. RP sorting has traditionally been performed manually and the development of automatic sorting is quite recent. Future progress in the development of RP sensors (on the basis of new techniques using a broader wavelength spectrum, i.e. in the visible, infra-red range, etc. - see page 53) and fast increasing performance of signal treatment and analysis technologies as well as in the development of automatic RP sorting technologies (like robots) is expected to increase the possibilities of sorting systems in a near future. Not only the different paper grades but also some printing and converting "additives" like flexo prints, labels and tapes, may become separable or removable at the RP sorting plants. This will consequently make work easier at the recycling and deinking lines while improving the final quality of recycled and deinked pulps. In addition, dry sorting processes do not require much energy compared to wet recycling processes.

Recycling technologies have been developed continuously for several decades, together with the development of recycling, and huge progress has clearly been achieved by the equipment suppliers. Recycling technologies are thus much older and mature compared to automatic RP sorting technologies. Pulping, screening, cleaning, flotation, washing, micro-flotation, kneading and dispersing technologies are basically the same since many years, though their efficiency has been increased progressively, namely regarding energy consumption and/or separation selectivity.

Indeed, no real breakthrough in recycling process technology should be expected around the corner as far as the same principles will be used in the different process steps of future recycling and deinking lines. The rather incremental than breakthrough progress expected in future recycling technologies is illustrated, for screening, in Figure 55, showing the decrease of slot widths practically used in mills since 1960.

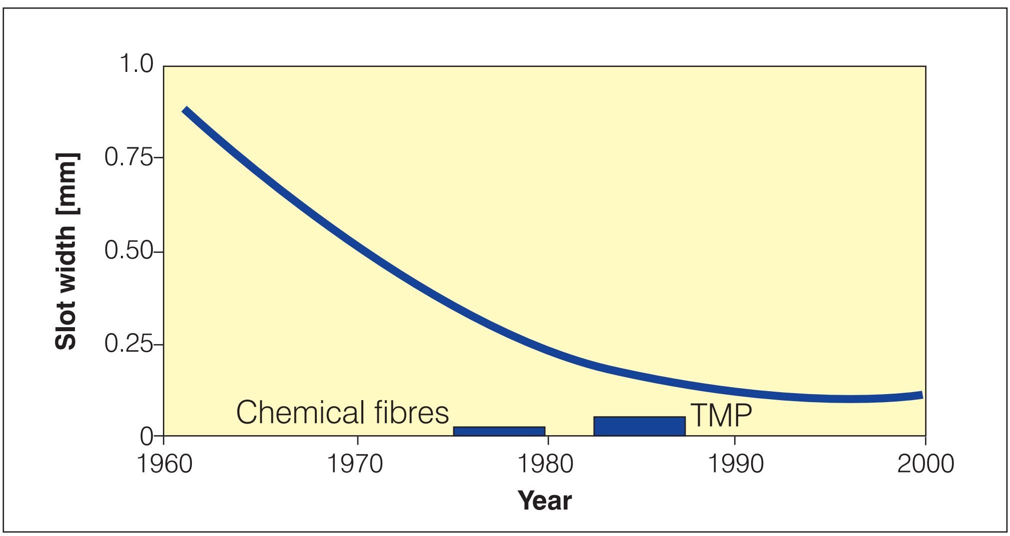


Figure 55: Decrease in slot width (screening) practically used in mills and size comparison with the width of chemical and TMP fibres[80]

Slot width has been drastically reduced with the development of profiled screen plates at the end of the 1980 but the lower limits are still between 0.10 and 0.15 mm width, depending on the type of pulp, the lowest slot width being used for wood-free DIP while 0.12-0.15 mm slots are used for wood-containing DIP, in order to avoid coarse TMP fibres to be rejected. Even smaller stickies have to be removed today but there are basically physical limits in the removal of very small stickies from the pulp, as the fibres have to be accepted by the screen at the same time.

Improving the separation selectivity of the recycling and deinking process steps at reduced energy and equipment costs is a major objective of the equipment suppliers when developing new equipment. This can be achieved through the optimisation of complex physical processes but it seems that the solutions currently proposed are close to the physical limits. Physical-chemical, chemical and bio-chemical process are also part of the recycling technologies. Some more radical changes may be expected in these fields. For example, the control of surfactants, i.e. the removal of unwanted surfactants from recovered paper, has been proposed recently, in the frame of the European project Ecotarget[81], to improve the selectivity of the flotation process. Progress in biotechnologies, for example with the development of more efficient and selective enzymes to promote the detachment of inks or the removal of contaminants, could lead to significant progress in recycling technologies, namely regarding energy.

Future changes in recycling technologies are believed to be rather due to future changes in recovered paper components as a consequence of the development of new paper additives, and new printing and converting technologies. The increase of recycling rates, namely in graphic paper grades, progress in papermaking technology and the development of new approaches with respect to use of recovered paper components as bio-energy source should also affect future recycling technologies.

Future changes in paper additives, including green chemicals, coating binders and new types of pigments and fillers, such as organic or hybrid pigments, as well as the development of new types of fibre raw materials, such as functionalised fibres and nano-fibres from celluloses (NFC) could lead to significant changes in the recycling process. New green coating binders or new organic pigments should behave much differently in the deinking process, namely at the flotation step, and may lead to the development of new deinking chemistry. The development of new paper grades with reinforced properties, e.g. using NFC, and functional properties like water, vapour and air barrier properties, may lead to changes at the pulping and dispersing steps.

Future changes in printing technologies may also impact significantly on the deinking processes. For example the development of water based inks in the newsprint sector, using the flexo printing process, is still a major threat for deinking, though no increase of flexo prints is predicted in the newsprint sector[82]. Digital printing will develop and lead to changes in the deinking ability of recovered paper. Laser inks are for example more difficult to detach from the fibres, but the problem can be solved with reinforced dispersing, i.e. at the expenses of higher energy consumption. On the other hand, the development of ink jet printing will be more difficult to handle, as the inks are soluble and tend to redeposit on the fibres. The development of flexo print and other water soluble inks may in general lead to large decrease of the deinking yield, as such inks are difficult to wash out without increased fine element losses.

Future changes in converting technologies should also lead to changes in the recycling and deinking processes. For example, the development of more efficient pressure sensitive adhesives (PSA) has led to softer and thus smaller adhesive particles after pulping, i.e. smaller macro-stickies and more micro-stickies. Small macro-stickies, also called mini-stickies[81], cannot be removed by fine slot screening, so that more efficient flotation conditions have to be implemented. Future development of green adhesives and glues may lead to more colloidal particles and soluble fractions. This means that, as for water soluble inks, recycling and deinking yields could be reduced in the future, and more efforts will have to be devoted to process water and effluent cleaning processes.

Finally further development of recycling in high-quality graphic papers (SC, LWC) will lead to higher DIP quality requirements. Such developments have already started and led to deinking process changes in terms of reduced yield (see pages 83-84). The

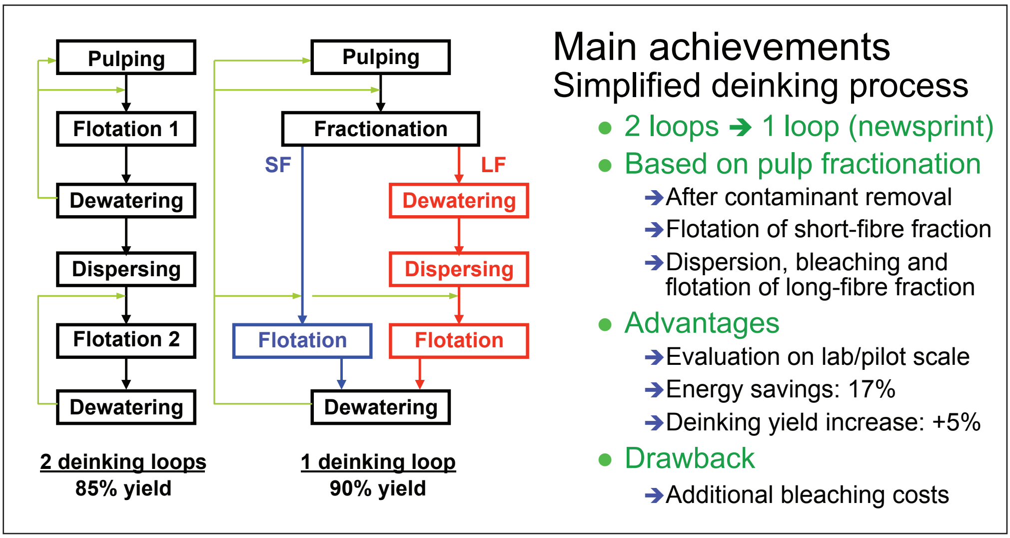


Figure 56: Fractionation processes: Simplified deinking line and use of pulp fractions[83-85]

increase of the recycling rates will also require a better use of the right fibres in the right paper product or layer. The development of fractionation processes in the field of deinking is expected in this respect as well as for energy saving aspects by applying the right treatment on the right fibres. Figure 56 shows fractionation processes developed in the Ecotarget project: on the left side the implemented of fractionation in a deinking line in order to simplify the process[83] and on the right side the use of pulp fractions, typically obtained with cleaners, in layered sheets in order to improve paper stiffness and surface properties with the flexible fibres (cleaner light fraction) in the surface layers and the coarse fibres (cleaner heavy fraction) in the middle layer[84,85]. Concerning how to simplify deinking lines, i.e. to replace a two-loops process by a single loop process, the goal can be achieved with some additional bleaching[83] or with reinforced flotation conditions[85] in order to maintain the final brightness.

Some changes might also take place in the optimisation of yield and the use of rejects. Increasing the yield through the optimisation of process selectivity has always been a priority in order to improve both raw material and energy efficiency. The recycled fibre biorefinery approach described in the next section may change the situation in the future, especially as competition on biomass for energy purpose will increase.

To conclude, and even if no breakthrough process technology changes are expected, important changes in the recycling and deinking processes should take place in the future, mainly driven by changes in RP composition and "contamination", which means that the eco-design of new paper products should be regarded as key issue. Recycling technology innovations and research developments will continue and it is believed that Europe will keep its leading position in this field.

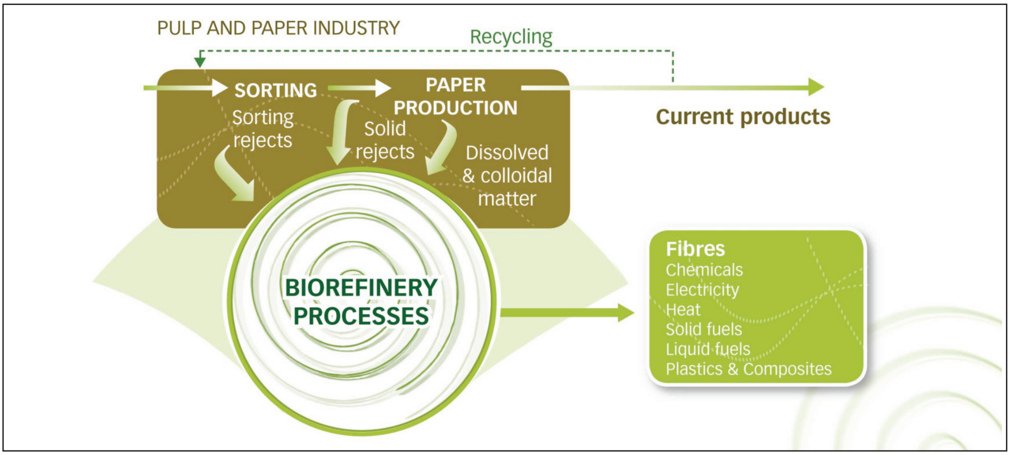


Figure 57: The "Recycled Fibre Biorefinery" concept [26]

1.5. The "Biorefinery-Issue"

The wood-based (or forest sector) biorefinery approach has been developed during the past decade and is already at industrial size demonstration phase (see section beginning on page 91). On the other hand, the recycled fibre (or recovered paper sector) biorefinery is still at the conceptual stage (Figure 57), though paper recycling and deinking mills already produce some bio-energy and side products from solid rejects and denking sludge. "Biofuels" in different forms (like fuels pellets from coarse rejects, methane from the effluent treatment plant) and other by-products (like cement products produced from deinking sludge incineration processes) are currently produced in some mills.

The objective of the recycled fibre biorefinery approach is to develop new concepts, towards "zero waste" and "energy neutral" mill sites with minimised CO_2 impact, and improved profitability through the production of new "side-products" and energy. Moreover, the development of such concepts where recycled fibres are primarily used for paper would retain jobs and add value, compared to municipal waste biorefinery scenarios where recovered papers would mainly be used for their heat value.

The biorefinery processes would essentially be developed on all the material collected with recovered paper, but less suitable for paper production. Non-paper materials as well as unwanted papers are removed at the sorting plants in a dry state. Non-paper materials (inks, adhesives, etc.) are then further removed during recycling, in a wet state, as coarse rejects (pulping, screening, etc.) and fine solid rejects (flotation and water clarification sludge). Dissolved matter is removed by effluent treatment. These organic rejects, as well as mineral fillers and coating pigments (generally rejected via deinking or primary sludge) are an interesting source of components or molecules to be characterised and converted for further utilisation in industrial sectors.

With the recovered paper sorting process included in the recycled fibre biorefinery domain, i.e. on the recycling mill site, additional raw material becomes available, namely for energy purpose. In addition, external biomass sources from agriculture residues[26, 27] or urban waste could considered.

Various recycled fibre biorefinery options could be investigated on the basis of the following ideas and technical objectives[28]:

- Collect more fibre raw material in the form of used paper and board products.
- Reuse only the "best fibres" for paper by removing unwanted components from the paper life cycle with adapted and new technology (used as kidney).
- Improve recycled paper quality to increase recycling in high quality paper grades and/or produce papers with lower grammage using less fibre raw material.
- Investigate bio-chemical processes, e.g. fermentation for ethanol production, and thermo-chemical processes, e.g. gasification, to be applied on selected recovered paper sorting and recycling/deinking reject streams for the production of energy (heat and electricity), biofuels and chemicals.
- Evaluate economic gains (increased added value from by-products and reduced energy and paper production costs) and assess environmental and social impacts.

One of the most important aspects in the recycled fibre biorefinery approach from a papermaking point of view is that the recycling yield should no more be considered as a decisive parameter to increase for the reduction of raw material and energy costs. The idea is indeed to reduce the yield by removing the pulp components with low papermaking value as far as higher values can be obtained from these components with relevant biorefinery processes (Figure 57). As an example, the removal of fines and their use for energy purpose, e.g. in the form of biogas or heat and electricity, becomes attractive in the context of relatively high energy prices (with respect to raw material) and offers additional advantage in terms of paper quality and production efficiency, including reduced drying energy. Moreover, even component with good papermaking value could be removed from the pulp and submitted to biorefinery processes as far as higher value would be achieved in a sustainable way.

Recycled fibre biorefinery is believed to become part of the future of paper recycling as recently stated in the January 2009 CEPI letter[29]:

> "Imagine a day when, in addition to making the top quality products customers will demand, the local pulp and paper mill treats the waste of its local community and provides all the heat and power local resident need; when it will emit cleaner air and water than it takes in; when it will use its know-how in recycling and biomass to make the most of the world's renewable resources. Pulp and paper mills in Europe are already well on the way to realising these ambitions"

1.6. Future Legislation

New EU Waste Directive - a Valuable Tool for Paper Recycling

The EU has adopted a new Waste Directive which replaces the previous, over-30-years-old Directive and repeals some others. In thirty years the thinking has changed radically from seeing waste as a problem to managing it as a valuable material for reuse and recycling.

The new measure, Directive 2008/98/EC, establishes the generic environmental standards for waste to be re-used or recycled, sets material-specific recycling targets for 2020, modernizes and clarifies a whole lot of recovery and disposal definitions, amongst which the by-products are clearly defined not being waste, and introduces a mechanism for waste ceasing to be waste.

The Directive also establishes a five-step hierarchy for waste. The waste hierarchy generally lays down a priority order of what constitutes the best overall environmental option in waste legislation and policy – while departing from such hierarchy may be necessary for specific waste streams when justified for reasons of, inter alia, technical feasibility, economic viability and environmental protection.

Tasks for the EU Member States

After entering into force on 12 December 2008, the Directive set a deadline for the member states to transpose it into their national law by 12 December 2010. Reporting on the progress in implementation is set for every three years thereafter.

All 27 EU member states must prepare a national waste prevention plan by 2013 and set up separate collection scheme for paper, metal, plastics and glass by 2015. They must promote high quality recycling, and meet a target of at least 50 per cent of paper, metal, plastic and glass from households being re-used and recycled by 2020.

Materials from other origins, as far as these waste streams are similar to waste from households, may be included to meet the target. Whether this means other materials such as green waste and food residues collected from households, or other sources of paper, metal, plastic and glass such as collection from offices and micro-businesses (similar to household collections) is left open in the Directive.

A higher target of 70 per cent is set for recycling construction and demolition waste. Also bio-waste is defined and the Commission is requested to submit proposal on management of bio-waste if necessary.

The Directive lays down the polluter-pays principle as well as extended producer responsibility. The former means an obligation for the waste producer or previous waste holders to carry the cost of waste management, whereas the latter applies to anyone who professionally develops, manufactures, processes, treats, sells or imports products in the EU. The same principle has been part of the specific measures on packaging, waste electronics, end of life vehicles and batteries for many years.

The introduction of producer responsibility is meant to support the design and production of goods that facilitate the efficient use of resources throughout their whole life cycle.

Further obligations for the member states aim to make the EU self-reliant in waste recovery and disposal and less reliant on exporting waste for such operations in other countries.

Key Points for the Paper Industry

The European paper industry was an active advocator for the revision of the Waste Directive. As over 60 million tonnes of paper are collected for recycling in Europe annually, and recovered paper is the most important fibre source for European paper manufacturing, legal provisions on waste have been an essential framework for the industry.

Before the revision, the industry felt under-served by the Directive as it considered recovered paper as merely waste to be disposed of, and not as a valuable raw material. It also did not support the industry's efforts to implement quality management which, with increasing paper collections and tapping into poorer quality sources of recovered paper, has become more and more vital. In particular, increasing volumes of co-mingled collection were spreading to more countries, causing serious problems in material efficiency. Finally, without clear guidance on waste hierarchy, a concern of recovered paper being used as a renewable energy source was growing.

The outcome of the revision process, however, was very positive. In addition to the general modernisation of the Directive, recovered paper was acknowledged as a secondary material. In particular, recovered paper was clearly noted as a priority stream for ceasing to be waste in a later case by case assessment by the Commission.

Member States shall take measures to promote high quality recycling and, to this end, shall set up, by 2015, separate collections of paper, metal, plastic and glass where technically, environmentally and economically practicable and appropriate to meet the necessary quality standards for the relevant recycling sectors.

Separate collection is conditioned to practicability, meaning that for example hygiene papers may not need to be collected separately, but otherwise separate collection seems to be both technically, environmentally and economically practicable: separate collection has been carried out in most of the Member States with small and big populations in high and low density for many decades; separate collection leads to best resource efficiency and avoids unnecessary transportation of unusable materials; several studies, notably from the UK (WRAP, 2008) or Italy (Comieco, 2008) show that it is the best economic solution.

The Directive sets a priority for recycling over energy recovery and a target of a 50% recycling rate for municipal (and similar) waste by 2020. This target means almost doubling the current household waste recycling rate (+/- 30%) and would necessarily require paper being recycled at a rate at least as high as it is now.

Recital 29 of the Directive raises paper recycling as an example member states need to promote: “Member States should support the use of recyclates, such as recovered paper, in line with the waste hierarchy and with the aim of a recycling society, and should not support the landfilling or incineration of such recyclates whenever possible.”

Finally, the new Waste Directive clarifies that by-products are not waste. This creates new possibilities for paper mills to increase the efficiency of managing by-streams and residues from production and recycling operations, and create new value-added with by-products.

The paper industry is preparing to turn a new page in paper recycling – years of technological and product development, investments in facilities and increasing capacity are now being supported by an up-to-date legislative framework at European level. Detailed advice for transposition and implementation of the Waste Directive in the EU Member States has been given in CEPI guidelines issued in March 2009 (reference to the document at CEPI website).

1.7. Societal Aspects of Paper Recycling

This section will describe societal aspects of paper recycling using the example of The Netherlands, where a detailed, long term study was performed on the influence of the collection systems on the contamination of recovered paper collected from households. Results of this study can be explained as the societal point of view on the proposed collection systems as being one of the limiting factors of paper recycling, this in terms of the quality of collected secondary raw material.

According to the results of research performed on various collection systems in The Netherlands in order to investigate their impact on the quality of recovered paper[93], the most effective system for collection of recovered paper (in terms of the quality of collected secondary raw material) is public collection with the use of 35m^3 containers. This is due to the fact, that in this system, consumers bring the collected material to identified collection points in relatively small amounts (1–5kg), pre–sorted at households. Consumers seems to be quite well informed on what kind of paper products are suitable for recycling, and what needs to be done to improve the collection. Similar situation, however with a little lower efficiency, takes place with the kerbside collection. On the contrary drop–off recycling parks were the least efficient (both with and without Diftar[94] based on the Polluter Pays Principle[93]). Here consumers bring collected recovered paper in bigger amounts (5–20kg), less often and less regularly, the material is not well controlled and as revealed the results, more contaminated.

Application of Diftar system, is considered as more efficient and more honest manner of charging consumers for generation of waste. However, it has definitely had a negative influence on recovered paper as secondary raw material collected from households. Higher level of contaminations was observed for systems with Diftar. It should be noted that recovered paper, along with glass, is one of the waste stream with ‘free disposal’; it would seem that consumers mix other ‘chargeable’ waste materials (often detrimental to paper) with the paper to avoid the extra payments. This does not happen in the municipalities without the system. These facts explain the high contamination level proved by the results from the collection systems, where Diftar was implemented[93].

Obligatory payments for wastes (other than paper) can cause the growth of contaminations in reusable materials containers (which are so far the only free of charge collected waste streams from households). Higher level of contaminations is also a side–effect of constant growth in recovered paper collection (increasing collection rates and amounts). While considering the matter of priorities, under the condition that paper mills can cope with some contaminations in recovered paper, the quantity of collection takes precedence over the quality. Nevertheless, improvements in that field of reduction of contaminations are expected and required.

The result of recent development of newspapers, magazines and brochures delivery towards moisture protection results in the application of polyethylene films around publications. Easy in handling for the consumer became an obstacle for recovered paper collectors and for paper industry. Packed in this way material (sealed papers), containing inside very often valuables fibrous fraction is difficult for processing.

Sealed paper was proven to be the main contamination up to 2% in weight of the recovered paper. The lowest contamination with sealed paper (0.6%) was noticed by the public collection system where recovered paper was collected with the containers 35m^3 in the municipality without Diftar. Sealed paper content in materials collected with curbside collection and at drop–off recycling parks is higher, up to 2.8% in weight than by public containers.

The above mentioned facts are the basis for the conclusion, that the low quality of today's collected recovered paper is a result of introduction of difficult for recycling paper based products, as well as addition of other non–paper contaminants to the collected recovered paper by consumers. It is much easier to prevent contamination with non–paper components than detrimental for processing in paper industry, difficult or impossible for recycling paper based products (laminates, wet strengths etc).

The increased collection rates have a negative influence on the quality, sorting can help but till a certain level, however, separate collection is an absolute must.

Collection is still developing, in some EU countries very rapidly. That means that collection of recovered paper is an international issue. In that respect public awareness campaigns should be carried out in all member states. Influencing awareness of consumers as well as rewarding for separate collection of high quality secondary raw material seems crucial factors in alleviating of the social limits of paper recycling.

Even with the most efficient collection systems for recovered paper, the collected secondary raw material will still contain certain amount of contamination. Those could be removed by further sorting processes, however, due to certain technical and economical factors are not removed and end up as a fraction of recovered paper that is finally generated as solid waste within stock preparation lines of recycling paper mills (see also section beginning page 41; Collection and Sorting Systems).

2. Scenarios for Paper & Board Recycling in Europe

2.1. Introduction

According to its MoU one of the main objectives of COST E48 was to collect facts, data and experiences and to develop on this basis scenarios which are able to describe the potential future of paper recycling in Europe.

These scenarios should reflect potential and basically likely developments within Europe. But it was neither the intention to predict the future nor to assess the probability of the scenarios to be developed to come true. It, however, was the intention to draw conclusions from each of said scenarios which could be instrumental in terms of

- identifying potential threats to paper recycling
- identifying research needs the results of which could in the medium or long term be instrumental in order to overcome the threats identified
- providing a better basis for investment decisions

With respect to the scenarios a comprehensive analysis of the pertinent literature[87-90] was conducted. This analysis revealed that corresponding work had been carried out in the last few years in a very professional way by several very competent groups. After reviewing these studies thoroughly it was decided to use the results of a work issued by the Joint Research Centre (DG JRC) of the European Commission and carried out by the Institute for Prospective Technological Studies[89]. Entitled "The Future of Manufacturing in Europe 2015-2020 - The Challenge for Sustainability" it was used as a basis for the discussion about how and how far the pulp and paper industry in Europe could be influenced by the developments characterising the various scenarios. This study was published in 2003.

The scenarios which were developed in this study offer imaginative pictures of potential socio-economic developments and new technologies that could possibly shape the European manufacturing sector as a whole over the coming years. They highlight important trends, possible trend-breaks, critical challenges and opportunities which were summarized in four possible visions of manufacturing in Europe until 2020.

These scenarios – and this has always to be kept in mind – had not been developed in a way that either of them might be the pure reality in a decade from now. Certain characteristics of one scenario might also happen in other scenarios. The objective as rather to map the space for developments in the coming years based on the personal views and judgements of the expert group involved in the scenario building exercise. And the same procedure has been applied by the members of E48 as when they interpreted the potential impacts of these scenarios for the pulp and paper industry.

The underlying scenario process focused in the first place on four manufacturing sectors – electronic components; measuring, precision and control instruments; basic industrial chemicals; and motor vehicles – and most of the information provided in the scenarios refers to these sectors. Important developments in other manufacturing fields (i.e. pulp and paper, aeronautics, the textile industry, food and beverages, pharmaceutical, and medical instruments) are therefore not adequately covered by the scenarios presented in this report. But there can not be any doubt that the very well elaborated master conditions characterising the various scenarios of this study can be considered the very same for any other industry.

2.2. The Scenario Work within COST E48

Against this background the main task of the scenario work within E48 therefore was to draw specific conclusions of how these master conditions would affect the pulp and paper industry in general and the recycling of used paper and board products in particular. The adapted scenarios and the conclusions thereof should be used as a tool to stimulate strategic thinking about policy options in order to be prepared for the paper and board recycling challenges ahead.

The evaluation of the potential impacts of the various scenario characteristics on the issues of paper and board recycling was performed on a basis of a list of questions related to those characteristics. These aspects were comprehensively discussed and assessed in the three working groups of E48 and separately commented (during the Sofia meeting). Based on the results of the individual assessments preliminary general conclusions were drawn and discussed in plenary meetings (during the Iasi meeting). On the basis of these efforts final conclusions were drawn and eventually adopted. The most important of these conclusions were then transformed in a list of activities which could be undertaken by the pulp and board industry and their administrative bodies in order to make sure that recovered paper and board is also in the mid and long run the valuable, environmentally compatible and well accepted raw material it has been for so long. The results of the scenario exercise within E48 have also been used to establish a list of research priorities which should be worked at in the next years.

2.3. Description of the Scenarios

The scenarios developed by the Institute for Prospective Technological Studies and used for the scenario discussion within E48 were called:

- GLOBAL ECONOMY
- FOCUS EUROPE
- LOCAL STANDARDS
- SUSTAINABLE TIMES

Each of these scenarios will be described in detail later. All of them are structured along two qualitative axes of change. On Figure 58, the first (vertical) axis relates to the modality of policy making, i.e. the integration of sustainable development (SD) policies. It ranges from Global Economy and Local Standards scenario to the Focus Europe and Sustainable Times scenario and includes issues such as geo-political developments, the balance between central decision-making and subsidiarity in

Europe, and the rate of co-ordination between different policy areas. The second axis refers to prevailing public values, consumer behaviour and demand patterns. The dimension also includes issues of public acceptance of new technology and backing of policies in support of sustainable development.

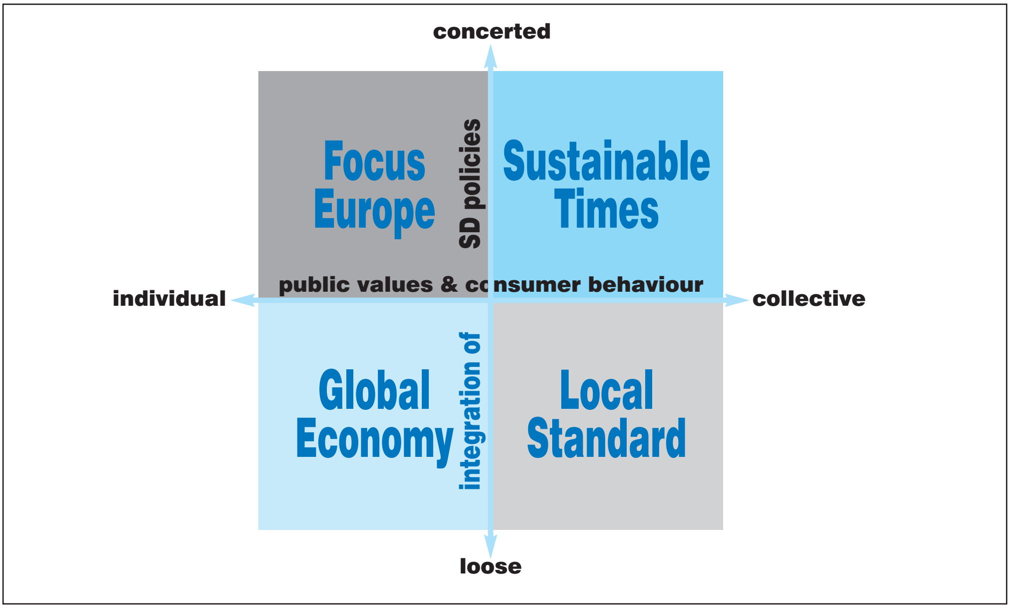


Figure 58: The four basic scenarios used for the discussion of the future of paper recycling in Europe

Global Economy

The global economy scenario describes a situation in which consumers in the first place pursue their own interests. Environmental and social impacts of production and consumption as well as environmental awareness is no longer very high on the society's agenda but has turned into a matter of individualistic preferences. Liberalism is considered the most effective way to allocate resources and to achieve sustainable development and consequently policy-making principally aims to strengthen market mechanisms and competition.

The long term aspects of sustainability, however, are sacrificed for more short or medium term economic goals. The influence of national or supra-national (e.g. the European Union) governments on international trade policies on a global level has become rather weak.

In technology areas in which global competitors have financed large R&D programmes, Europe has already or is at risk of falling behind particularly due to a considerable lack of R&D budgets in universities (for basic research) and public research organisations (for advanced research). Technology progress has been uneven. Manufacturers focus on customisation and individualisation of products rather than on their potential re-utilisation or recycling.

Environmental progress in manufacturing - if at all - happens as a side effect of efforts aiming at cutting costs by making more efficient and more economical use of energy and resources.

The structure of the industry is highly specialised and diverse. Product liability governs health, safety and environmental standards and regulations. Court litigation becomes an important though somewhat questionable source of product innovation – and a reason for the lack of it.

Voluntary industrial agreements and self-compliance of industry on basic environmental and safety standards are the main instruments to stimulate sustainability. Their installation, however, depends largely on the individual sense of responsibility of company leaders and to a much lesser extent on the influence of policy or environmental groups.

The scenario favours short-term industrial research activities the results of which have to have an as high as possible ROI in an as short as possible time – usually not exceeding a period of a year or two. Energy intensity of production remains rather high, because the necessary R&D efforts which typically have a much longer ROI suffer from a lack of funding. The need for better energy and resource efficiency, however, becomes more and more obvious since manufacturers are urged to reduce energy costs in times of sky-rocketing energy and raw material prices. Problems in the enforcement of recycling practices inhibit the adoption of recycling.

Local Standard

In this scenario national and local authorities have gained new powers. Regional governments determine policy priorities and drive regulation. European institutions have not been in a position to co-ordinate the diverse interests of regions and Member States effectively. The civil society pursues most of their interests through a large number of NGOs, which have become an important player in policy-making processes.

Consumer and citizen groups push their agendas on local and environmental issues. The economic disparities between European regions and between Europe and its neighbours remain high. However, at local level diverse and creative regional clusters – new sources of innovation – have emerged. Multiple local markets have surfaced, linked and co-ordinated through ICT. Complex systems management tools help industry to cope with a challenging business environment. Some risky industry sectors face public opposition to the construction of new plants and witness the relocation of production abroad.

However, strict environmental regulation has also lead in some regions to the fast adoption of radically new manufacturing approaches and concentration of manufacturing activities in industrial clusters to retain production: localised alternative energy production concepts have been realised and new small-scale production systems have reached application stage.

The Local Standard scenario implies both the centralisation and the decentralisation of manufacturing operations depending on sectors, processes and products. Regional demand structures require new solutions for flexible specialisation in manufacturing. Industry adopts new design strategies to focus on modular, simpler, and robust components. Intelligent logistics plays a key role. In some regions consumer choice drives manufacturers towards flexible specialisation and cleaner, more socially responsible production. At regional level specialised advanced technology clusters emerge, though overall public acceptance of new technology which might cause negative second order effects remains rather low. Since there is little trans-regional co-ordination of policies broader transitions such as the hydrogen economy are unlikely to materialise in this scenario.

Sustainable Times

Due to strong initiatives and the fact that the impacts of resource over-utilization and global warming have become obvious for large parts of the society, the awareness that the ecological footprint of humanity was far too high, particularly in Europe, has grown. The citizens support the objectives of national and supra-national authorities to reconcile the economic, environmental, and social dimensions of sustainability and to reduce the ecological footprint. A European governance system has been established which strategically promotes sustainable development. The European Union takes the objectives defined in the early years of the century seriously and implements clear sustainability policies based on broad stakeholder participation, within Europe and between national governments. This policy expresses itself both in market incentives (e.g. energy taxes, emission charges, other financial incentives) and regulation (market regulation, performance and direct regulation) all aiming at fostering sustainability. Emphasis is – also from the industry - given to socially responsible technology development. European manufacturing has been able to break the links between growth and resource use.

Many industries have undergone substantial changes in a rather short period of time because technological opportunities as well as organisational and social changes were linked successfully. The energy supply has already to a large extent undergone the transformation towards renewable resources. Bio-resources gradually begin to replace non-renewable materials.

The manufacturing industry focuses on the provision of services not only on selling products. In the Sustainable Times scenario competitiveness is no longer just market success but takes into account environmental and social aspects of production and consumption. Major technological breakthroughs aiming at de-coupling material and energy use from production are on their way or have already been transferred into industrial practise. Renewable energy and bioresources help to reduce CO_2 emissions.

The optimisation of product life-cycles has become another core objective of the manufacturing industries. The demand for a highly qualified labour force able to operate and manage sustainable production systems is higher than in any other scenario. Public acceptance of new technology (e.g. ICT applications or nanotechnology) has grown substantially as governments and industry pay attention to the environmental and social implications when designing and implementing their strategies.

Focus Europe

In the Focus Europe scenario, the development towards sustainability is regarded part of government's responsibilities. Europe has become as powerful actor to guide the societies of its member countries towards sustainability and has pursued a corresponding strategic industrial policy, aimed at creating lead markets for sustainable technologies.

This approach proved to be successful, creating new export opportunities for European manufacturing industries. Strong emphasis is given to integrated utility of policy measures (i.e. balance economic, environmental, and social utility in sustainable development). Discussions between regulators and industry about adequate performance goals (i.e. What is Best Available Technology?) and the most appropriate means to implement policies (regulation, self-regulation, standards, taxation, fiscal incentives etc.) have led to rather slow policy implementation processes.

At international level, Europe is confronted with new competitors, especially from Asia (e.g. China and India). The WTO has facilitated international trade, though there has been little willingness of WTO members outside Europe to take environmental and social issues on board. Since behaviour patterns of consumers have not changed significantly, the scope for broader socio-technical innovations is limited. Application of new technology follows more traditional trajectories and does not break societal, technological or infrastructural lock-ins. For example, the zero-emission-car based on the internal combustion engine has become reality but the problems associated with car-use prevail. Advanced ICT is implemented in both the public (e.g. intelligent transport systems) and the private and industrial sphere (e.g. for control, surveillance and tracing applications).

In the Focus Europe scenario, regulation provides incentives for industry to invest in sustainable manufacturing solutions. Innovation is geared towards resource efficiency and clean production. Well designed and coordinated policies drive technology development towards lower carbon dioxide-intensity. Strong policy support for large scale European research leads to more top-down innovations. However, the scenario favours developments along existing application trajectories. Opportunities offered by new technology cannot be fully exploited, since short term cost-effectiveness does not favour radical innovation for sustainability and consumer attitudes do not support them either. The priority given to strategically important sustainable technology development strengthens Europe's competitive advantage in advanced manufacturing technologies. Industry works hard to attract and keep personnel experienced in using advanced manufacturing tools, managing virtual factories, using simulation methods, etc.

2.4. Summary of Basic Scenarios

The scenarios suggest that the interplay of a variety of drivers – most notably related to:

- globalisation;
- new technology;
- market demand;
- public values;
- fiscal measures;
- regulations and legislations;
- overall societal change.

will contribute to shaping the future landscape of manufacturing in Europe, the pulp and paper industry being part of it. Many of the driving factors can be shaped and influenced (within limits) by European policy to support the achievement of the goals and objectives laid down in the European strategy for sustainable development.

The conclusion to be drawn from the analysis of the scenarios is: Whether sustainable manufacturing will become a reality seems to be hardly a question of technological opportunities alone. New technology, socio-economic factors, and the policy framework will jointly determine the dynamics of change. The scenarios indicate that progress towards sustainability will depend on the successful alignment of technological, organisational, and societal factors that are required for 'system changes' towards sustainability.

The scenarios also suggest that the main obstacles to achieve progress towards sustainable manufacturing seem to be primarily located in the political and market arena, rather than being caused by a lack of technological opportunities.

The interfaces between the various technological, socio-economic, and policy factors presented in the scenarios point to potential triggers for system changes towards a more sustainable manufacturing future.

3. Assessment of the Scenarios

3.1. Paper & Board Recycling Situation in the Various Scenarios

In order to develop ideas with respect to how the future of paper & board recycling would develop under the possibilities and constraints described above for the various scenarios, the Action's participants formed working groups which discussed these issues with the help of questionnaires.

3.2. The Relevance of the Scenarios Characteristics & their impact on Paper & Board Recycling

A first analysis aimed at identifying the relevance of the characteristics of the various scenarios for paper and board recycling in general without assessing the specific impact. This analysis was performed by all working groups from their specific point of view during the meeting in Bilbao in Spring 2007.

In a second joint activity which took place during the meeting in Sofia in October 2007 the impact of those characteristics which had been considered of strong or at least medium influences on selected criteria were discussed. The results of this work are summarized in what follows.

These criteria were:

- The environmental awareness within the society;
- The performance of collection systems;
- The economic efficiency of RP sorting;
- The development of RP treatment technologies;
- The competition between recycling and energy production;
- The recycling-friendliness of printing & converting techniques;
- The consumer's behaviour;
- The consumption of communication paper;
- The consumption of packaging paper;
- The impact of legislation RP recycling;
- The impact of RP composition on recyclability;
- The supply of recovered p&b regarding world-wide developments;
- The importance of sustainability in policy;
- The impact of the structure of the EU paper production;
- The impact of product liability policy;
- The speed of harmonization within the EU;
- The influence of further acquisition & merging in the p&p industry;
- The consumer "education";
- The transport cost development;
- The trends in mill size;
- Monitoring technologies;
- Trends in paper production;
- Paper product diversity.

Eventually the impacts of the various scenarios were comprehensively discussed in several meeting of the steering group. The results of these efforts are summarised in the following.

3.3. Paper & Board Recycling in the Global Economy Scenario

The main characteristics of the Global Economy scenario might be summarized as follows:

- Industry structure is highly specialised and diverse
- Product liability compensates for safety and environmental standards
- Court ligitation becomes a source of innovation – and a reason for the lack of it.
- Voluntary industrial agreements and self-compliance of industry on basic standards are the main policy instruments to stimulate sustainability
- Short-term industrial research activities are favoured
- Energy intensity of production remains high, though energy and resource efficiency improve since manufacturers are urged to reduce costs
- There is little prospect for the adoption of radically new approaches
- Problems in the enforcement of recycling practices inhibit the adoption of recycling

The following more detailed characteristics were considered to have a strong influence on paper and board recycling:

- The EU Member States' put strong emphasis on the role of market forces and free competition as the key enabler of economic development & technological innovation.
- The challenges by the new economic powers such as China and India have further grown.
- The global competition is becoming fierce and increasingly cost-driven.
- The stimulation of sustainability is to a large extent based on voluntary industrial agreements as basic environmental and safety standards are on self-compliance of industry.
- Policy objectives have been set on sector levels with little emphasis for integration across institutions or policy fields. Compared to its global competitors, Europe is under heavy pressure.

Conclusions concerning the impact on p&b recycling

Criterion	Conclusion
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Environmental awareness Society's environmental awareness will play a far smaller role than it used to. The conviction that there are ecological advantages of paper and board recycling, however, will not rapidly disappear – at least not in those countries where recycling has some tradition. But it will definitely become less likely that corresponding attitudes can be generated in societies without such a history. This will result in gradually decreasing RPB quality and p&b collection rates in Europe at least as far as separated collections is concerned which from today's point of view is the major prerequisite for using p&b economically as a raw material for the paper industry.	**Ebbing environmental awareness results in decreasing growth rates for collection and utilization rates as well in deteriorating qualities of recovered paper.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Performance of collection systems The increasing role of market forces and free competition will lead to an intensified collection and utilization of waste in general. The main driving forces, however, will no longer be a pronounced responsibility for resource utilization or the worry about a safe environment but rather economical considerations: The further increasing demand and the premium prices paid for RPB in developing countries. Alternative uses of RPB outside the p&b industry will gain importance and as a consequence of that, collection criteria will change. If this becomes a strong trend, separation from other waste potentially detrimental to paper recycling will loose importance.	**World wide growing demand for RPB will strengthen collection activities.** **However, due to increasing exports, availability of recovered paper and board for the EU paper industry declines – at much higher prices. An increasing use of RP for energy purposes may influence the structure and performance of collection systems. Less sorting would be needed.**

Criterion	**Conclusion**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Economic efficiency of RP sorting The increasing demand for RP from outside Europe and the corresponding quality requirements will influence the sorting strategies. As long as sorting of high grades for the utilization in the p&b industry and the utilization of the rest for energy recovery is economically acceptable and as long as the paper industry is prepared to pay premium prices for high quality sorted RPB, sorting technologies will be further developed though probably far slower than in the past.	**Increasing RPB prices will allow for the development of more sophisticated sorting techniques.** **But this will not necessarily result in a better availability of the RP grades the European p&b industry needs as global trade with mixed RP and sorting at destination country (cheaper manual sorting costs) might increase.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Development of RPB treatment technologies Taking into consideration the strong competition with other ways of utilizing RPB only small steps can be expected in the development of new, innovative recycling technologies. In particular as long as the growing demand from developing countries focuses on low or medium qualities for the production of e.g. packaging grades and newsprint. Revolutionary innovations are anything but likely.	**The necessity to develop more efficient recycling technologies for recovered p&b gradually looses importance but still remains. Technological challenges to improve treatment technologies increase. Differences between paper grades and regions will increase.**

Criterion	Conclusion
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Competition between recycling and energy production In the global scenario the installation of new nuclear power plants all across the world to control greenhouse gas emissions and environmental taxes on energy is very likely. Building up of power generation capacity will control the rises in energy prices – to some extent. This might favourably influence the competition between recycling of RPB and turning it into energy. This however applies only to regions where nuclear power is available. In all other regions energy generated from waste will become an economically very attractive alternative. This particularly applies to RPB due to its rather high heat value even or especially if not separated from e.g. plastic waste. Compared on the basis of heat content per mass unsorted recovered paper grades might become a cheaper energy source than crude oil, coal or gas. Liability, however, might become an issue. The owner of used p&b products – the consumer – will see more and possibly more economic alternatives than collecting p&b for the paper industry without being rewarded.	**Slower increase in energy prices due to the installation of new nuclear power capacities all across the world might reduce the pressure on the competition between recycling and energy generation in some areas.** **In regions, however, where "cheap" energy is not available, waste containing sufficient organic compounds like un-sorted RPB containing plastic waste and other high caloric substances will be increasingly used as an economic fuel.** **As a net effect, RPB availability will decrease and prices will go up.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Recycling-friendliness of printing & converting techniques As recycling within the p&b industry is possibly no longer the most economical alternative for used p&b the pressure on printers and converters to use e.g. recycling friendly inks or adhesives lessens further. The same applies to printing and converting techniques which may also have detrimental effects on the recyclability of the final products. Recyclability is no longer an accepted obstacle to introduce new substances potentially problematic detrimental to recycling in the paper chain.	**Quality of RPB in terms of content of detrimental substances and recyclability decreases.**

Criterion	Conclusion
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Consumer's behaviour The establishment of a Global Economy which basically trusts that technology will solve the problems caused by itself, the consumer's behaviour will also gradually change in terms of environmental awareness and responsibility. Contributing to closed and sustainable strategies is no longer regarded particularly important.	**Faith in technology and uncontrolled economic growth reduces environmental awareness and sensitivity for sustainability. In developed countries the development might be less pronounced.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Consumption of communication paper The consumption of communication paper will slightly decrease in highly developed countries but show medium to strong increase in developing countries. The growth, however, compared to packaging paper will be definitely smaller.	**Stagnant demand for p&w papers in developed countries, medium and strong growth in developing countries where the demand for "white" RP will keep growing.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Consumption of packaging paper The demand for packaging material in general will grow considerably because of an intensified regional and worldwide trade. For cost reasons, paper and board based packages should be in a position to secure or even extend their market shares if they successfully meet the growing demand for smart packaging. Both the content of recycled material and the recyclability of the finished packaging unit will dwindle away to purely emotional sales arguments. Again for cost reasons, the amount of packaging material per unit will decrease.	**The demand for packaging papers will grow considerably and all across the world. And so will the demand for suitable RPB.** **Economics, however, is more important than recyclability. The quality of "brown" RPB will further go down.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Impact of legislation on RP recycling As market interests are considered the most effective way to allocate resources and to achieve sustainable development there is not much support neither any direct discrimination. The lack of support may inhibit the adoption of recycling practices.	**The installation of effective recovery systems for p&b will not be strongly supported.**

Criterion	Conclusion
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Impact of RPB composition on recyclability The increasing demand for more sophisticated paper and board based products can only be satisfied by more complex and in many cases composite products, i.e. by combining paper and board with an increasing variety of other materials. Simultaneously the progress in printing technology will further accelerate and introduce new techniques and particularly new inks in ever shorter intervals. RPB therefore will become more heterogeneous. And the decreasing environmental awareness of the Global Economy society will make its own contribution to this heterogeneity. All these developments will inevitably deteriorate the quality of RPB requiring either better sorting or treatment techniques if it should serve as a valuable raw material for the paper industry.	**The composition of RPB will become even more heterogeneous in terms of non-paper components and printing inks and recyclability even more challenging.** **RPB might loose of its attractivness for the manufacturers of p&w papers because reprocessing extremely heterogeneous RPB is less economic.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
RP supply regarding world-wide developments An increasing number of developing countries – no longer restricted to China and India – will benefit from global economy and gain more prosperity, which – at least in the past – has always strongly correlated with increasing p&b consumption. It can be assumed that this holds true for the future as well – though probably to a far lesser extent. But taking into account the rather low per capita consumption a significant additional demand for paper based products can be expected in such countries. Due to the prevailing lack of wood resources and efficient collection systems for used p&b, imported recycled fibres will become one of the major options to satisfy this demand. Another aspect is the attractiveness of particularly unsorted waste containing p&b products or unsorted RP as a substitute for fossil fuel particularly as long as environmental standards allow for this.	**RPB will become an even more attractive material for both paper production and energy generation. This will lead to increasing prices for well sorted and high quality RP grades globally.**

Criterion	Conclusion
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Impact on the structure of the EU paper production The manufacture of commodity paper grades in medium sized or small production units is becoming increasingly expensive in Europe and therefore gradually shifts to other countries. Europe will focus on RP based large consumption products as well as on specialised products and innovations.	**Europe will focus on RP based large consumption products as well as on specialised products and innovations. Recycling requires virgin fibre injection.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Influence of further acquisition & merging in the p&p industry The international paper industry – still rather fragmented compared to other branches – will experience rapidly increasing M&A resulting in a far smaller number of big international players.	**Decreasing number of players will improve the control of collection and recycling chain including cost savings in logistics.**
Global Economy . . . Global Economy . . . Global Economy . . . Global Economy . . .	
Consumer "education" As the Global Economy relies on market forces not too much attention will be paid on consumer education neither on the development of environmental awareness.	**Environmental awareness is not very high on the society's agenda. Sustainability, and together with it, material recycling will play a less important role.**

3.4. Paper & Board Recycling in the Local Standard Scenario

The main characteristics of the Local Standard scenario might be summarized as follows:

- The Local Standards Society implies both the centralisation and the decentralisation of manufacturing operations depending on sectors, processes and products.
- Regional demand structures require new solutions for flexible specialisation in manufacturing.
- Industry adopts new design strategies to focus on modular, simpler, and robust components.
- Intelligent logistics plays a key role.
- In some regions consumer choice drives manufacturers towards flexible specialisation and cleaner, more socially responsible production.
- At regional level specialised advanced technology clusters emerge, though overall public acceptance of new technology which might cause negative second order effects remains rather low.
- Since there is little trans-regional co-ordination of policies broader transitions such as the hydrogen economy are unlikely to materialise in this scenario.

The following more detailed characteristics were considered to have a strong influence on paper and board recycling:

- In many industries manufacturers are under heavy pressure to improve their environmental performance.
- The civil society has become an important player in policy-making, especially at local level.
- Consumer and citizen groups push their agendas on local and environmental issues.
- Whereas in some regions the society has shown a high level of awareness to environmental and social issues. in other regions economic and employment considerations have attained more attention.
- European regions have competed within the general European market framework. In line with the subsidiary principle the regions have developed their own specific policies related to sustainable development (e.g. industry policy. environmental policy. consumer protection standards. RTD policy. taxation. etc.).
- Strict but regionally diverse regulatory frameworks have changed the organisational structure of the manufacturing industry.
- Local authorities and regional governments have gained new powers.
- The new European regionalism puts limits on policy co-ordination in Europe. European institutions face severe difficulties to co-ordinate the interests of regions and Member States.

- Strict environmental regulation in certain regions has partly led to the concentration of production sites which offer favourable regulatory conditions. partly to the adoption of radically new manufacturing approaches to retain production. and partly to the relocation of production abroad.
- Local authorities and regional governments have gained a powerful role in key policy areas. Regional governments determine policy priorities and drive regulation.
- The voice of Europe at international level has not always been harmonious. The EU governance system has aimed – not always successfully – to provide co-ordination and reconciliation between sometimes conflicting interests.

Conclusions concerning the impact on p&b recycling

Criterion	Conclusion
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Society's environmental awareness Different social groups in different areas of Europe have different expectations which affect product quality requirement, hence production techniques involved / utilised. Social awareness can also drive demand for recycled products. Incorrect expectation can have a severe negative impact.	**Social (and green) groups can have a profound impact both on recycling and paper consumption. Misinformation can also be used indiscriminately and in an unpredictable way.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Performance of collection systems The performance of these systems depends strongly on regional cultural & educational differences and thus on differences in what importance is ascribed to sustainability. Local administration / legislation shape and adjust collection systems according to prevailing conditions. The structure of the industry may shape the collection system to some extent. Regional "selfishness" may distort the waste hierarchy. E.g. local energy production may override recycling.	**Local administration frequently chooses the least cost option, which appears to comply with the legislation. This is not necessarily the best solution for the paper industry.**

Criterion	Conclusion
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Economic efficiency of RP sorting Collection and sorting systems affect the quality of "raw" recovered paper. Local economy determine the sorting systems used. Everything from non-existing to extremely efficient collection system can be found in the Local Standards Europe. The economic efficiency of sorting systems will only be high in regions where recycling is important and so will the quality of RPB. In other regions only lower qualities will be provided. This might lead to shortages in some RPB grades in Europe.	**Due to local approaches unintented consequence on collection rate and on local and export markets could occur. By and large this situation will bear the risk of shortages in the supply of clean and high quality RPB.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Development of RP treatment technologies Specific Market conditions drive the development of specific treatment solutions. But due to high investment costs the development of more sophisticated advanced technology could probably not be local and due to heterogeneous markets the development of breakthrough technologies becomes rather unlikely. Local waste sources probably shape the development of local mills (up to a point). Local needs to utilise the available raw material base may enhance the development of new treatment technologies in some areas.	**The net effect, though difficult to predict, could be that the development of advanced recycling technologies will not be pushed.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Competition between recycling an energy production Local energy prices (and regulations) determine the desire to use RPB as an energy source. Local standards can promote one or the other option.	**In regions with poor or insufficient fuel for energy generation and marginal p&b industry RPB might become an attractive and CO_2 free fuel.**

Criterion	Conclusion
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Recycling-friendliness of printing & converting techniques Locally increasing demand for high grade RP grades might put some pressure on developing recycling friendly printing & converting techniques. However, if local conditions favour energy recovery, the need to improve recycling friendliness will fade away.	**Even if locally developed they would probably only be accepted if they were more economic than what is state-of-the-art. Generally no positive impacts can be expected.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Consumer's behaviour Consumers' education, awareness and behaviour have a great effect on collection activity. Increase in GNP per capita generally leads to improved recycling. Environmental pressure groups, legislation and waste handling costs all influence consumers' behaviour.	**As the role of local authorities and waste management companies/ RP collectors is essential to provide the basis for recycling, a very diverse scattered picture can be expected in the Local Standards scenario.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Consumption of communication paper The level and development trends of communication papers consumption largely depend on local conditions. The development of information technologies has a great overall effect on the consumption of communication papers.	**Rather independent of local conditions in most regions the competition with electronic media will lead to a declining demand for communication papers. This will in general have some effect on the composition of RPB.**

Criterion	Conclusion
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Consumption of packaging paper The overall consumption of packaging paper in a region is a function of the export/import situation. Local Standard also means that the trade connections to other countries are less intensive than with other scenarios. Consequently the consumption of packaging grades will stagnate or only slightly increase.	**The consumption of virtually all packaging material will slightly decrease.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Impact of legislation RP recycling Overall European standards do not necessarily reflect local situations and will be replaced with local instructions taking into account local conditions.	**The world of European legislation is full of unintentional consequences, some regions might choose to ignore it and do what is best for the local paper industry.**
Local Standards . . . Local Standards . . . Local Standards . . . Local Standards . . .	
Influence of further acquisition & merging in the p&p industry In established markets A&M can reduce the number of players, in developing markets A&M bring new technology.	**Further acquisition and merging in the P&P industry will decrease the differences between regions and thus slightly level out the effects of Local Standards.**

3.5. Paper & Board Recycling in the Sustainable Times Scenario

The main characteristics of the Sustainable Times Scenario might be summarised as follows:

- Competitiveness takes into account environmental and social aspects of production and consumption.
- Industry seeks major technological breakthroughs to de-couple material and energy use from production (e.g. bio-materials, renewable resources).
- Renewable energy and bio-resources help reduce greenhouse gas emissions.
- The industry strives for the optimisation of product life-cycles, introducing full lifetime control and management for their products.
- The manufacturing industry strongly pursues service-orientation in product design, and the product becomes less important within the value chain.
- Rebound effects due to lack of public acceptance of new technology (e.g. ICT applications or nanotechnology) are unlikely.
- Governments and industry consider environmental and social implications of new technology when designing and implementing new strategies.

The following more detailed characteristics were considered to have a strong influence on paper and board recycling

- European manufacturing has been able to break the links between economic growth and resource use.
- The energy supply system is in transformation towards renewable resources and fuels. Bio-resources have started to replace non-renewable materials.
- The introduction of mandatory systems for take back & recycling has required manufacturers to invest in lifetime control of their products. This, in turn, has stimulated innovation in modular design, re-use technology, collection and separation technology, and reprocessing.
- European citizens support the government's co-ordinating and regulating role to reconcile the economic, environmental, and social dimensions of sustainability.
- Life-cycle optimisation of products & services has become a key feature in manufacturing. Industry has aimed at radically improving resource efficiency and de-materialising production. Producers have adopted product stewardship programmes.
- The European energy system has shifted gradually towards the use of renewable resources (e.g. bio-mass, wind, sun). Fuel cells have become widely available for stationary applications.

- Both market incentives (e.g. energy taxes, emission charges, other financial incentives) and regulation (market regulation, performance and direct regulation) are used as policy tools to foster sustainability.
- A global governance system has emerged that promotes sustainable economic development. Industry has been an active partner in sustainable development, closely collaborating with governments and the civil society.
- The EU has adopted a policy approach towards sustainable development that strongly emphasises multilateral action on economic, environmental, and social challenges (e.g. climate change, environmental consequences of the catching-up process in developing countries, etc.) in accordance with the international community.
- The emergence of global level governance systems supports world wide sustainable development.
- The manufacturing industry has considered its role as a responsible actor and corporate citizen, working together with governments and consumers to solve problems on local and global levels.
- The industry has closely co-operated with governments on regulation in support of sustainable development.
- Manufacturing industry has sought to reduce material consumption through design, re-use, and recycling measures.

Conclusions concerning the impact on p&b recycling

Criterion	Conclusion
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Society's environmental awareness Environmental awareness is generally high. The utilization of natural resources (wood) is examined critically but industry also has to prove environmental advantages of recycling. Once accepted public support is strong.	**European wide recycling rate will reach 75%.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Performance of collection systems Public is motivated to accept source-segregated collection systems. In order to facilitate material recycling convenient and powerful collection systems are installed.	**Quality of recovered will improve or at least stay equal. New EU Waste Directive ensures this.**

Criterion	Conclusion
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Economic efficiency of RP sorting Consumers follow the recommendations concerning separate collection of paper and board and keep both separate from other used material. Sorting efficiency will be high if needed at all.	**Higher quality, greater value and wider possibilities for RP use in paper production at no or only minor additional costs.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Development of RP treatment technologies The improved cleanliness of RPB allows industry to focus more on the fibre properties instead of mainly removing contaminants which is important due to the increasing age of the fibres. New technologies will be developed – also with public money - which support these objectives.	**Strong R&D efforts are undertaken to improve material recycling technologies and to upgrade recycling based raw materials. Quality of RPB and pulp made thereof will significantly improve.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Competition between recycling an energy production The ecologically sensitive society understands that the thermal energy of fibres is not lost due to recycling but can be exploited even after many recycling cycles. On the other hand RPB is considered a CO_2-neutral energy source. The primacy of recycling over energy generation is only largely accepted if the p&b industry provide convincing evidence that this is – from a holistic point of view – the better strategy.	**CO_2 neutral generation of energy is of paramount importance and using RPB as fuel is basically accepted. The p&p industry has to strengthen efforts to convince the society that recycling is the better way.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Recycling-friendliness of printing & converting techniques Recycling-friendliness of all products gains importance and might even become a subject of legislation or at least ordinances. This scenario, therefore, supports industry's attempt for recycling-friendly printing & converting techniques.	**The joint responsibility of paper producers and converters as far as the recyclability of their products is concerned leads to easier to recycle RPB. This allows for less complex treatment plants with less energy consumption.**

Criterion	Conclusion
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Consumer's behaviour Possible de-coupling of GDP and consumption, but at high recycling rate; demand shifting to recycled paper grades.	**Danger of unbalance between virgin and recycled fibres with negative impact on the development of p&b products and the long term quality of RPB.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Consumption of packaging paper Paper and board based packaging material will outperform a number of competing products due to their advantages in a sustainable ecomomy.	**Packaging paper products will strengthen their market position but might become more complicated for recycling in order to substitute less sustainable material.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Impact of legislation RP recycling Legislation will support paper recycling as all kinds of material recycling though energy generation from renewable raw material based used products is equally well accepted.	**By and large positive aspects should prevail. But the energy option will be there.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Impact of product liability policy It can be expected that the Sustainable Times society sets great value upon product liability. Sustainability comprises sustainability from "cradle to grave". Any potential health threats originating from no matter which product are of concern.	**Market position of certain products being produced on the basis of secondary fibre will become more complicated.**
Sustainable Times . . . Sustainable Times . . . Sustainable Times . . . Sustainable Times	
Paper production trends Energy and resource / raw material efficiency has become a major issue of product design. e.g. functionality of paper and board products is a more important criterion than appearance (like brightness, gloss, smoothness etc).	**The stronger emphasis on functionality over appearance facilitates recycling of used p&b products in some areas.**

3.6. Paper & Board Recycling in the Focus Europe Scenario

The main characteristics of the Focus Europe scenario might be summarized as follows:

- Regulations stimulate investments in sustainable manufacturing solutions
- Innovation is geared towards resource efficiency and clean production
- Policies drive technology development towards lower carbon dioxide-intensity.
- Policy support large scale European research which leads to more top-down innovations particularly along existing application trajectories are favoured.
- New technology are not fully exploited, since neither ROI objectives nor consumer attitudes favour radical innovation for sustainability
- Priorities given to strategically important sustainable technology development strengthen Europe's competitive advantage in advanced manufacturing technologies.
- Industry strongly tries to attract and keep personnel experienced in using advanced manufacturing tools, managing virtual factories, using simulation methods, etc.

The following more detailed characteristics were considered to have a strong on paper and board recycling:

- There has been strong emphasis on the role of new technology to achieve these objectives. The EU has imposed legislation that sets clear performance and efficiency standards for industry to meet sustainable development goals.
- The development of environmentally benign products and services has become a strategically targeted industrial policy in Europe has which resulted in new business opportunities for European manufacturers in international markets.
- Europe's industry has invested in eco-design production techniques to increase resource efficiency and reduced the direct and indirect environmental impacts.
- Fiscal instruments of European policies have generated incentives for sustainable production in industry.
- At international level, Europe has been confronted with new competitors, especially in Asia (e.g. China and India).
- Citizens see governments being principally responsible to achieve sustainable development.
- The European Commission has become a powerful actor to guide society towards sustainability.
- International trade has been facilitated, though there has – outside Europe - been little support to take environmental and social issues on board. Since consumer's consumption behaviour patterns have not changed much, the scope for broader socio-technical innovations has been limited.

- EU has taken the lead in sustainable development has implemented sustainability policies for manufacturing, in which it has presented a vision of highly competitive industry that at the same time actively pursues the minimisation of negative environmental effects & safety risks.
- However, discussions between regulators and industry about adequate performance goals (i.e. What is BAT?) and the most appropriate means to implement policies (regulation, self-regulation, standards, taxation, fiscal incentives, etc.) have led to rather slow pace of policy implementation.
- Europe has also been successful with developing new materials while finding innovative ways to reduce emissions, the use of hazardous substances and the generation of waste in the production processes.

The impact on paper & board recycling

Criterion	Conclusion
Focus Europe . . . Focus Europe . . . Focus Europe . . . Focus Europe . . . Focus Europe	
Society's environmental awareness The objective to increase resource efficiency leads to a better developed environmental awareness. But there is a need for guidelines? How do they get needed information? There are substantial differences between the European countries with respect to the way and the speed of development. Although some countries have already received high level of environmental awareness there is a necessity for further improvements all Europe.	**Environmental awareness gradually increases and harmonizes across Europe. As material recycling is considered important the net effects for paper recycling are positive as well.**
Focus Europe . . . Focus Europe . . . Focus Europe . . . Focus Europe . . . Focus Europe	
Performance of collection systems Rules are established which lead to more standardized collection systems. Awareness and control are important. Find someone responsible (to look after and perhaps control) for collection systems. Economical tools to support collection system performance. Description of best practices.	**Rules leading to more effective collection systems which take into account local conditions.**

Criterion	Conclusion
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Economic efficiency of RP sorting Recommendations and ordinances aiming at making material recycling more efficient and economical also had positive effects on the development of sorting strategies. The segregation of usable paper & board from other used materials as early as possible in the collection chain is gradually becoming the rule all over Europe.	**Logistics have to be optimized in order to respect the directive of separate collection to maximize the economic value of recycled material.**
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Development of RP treatment technologies The development of more effective and sophisticated recycling technologies is stimulated by policy objectives aiming at improving the sustainability of manufacturing processes. It is simultaneously stimulated by the necessity to cope new lower grade materials entering the process.	**RP treatment technologies will be further developed allowing for the treatment and upgrading of lower and difficult to process RP grades in order to prevent downgrading.**
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Competition between recycling and energy production There is a strong emphasis on sustainability in the Focus Europe Scenario which means that the utilization of used products has a higher priority than the generation of energy from waste. Material recycling is protected by the European legislation as far as it bears benefits against other alternatives. Difficult to recycle p&b or grades which would produce high quantities of waste can be used for energy production. A synergy between recycling and energy production might result.	**RPB recycling is considered to be more sustainable than energy generation as long as environmental benefits prevail.**

Criterion	Conclusion
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Recycling-friendliness of printing & converting techniques The development of recycling-friendly products is supported by policy. Radical changes, however, do not happen because the possibilities available are not fully exploited due to a too low ROI or because the society is not prepared to accept radical changes. The development of more recycling-friendly inks as well as more powerful de-inking technologies will be supported.	**Communication along the whole supply chain is expected to improve. As a consequence recycling-friendliness of printed and converted products and thus their recyclability will increase, although not as quickly as it could.** **Eco-design aspects will be enforced by legislation.**
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Consumer's behaviour Consumers are motivated to buy products just fit for their specific purpose. Printing and writing paper have too high brightness, whiteness and archival life. Newsprint quality is unnecessarily high. People consume paper because it is still the most economic and convenient substrate for information. The decisions which product the consumer can by, however, will largely stay with publishing companies and trade chains.	**Policy and education have shaped the consumer's behaviour. There is a strong preference for eco-friendly products (in all aspects!) and paper producers should supply the needed products.**
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Consumption of communicaton paper Role of communication paper remains more or less the same but the basis of information slightly shifts from paper to electronic media.	**P&W papers are becoming a low growth product group which possibly make it more difficult to justify separate recovery.**

Criterion	Conclusion
Focus Europe . . . Focus Europe . . . Focus Europe . . .	Focus Europe . . . Focus Europe
Consumption of packaging paper Packaging paper will increase, tailor-made products, individual products. Even if communication paper consumption declines, packaging paper will still be needed. More complex packaging products, more complicated to recycle (composite products). Trade flows of packaging materials need to be find out, while they are not in statistics as such but they are in collection potential. Different shares in different countries.	**Consumption of packaging papers (which will become more specialized) will grow and recyclability may become more difficult. More information about the actual volumes and the recyclability are needed.**
Focus Europe . . . Focus Europe . . . Focus Europe . . .	Focus Europe . . . Focus Europe
Impact of legislation RPB recycling One of the key issues. Control has to be developed, and it is local. Guidelines for all European countries, RP classification system and practices should be adopted in all European countries. Better statistical system needed for different end uses. Transparency is essential	**Implementation of new legislative principles needs agreements on definitions and statistics in order to provide transparency and reliability of statistics which are essential for achieving the political goals.**
Focus Europe . . . Focus Europe . . . Focus Europe . . .	Focus Europe . . . Focus Europe
Impact of RP composition on recyclability This is a very complex issue. The composition of RP is going to become more complex, the recyclability of these materials should be taken into account during the development. New definitions in EN643 should be taken into account. More sophisticated collection and sorting systems needed.	**Recyclability issues should be taken into account when developing new paper products. Declaration of substances (materials) on the composites packaging materials. EN643 should be revised.**

Criterion	Conclusion
Focus Europe . . . Focus Europe . . . Focus Europe . . .	**Focus Europe . . . Focus Europe**
Paper production trends Too much paper on the market. Will increase, mainly in packaging. The problem is that the virgin pulp is more expensive than the RP. If the virgin paper mills close, how to get the virgin pulp, as the recycling paper production is increasing. Virgin fibre paper is too cheap to cover the costs. However, it is needed to produce paper for recycling.	**Paper production will grow and the share of RP paper will increase shortage of virgin fibre will occur.**

CHAPTER FOUR

CONCLUSIONS:

INTRODUCTION:

Recovered Paper provides an essential 'Raw Material' for the European Paper & Board Industry and, if the industry is to survive, supplies of this material must be protected, nurtured and developed in a manner which is analogous to the management of Forestry resources used for the production of timber and pulp.

The consideration, analysis and discussions of the various scenarios described in Chapter 3 suggested a number of potential 'threats' to this supply of raw material, but also provided possible solutions which form the basis of recommendations to the European Paper Industry and the stakeholders along the Paper Value Chain.

The following section summarises these recommendations in a series of 'Key Actions' and 'Research Needs' which form the framework of a possible industry strategy to protect these essential resources and ensure the 'sustainability' of the 21st Century Paper Industry.

Increase Consumer's Environmental Awareness:

Some General ideas regarding the education and informing of members of the public

- Describe the Role of the Paper Industry as a 'Sustainable Industry'
- Increase awareness that both the Forest and Post-Consumer Paper & Board Products (the 'Urban Forest') have a role to play in a sustainable society and the management of atmospheris Carbon Dioxide.
- Increase awareness that the vast majority of Post-Consumer Paper & Board (and Wood) is far too valuable a resource to be incinerated before all other options have been exhausted.
- Already Paper & Board Products are produced using Renewable (in the case of the Forest) or Recycled (in the case of the Urban Forest) Raw Materials and this could be further developed.
- The Paper & Board Industry is one of the oldest and largest Recycling Industries in the World and Paper is acknowledged as being one of the truly Sustainable Products available.
- The Balance between the use of Virgin Fibre and Recycled Fibres is a Key Tool in Maximising the Recycling Potential and further developing a Sustainable Industry.

The Paper Industry should take control of the Recovered Paper Supply Chain and develop 'Consumer Friendly' Collection Systems:

- Wherever possible, Co-mingled Collection should be avoided
- The Industry should work to develop, secure and improve Recovered Paper Supplies and Quality to ensure cleanliness.
- National Strategies should be adapted at a Local Level to accommodate both the Consumer and the Indigenous Paper Industry demands.
- The Industry should be 'transparent' regarding the economics of Collection and Recycling, with this information made available to Consumers.
- Consumers could be 'rewarded' (either directly or indirectly) for their Recycling Efforts.

The Paper Industry should engage in two-way dialogue with other Stakeholders in the Value / Supply Chain:

- Encourage the Recycling of Suitable Paper Based Products
- Improve the Understanding of the Opportunities, Possibilities and Limitations within the Recycling Process.
- Work with others to reduce the Environmental Footprint of the Whole Value Chain from Forest to Final Disposal.

The Paper Industry (working with Suppliers and Research Organisations) should continue to refine existing technology and to develop new technologies:

- To ensure and safeguard the Quality of Pulp produced from Recovered Papers
- To meet the demands of the Paper Industry's Customers in the Printing & Converting Sectors and to reduce improve their Environmental Performance

The Paper Industry (& Researchers) needs to maximise the Potential of Recovered Paper Based Raw Materials:

- Maximise the Separation and Quality of Fibres for use in the Papermaking Process.
- Extract any High Value Components (either before or after the Paper Mill) suitable for use in other Industry Sectors.
- Develop the Use of Existing and New Processes to utilise the Potential of Material Rejected from the Papermaking Steam (including use for Energy Production).

Research Needs:

- The Paper Industry's Future Capacity to generate 'wealth' will rely greatly on the Research Communities ability to generate Robust Scientific Answer and develop Innovative Solutions to the issues which face the Industry; these include:

- Developing a comprehensive, balanced understanding (by means of a Life Cycle Assessment) of the full Paper Value Chain from Cradle (the forest) to Grave (Disposal). Such a comprehensive study should include:
- The Environmental Impact of the Whole Production Process, including elements such as Carbon Footprint, Water Footprint and Sustainability for a wide range of Paper & Board Products.
- Collecting and Reporting reliable and complete statistics describing the availability of Recovered Paper Streams by various grades to provide greater understanding and improved accuracy for Future Forecasts.
- Developing and commercialising innovative new technologies for the Separation of Paper (fibre) from the Waste Streams.
- Developing and commercialising innovative new technologies to reduce the Energy Demands of Paper & Board recycling operations.
- Developing New Concepts to form the basis of the 'Urban BioRefinery', including research into Bio-Chemical and Thermo-Chemical Processes to treat residues
- Develop a 'Model' and Tools to identify the Sustainable (Environmental, Energy and Economic) Level of Recycling for a given product in a given Papermaking Environment.
- Develop new technologies to 'upgrade' and 'rejuvenate' the Papermaking Properties of Recycled Fibres.
- Develop new products to improve the compatibility of Paper & Board with Downstream Printing & Converting Processes whilst, at the same time, enabling Printers & Converters to 'build in' Recyclability into their Products to be returned to the Paper Mill, effectively 'closing the loop'.

APPENDICES

Appendix 1: Participants in the Management Committee

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Kalina Todorova
Svetla Tsanova
Ivo Valchev

Croatia

Sonja Jamnicki
Branka Lajic
Branka Lozo
Maja Stanic

Finland

Ilpo Ervasti
Isko Kajanto
Jan-Erik Levlin
Tom Lundin
Donald McNeal
Tiina Pajula
Juha Saari

France

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Alain Couchaux
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Kai Blasius
Jörg-Karl Bösner
Harald Grossmann
Georg Hirsch
Adrian Manoiu
Alf-Mathias Strunz
Jörg Wagner

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Vasiliki Mantzari

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Szilvia Biro
Zoltan Dobovari
Zsuza Isepy
Piroska Karolyi-Szabo
Istvan Lele
Zsofia Markne Varga

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Graziano Elegir
Eliana Farotto

Latvia

Lubova Belkova

The Netherlands

Arie Hooimeijer
Ania Stawicka
Bartek Stawicki
Loud Van Kessel
Annita Westenbroek
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Tomasz Malinowski

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Florin Ciolacu
Dan Gavrilescu
Petronela Nechita
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Damjan Balabanic
Diana Gregor Svetec
Tadeja Muck
Vera Rutar

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Cristina Afan
Angeles Blanco
Ruben Miranda
Carlos Negro
Angels Pelach

Sweden

Marianne Björklund Jansson

United Kingdom

Roland McKinney
David Powlson
Barry Read

Appendix 4: Invited non-Action Speakers

J. Baas	AVEBE, THE NETHERLANDS
David Barrio	PPCG
Angeline de Beaufort	FEFCO
M. Biera	KADANT LAMORT, FRANCE
Kevin Bradley	CITPA
Armando Cafiero	ASSOCARTA, ITALY
Maryse Chappin	UNIVERSITY OF UTRECHT, THE NETHERLANDS
C. Chirat	ECOLE FRANÇAISE DE PAPETERIE, FRANCE
Werner Förster	PTS, GERMANY
Karolina Fras	DG ENVIRONMENT, EUROPEAN COMMISSION
Dominika Gajda	UNIVERSITY OF LODZ, POLAND
Gerard Galland	CTP, FRANCE
N. Gómez	CIFOR-INIA (CALIFORNIA)
Alain Fernandez de Grado	KADANT, FRANCE
Elisabeth Hanecker	PTS, GERMANY
R. Daniel Haynes	AKZO NOBEL, EKA CHEMICALS INC.
Jukka Heimonen	METSO PAPER, FINLAND
Erwin Hertl	ANDRITZ, AUSTRIA
Geoff Hill	ST. REGIS, UNITED KINGDOM
Ulrich Höke	STORA ENSO, GERMANY
Gerfried Jungmeier	JOANNEUM RESEARCH, AUSTRIA
Manuela Kron	COMIECO, ITALY
Gerhard Lambrecht	PTS, GERMANY
Hanneke de Leeuw	FEFCO
Jari Leppakoski	METSO AUTOMATION, FINLAND
Carlos Lopez	ITENE, SPAIN
N. Marlin	CENTRE TECHNIQUE DU PAPIER
Noelia Martin	POLYTECNIC UNIVERSITY OF MADRID, SPAIN
Massimo Medugno	ASSOCARTA, ITALY
Roberto Di Molfetta	COMIECO, ITALY
C. Molleda	HOLMEN PAPER, MADRID
Graham Moore	PIRA INTERNATIONAL, UNITED KINGDOM
M.A.B. Moura	KLABIN S.A., BRAZIL
Josef Murr	PTS, GERMANY
Gert-Jan Nabuurs	ALTERRA WAGENINGEN, THE NETHERLANDS
Bernhard Nellessen	NOPCO PAPER TECHNOLOGY, GERMANY

Hermann Onusseit	HENKEL, GERMANY
B.H. Peres	FEDERAL UNIVERSITY OF VIÇOSA
A. Rodríguez	HOLMEN PAPER, MADRID
J. Rodriguez	ASPAPEL, SPAIN
Álvaro Sánchez	HOLMEN PAPER MADRID, SPAIN
L. Sánchez	METSO PAPER, FINLAND
Anne-Dirk Siebenga	BOLLEGRAAF, THE NETHERLANDS
C.M. Silva	KLABIN SA, BRAZIL
Marianne Svensen	SWEDISH FOREST INDUSTRIES FEDERATION, SWEDEN
Andras Szöke	DUNAPACK, HUNGARY
Henry Vermuelen	CEPI
V. Vida	EUIT FORESTAL, SPAIN
J.C. Villar	EUIT FORESTAL, SPAIN
José Luis Vinuesa	GL&V SWEDEN AB, SWEDEN
Thomas A Wielema	AVEBE, THE NETHERLANDS
R. Wilken	PTS, GERMANY

Appendix 5: Current Research Projects on Paper Recycling

DEINKING PROCESS & FURNISHES	
Deinking Process Improvements	
France	5
Germany	3
Croatia	2
Total Number	**10**
DIP Characterisation & Improvements	
France	5
Germany	5
Total Number	**10**
Stickies	
France	3
Germany	1
Spain	1
Total Number	**5**
Total Number Deinking Process & Furnishes; Stickies	**25**

Table 12: R&D Projects: Deinking Process and Furnishes

Recycling Process & Recovered/ Recycled Paper Properties in General; Other	
Spain	6
Germany	2
Sweden	2
Poland	1
Latvia	1
Total Number	**12**

Table 13: R&D Projects: Recycling Process and Recovered/Recycled Paper Properties in General; Other

Collection, Sorting; Recovered Paper Trade Quality Issues	
Germany	4
Slovenia	1
Spain	1
Romania	1
Total Number	**7**

Table 14: R&D Projects: Collection, Sorting; Recovered Paper Trade Quality Issues

Recovered Paper for Packaging Papers, Improvements	
Germany	5
France	2
Romania	1
Total Number	**8**

Table 15: R&D Projects: Recovered Paper for Packaging Papers, Improvements

Recycling Process Rejects; Other Uses of Recovered Paper; Biorefining	
Germany	3
France	2
Spain	1
Finland (*)	
Total Number	**6**
* see text on page 20	

Table 16: R&D Projects: Recycling Process Rejects; Other Uses of Recovered Paper; Biorefining

Appendix 6: Equipment Supplier's standpoint on Limits of Paper & Board Recycling

Andritz

Energy efficient technologies for packaging paper production

Introduction

Over the past few years the development for packaging paper production has been aimed to increased PM sizes, higher operating speed and lower basis weight. On the one hand (Figure 1) the quality of the used waste paper decreases, on the other hand the contaminant level gets higher. To meet the targets and keep the quality, the complete system and subsystems, as well as all the single machines must be designed and optimized to fulfil the demands. With the increased costs for utilities, energy saving is one of the most important targets for all paper mills supported by the efforts of the machine supplier.

Figure 1: Raw material contaminants

Process

Depending on the final paper grade and PM configuration, the correct system design is critical.

Figure 2 shows a system intended for testliner, where cleaners and fine screens are located in the stock preparation for highest cleanliness of the stock. High cleanliness is essential for paper machines running up to 1500m/min and producing lower basis weights down to 80g/m^2. For fine sand removal and reduced wear of subsequent screens there are several locations where the cleaner can be installed. For highest quality of final products a disperser is also an option.

Figure 3 shows a system, which is typically used to produce a filler layer for a folding boxboard application. In this application there are also different possibilities to install the cleaner plant, but it is not so critical (especially if the filler layer will be made at a high basis weight). Further on in the plant a fractionation is installed and the long fibre will be dispersed to reduce bleed through to the outer layers.

Pulping

Alternative pulping solutions are available. If we compare energy consumption of drum pulping and LC pulping, these are on a similar level. The FibreFlow® drum pulper (Figure 4) works as continuous pulper in a high consistency range of approx. 20%. minimum breakdown of contaminants and lowest sticky, dirt and flake content The shear forces for pulping are created by rolling and dropping of the waste paper in the slushing zone of the drum pulper. This leads to a very gentle pulping action on the accepts and operates with lowest maintenance costs and practically without wear. In addition the single drum design ensures plug-free operation.

The LC pulping system is the most commonly used system for this application. The pulping process can be divided into three different forces: mechanical forces, which break down the bales into smaller parts; hydraulic forces created by the rotor, responsible for the mixing of paper and water as well as creating fibre-to-fibre friction; attrition between rotor and screen plate, which will further cut down the waste paper to smaller particles.

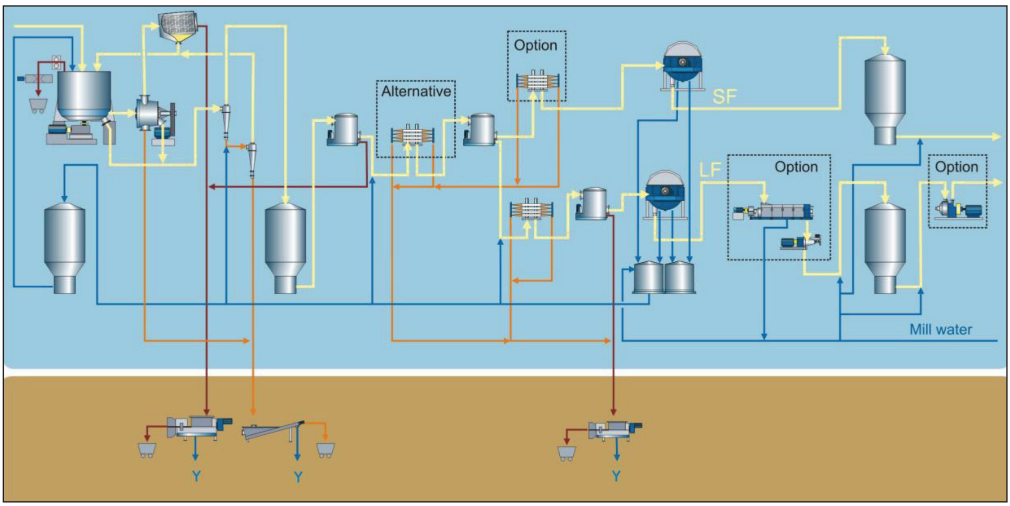


Figure 2: Testliner – LC-pulper

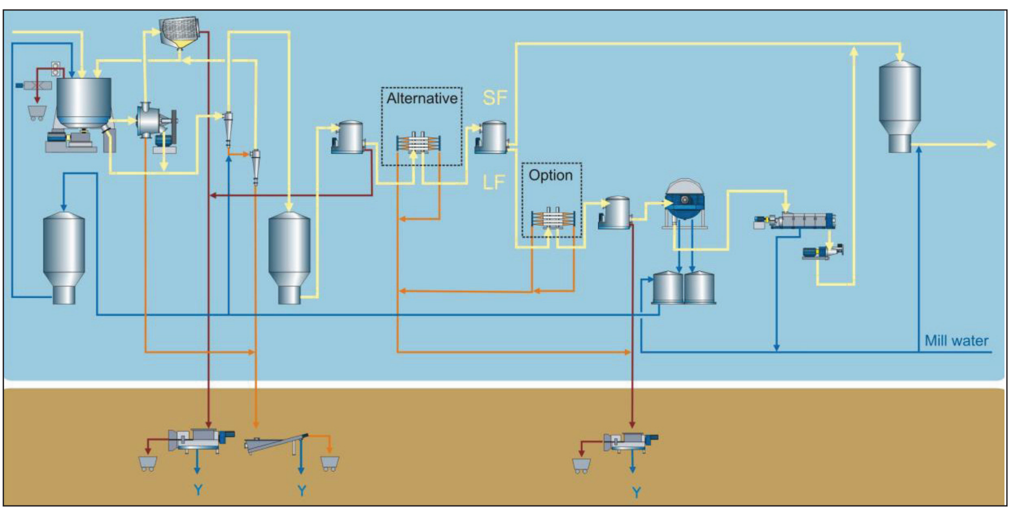


Figure 3: Filler – OCC/MW

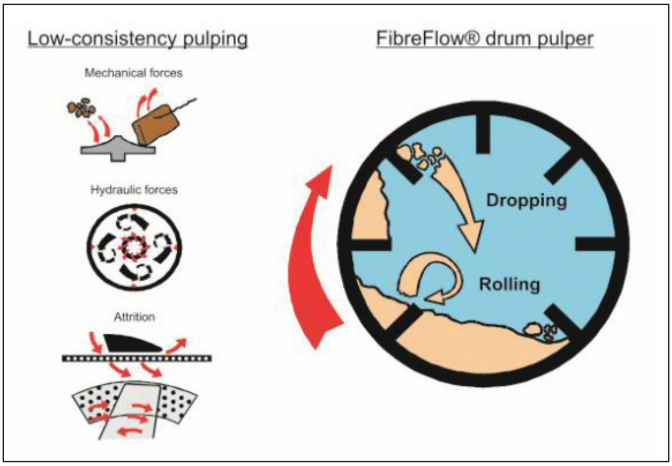


Figure 4: Pulping technologies

The design of the FibreSolve pulper has several different features. The main difference to conventional LC pulpers is the rotor, which is designed to achieve two different targets. The lower part of the rotor is equipped with cleaning blades, which introduce mechanical forces between rotor and screen plate. Those are generating pressure pulses towards the screen plate with the leading edge to increase the throughput. With the slanted trailing edge negative pulses are then created to remove debris from the screen plate.

The upper part of the rotor with pumping blades is responsible for the turbulence to enable operating consistencies of up to 8%. This higher operating consistency leads to high fibre-to-fibre friction, which ensures good pulping efficiencies.

These benefits can be gained with rebuilds and particularly with new installations. In rebuilds the major part of savings results not only from the lower power consumption, but also from installation costs if an existing pulper can be used. The ROI figures shown below (Table 1) are based on data collected from several installations after one year of operation.

	Before rebuild	**After rebuild**
Power consumption	277 kW	230 kW
Consistency	4.5%	5.0%
Feed (cont)	260 t	325 t
Net volume	41 m³	41 m³
Spec. energy input	6.8 kW/m³	5.6 kW/m³
Spec. energy consumpt.	25.6 kWh/t	17.0 kWh/t
Power saving		**33%**

Table 1: Payback calculation

	Competitor	Andritz
Power consumption	1000 kW	750 kW
Consistency	4.0%	5.5%
Feed (cont)	1100 t	1100 t
Net volume	130 m^3	120 m^3
Spec. energy input	7.7 kW/m^3	6.2 kW/m^3
Spec. energy consumpt.	21.8 kWh/t	16.4 kWh/t
Cost saving		**25%**

Table 2. Cost calculation

In new installations (Table 2), there are high savings on installation costs achieved as smaller pulpers, motors and gear boxes can be used. But also in this case, the main savings are achieved due to the low energy consumption. Comparing a pulper with a size of 120m^3 and energy costs of 85 €/MWh, cost savings of approx. 185 K€ within 1 year are possible.

Coarse screening

When designing a coarse screening system, the pulping system must be investigated first. In this area the main issue are flakes and the contaminant level in the pulper accepts. With a FibreFlow® drum pulper a very low contaminant level as well as flake content (Figure 5) is reached with very low influence regarding furnish. Due to this low flake and contaminant level, screens with low deflaking potential operated at lower reject rates can be used, e.g. ModuScreen CR or F. If LC pulpers are in front, the debris content and especially the flake content is considerably higher (Figure 6) compared to the FibreFlow® drum. This requires a different coarse screening set-up

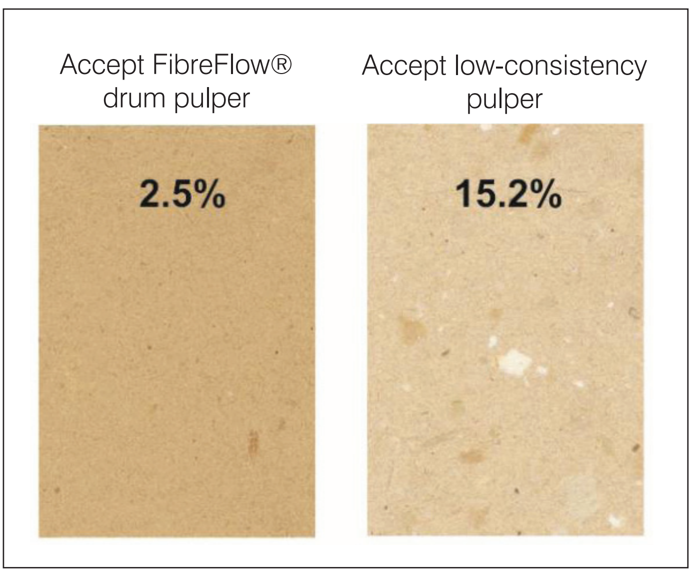


Figure 5: Pulp flake content

where the furnish composition must also be taken into consideration. When waste paper with lower pulping resistance will be used, a ModuScreen CR or F can be installed in the first stage. In the second stage, a screen with a high deflaking potential, e.g. ModuScreen D, must be installed. This set-up ensures that the final stage will not be overloaded with flakes as this would lead to high fibre loss.

Waste paper with high pulping resistance needs deflaking screens in the first stage to reduce the flake content to the subsequent screens and to reduce the fibre loss.

The tailing screen, e.g. ModuScreen TC, must be able to handle all the rejects and to reduce the flake content in the rejects, which would be rejected and counted as fibre loss. The final rejects must also be dewatered to a certain dry content, which allows the direct feed into the reject press.

Fine screening

As the contaminant level in waste paper is increasing together with the fact that more systems are being designed without dispersion, fine screening is becoming increasingly important.

For high PM runnability and high quality, excellent fine screening is a must. To ensure a high screening efficiency, a ModuScreen A (Figure 9) has to be installed, equipped with BarTec W baskets assuring high accuracy of the slot width.

But to fully exploit the high efficiency of these baskets, hydraulic flow conditions inside the screen are critical. Stable hydraulic conditions are achieved firstly with the inlet cone to guide the flow into the direction of the rotor. Secondly, the parabolic-shaped rotor body allows feeding of fresh stock down to the bottom for reduced thickening and also ensures a constant flow velocity on the feed area.

On the accept side, the double-cone shaped housing design assures a constant flow velocity in the accept area, achieved by adjusting the accept room according to the mass flow.

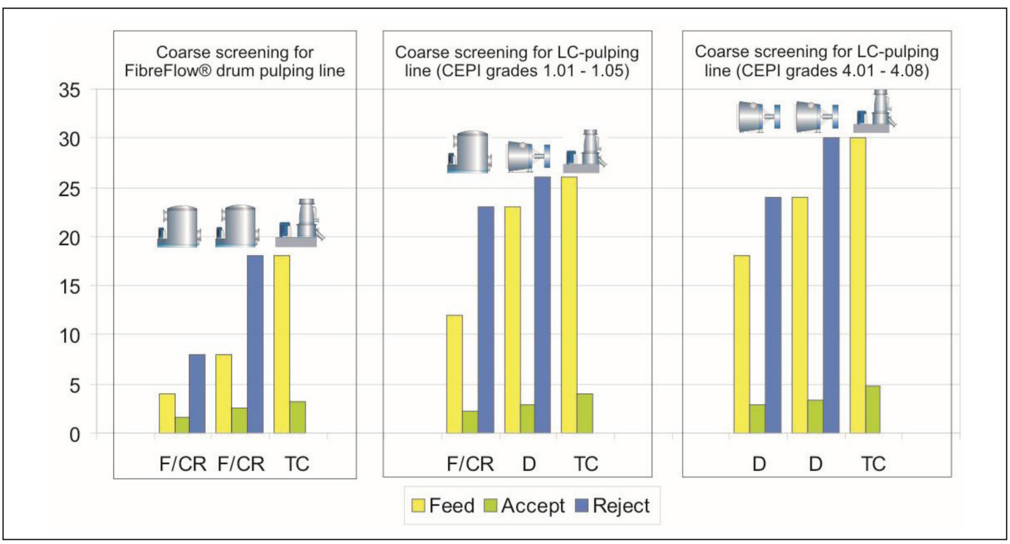


Figure 6: Comparison flake development

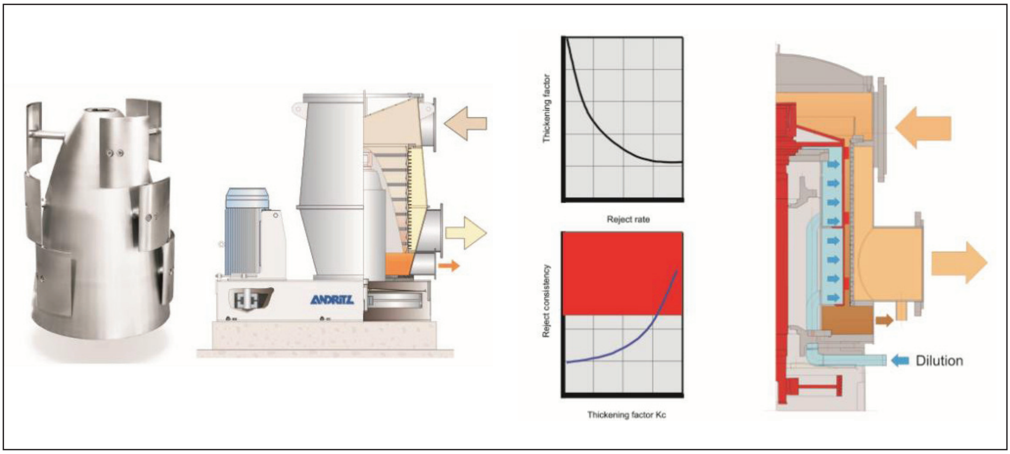


Figure 7. ModuScreen A – principle of operation

For the final stage, besides a high screening efficiency also a low fibre loss must be ensured. In addition, this final stage furnish is very coarse, which makes this target much more challenging, This leads to high thickening which causes high reject rates and, consequently, a low yield. To overcome this situation, a special rotor design was developed. To reduce the thickening, dilution water is fed through the rotor body between the rotor and the screen cylinder. Turbulence caused by the rotor mixes the water with the pulp efficiently, reduces the consistency and this ensures constant screening conditions over the whole screen cylinder area. With this unique design the expectations of a tail screen are fulfilled.

Dispersion

For highest grades dispersion systems are also used to reduce the amount of dirt specks and stickies, as well as to achieve a homogeneous appearance of the sheet. The CompaDis dispersion system (Figure 8) without separate heating screw enables a compact layout with reduced space requirement. A unique design is realized with the CompaDis disperser CDI, which comprises an integrated feeding and heating screw. With this screw, a plug is formed through a plug screw feeder after thickening, which afterwards will be fluffed first into small pieces (Figure 9). Then steam will be

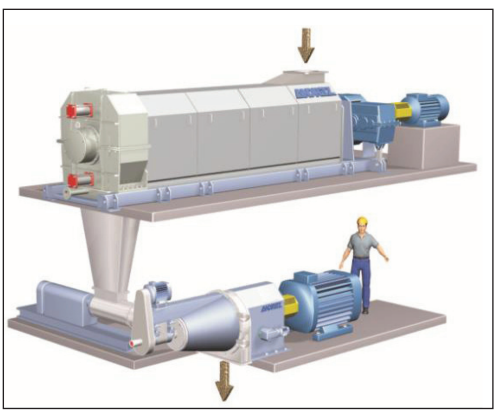


Figure 8: Dispersing system

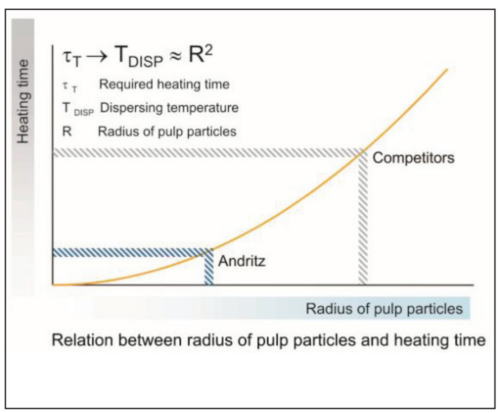


Figure 9: Heating of pulp particles

added and, due to this fluffed stock, heating is rapid and even which leads to high dispersion efficiency. And as the steam is prevented by the plug screw from flowing backwards, the steam consumption is further reduced.

Conclusion

The presented technologies and practical results show, that the necessary investment costs soon pay off. Another important advantage of this technology is a more constant product quality. Furnish quality fluctuations can be compensated for, with suitable adjustments of the subsystems. With the developments in pulping, screening and dispersion Andritz can provide already today leading technologies for a successful future. In the future, the reject handling will become more important due to the increasing amount of impurities. To save resources and to improve the overall economic situation of a paper mill, it will be economical feasible to turn the reject into reusable material and sell it to other industries.

Kadant

Introduction

With more than 100 years of experience in the field of cellulose fibres handling and paper recycling, Kadant Lamort and Kadant Black Clawson have participated to the successive changes and trends in the paper industry. This paper will propose a vision of the future of paper recycling in relation to the present situation.

Kadant is a key supplier for the paper industry and has always driven innovation to the market. Focused on the paper industry, Kadant is involved in Fibres stock preparation (through Kadant Black Clawson and Kadant Lamort), Paper Machine equipment such as Doctors, Blades, Steam management (through Kadant Johnson) and Water treatment (fig1). For more information, visit the Kadant website www.kadant.com.

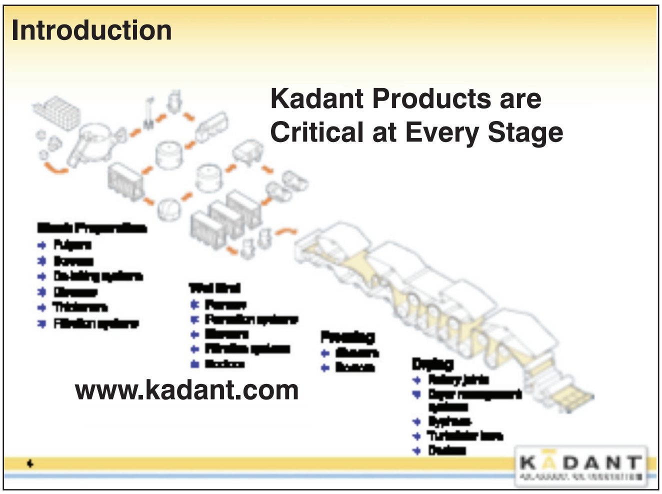


Figure 1: Kadant activities

Figure 2: Research Centre / France

The difficulty in presenting views on limits of paper recycling is that this question can be understood either as "what are the existing limits of paper recycling" - this question being answered with a simple factual presentation of the existing technologies used to recycle paper, or as "what will be the future of paper recycling" – this being answered with a much more difficult exercise of multi criteria "divination".

In this article we propose this second method as it is more challenging.

The question of future is also related to the potential of companies to overcome obstacles by constant adaptation of products and processes on emerging new market demands. Kadant' activity in Stock Preparation proposes always such "on demand" solutions, supported by its R&D pilot station located in France (fig2) (previous page).

In this paper we propose to consider the paper recycling as a global process with inputs (recycled paper, energy, water, chemicals) and outputs (final product like printing papers, tissue papers, packaging papers and rejects …). In between, the stock preparation process and the paper machine process can be characterized by complexity (= cost of investment) and runability (representing a huge amount of money as directly connected to tonnage of paper produced by day) (fig3).

For each item, a description of present limits and probable future evolution of paper recycling technologies is proposed.

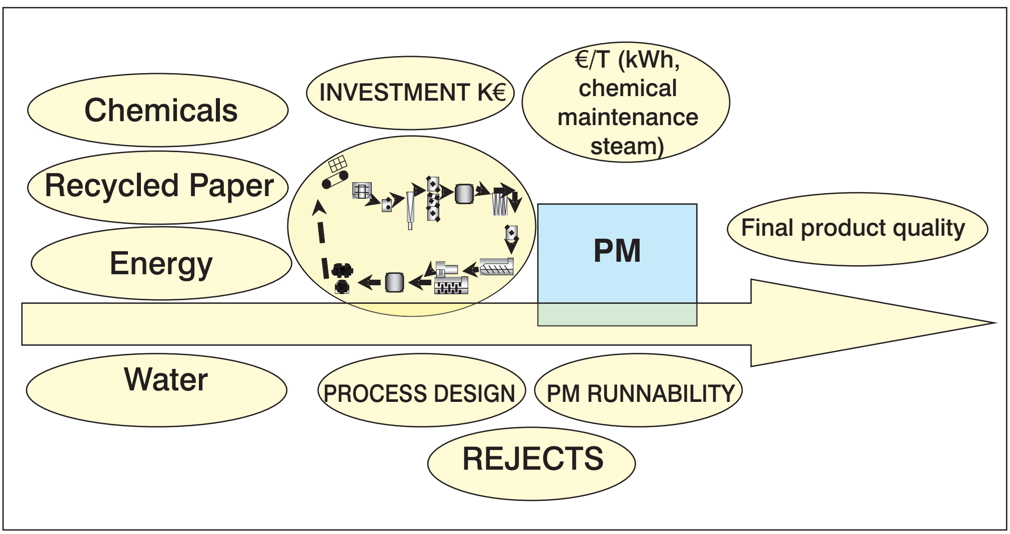


Figure 3: global loop in Recycling Mill

Inputs of RCP recycling

The quality of RCP is not under control

The recycled paper trading is a worldwide activity and the pressure to find more and more sources is high. The main consequence is that quality of sorting of Recycled Paper (RCP) is decreasing. This corresponds to a basic truth: the main "contaminants" present in the bales at the inlet of the recycling mill have been previously created by the paper producing and converting industries.

For example, standard flexo ink and digital ink is a threat to basic deinking loops, but it is also a good tool to promote the consumption of waterbased printed packaging or papers printed on demand.

The ash content is increasing and requires a better deashing effect in stock preparation lines, but this ash is introduced in the sheet by papermakers to reduce the cost of final product and also to develop special properties.

The presence of adhesives in the bales is always a pity, but it is the consequence of the wonderful potential of papers combined with glues to be used in a huge number of converting applications.

This situation of auto-contamination of paper sources is somehow a price of success; and this trend will hopefully continue because it proves that cellulose fibres will continue to be a highly interesting product base, to create high value complex products.

Added to that, new sensors are actively tested to separate papers according to their nature. It may be soon possible to define very precisely the composition of a RCP bale, and this knowledge would force to reconsider the definition of RCP grades. Today the grades definition expressed by the EN643 norm is based on statistic composition allowing or not the use of the bale for such or such production. If, in the future, it is possible to characterize precisely the composition of the bale, then the papermaker will forecast the cost of undesired components in the bale that the stock preparation will reject. It could definitely change the relationship between sorters and papermakers. (fig4)

Figure 4: Intensive manual sorting

Is the potential of recycled fibres compatible with targeted market needs?

Once the composition of RCP is defined (= where we are), it is fundamental to check that this raw material is compatible with the market targeted by the customer (where we want to go). It is not always possible to go from any RCP to any final product. Typical distinction is made between Packaging grades and Deinking grades. And within Deinking, wood-free and wood-containing papers are another major subdivision.

From this separation motivated for example by the final brightness objective, the knowledge of RCP potential is possible thanks to specific easy lab test methods and equipments (for example pulping kinetic potential, screening, bleaching, flotation, washing, etc). After a detailed lab analysis, it is possible to check if the available RCP "can do the job or not", particularly in relation to the design of an existing recycling line. More precisely it can define the general process organization required (1 loop, 1.5, 2 loops, …) and the specific optimized position of steps like cleaners, flotation, etc.

Today, the experience of machinery suppliers can make 80% of the best process definition job, but, in the future, increased contamination or special contamination like improved flexo or digital ink could require specific customer oriented pilot tests rather than a duplication of existing reference processes.

Water: a world issue and a challenge for the paper industry

A goal of zero effluent will become more and more strategic and needed for our industry. Challenges in this direction will be numerous. Some packaging mills are now close to this objective and technological innovations will make this today dream feasible.

But closure of water circuit creates increase of temperature and a higher load of suspended solid or rather unknown colloids (fig 5). This has consequences on the pH and bacteriological state of the whole stock prep.

But optimistically, closing circuit is also a challenge to salts consideration; and since ionic difference is also driving energy, why not to see highly loaded process water also as an energy source?

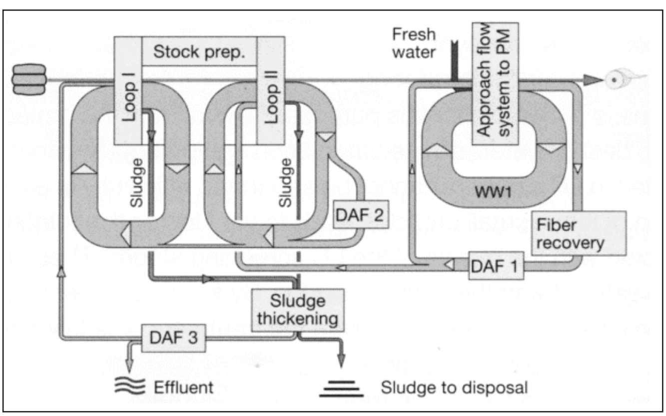


Figure 5: Typical water loops

Figure 6: Is burning ecological?

Energy: Burning is ecological?

The rising cost of energy has given the idea to some people that the best way to recycle paper is to burn it (figure 6). Except the fact that destruction has never been a “recycling activity” – it is exactly the definition of “non recycling”; the key point for environmental impact calculation is probably the number of utilization before destruction. The production of virgin fibres is a sort of investment made by the paper industry to feed the worldwide cellulose fibres market. And each time a virgin fibre is destroyed, an initial investment is destroyed and will require the production of a new virgin fibre, at high cost.

In the same way that agricultural products are first dedicated to human and animal feeding, paper fibres are for paper making. Some of these basics have been a little forgotten nowadays but wise views will reappear: to reserve agro products for human and animal food and to use only rejects from those processes for biomass energy generation.

Reject is a fuel

A possible positive consequence of increased contamination of RCP is that the amount of contaminants (basically made of plastics and burnable) is increasing. Several experiences exist on pellets of rejected plastics and energy generation by incineration. In the future, part of the stock preparation line could be devoted to reject separation depending on the energy generation potential.

Chemicals: removal or accumulation?

One particularity of modern paper is that it is not made only from fibres. Several chemical agents are introduced to improve the paper machine runability or the quality of the final paper. Those contained in the paper are then collected back and reintroduced in the mill in the pulper stage. With the increased water circuit closure, it is obvious that those components remain in the pipes and will have an effect on the fresh chemicals. This uncontrolled chemical composition in RCP stock preparation lines will reinforce, for the reasons stressed before.

Some solutions for reduction of such unexpected chemicals are now introduced on the market. For example the CTP (Centre Technique du Papier – Grenoble – France) has patented solutions to decrease the load of surface tension active substances in the pulp. Kadant proposes industrial machines to apply this licenced patent. Major consequences of such chemical control is an improvement of the deinking efficiency during flotation, and a reduction of consumption of chemicals on the paper machine.

Outputs of RCP recycling

Environmental awareness is improving all over the world

Final customer is sensitive to environmental issues and planet protection. This is driving up recycling processes, and generates new challenges right now. Recycled fibres can be implemented in all paper grades and the question is not any more “Is recycled stock able to reach this or that quality?” but it is “how to do it cheaper with less machines, less operational costs, less final rejects?”

But we are not yet at a position where all consumers accept to use recycled papers of lower quality than the one obtained from virgin fibres. Some exceptions exist locally, like a higher speck count accepted in North America on writing papers, or a lower brightness. Worldwide speaking, RCP is well accepted and even preferred if it allows the same usage, as equivalent product made from virgin fibres.

Rejects are not losses

It is frequent to consider that a recycling stock preparation line has this or that yield performance. But this is a partial evaluation. Depending on the type of paper produced and the composition of the RCP introduced in the pulper, the recycling line must remove some material. It can be ash and fines for the production of Tissue or Wet strength papers accidentally mixed with a furnish of ONP OMG, etc ... The performance of this removal must be called efficiency and not losses. Even some cellulose content can be removed on purpose, like shives with very poor mechanical properties potential.

Then the definition of losses should only refer to the components removed whereas the target is to keep them in the pulp. And the components removed intentionally are proving the efficiency of the process.

But even here, we find sometimes situations where some fibres are needed in the sludge to allow its thickening. If the sludge contains no fibres, then it will not be possible to thicken it at an acceptable dry content and it will not be possible to burn it economically. In such case, rejected fibres in the sludge are not losses, until the required percentage needed for correct thickening is reached.

Challenges will be to find the best valorization of so called process rejects to consider them as a raw material for another final product development or energy recovering. This behavior will change today's paper cycle thoughts and will drive paper mills towards the zero reject objective. Like in Nature, the design of paper process will tend towards a fully integrated worldwide material loop.

Think Global, Act local

This very famous global environmental approach is very real in our industry and in the recycling business. Collection and sorting should improve in all countries, mill size could be reviewed in order to better serve local conditions and propose a wider products range. Could we imagine flexible industrial sites, with different synergies between paper, chemicals, energy and other industries? Vegetable fibres molecules, trees might be the best alternative to replace petrochemical products in the future. This will create path for new complex products and new processes for virgin fibres as well as for recycled fibres.

Stock prep process of RCP recycling

Sensors and actuators make it easy

Very often the lines are operated with constant parameters to maximize the stability of operation. The fact that RCP quality is not constant means that it could be advantageous to continuously survey RCP quality variations and adapt and change the process operation parameters.

Some equipment can be easily adapted to that change. For example a batch pulper equipped with a variable frequency drive gives the possibility to adapt the pulping time and energy and increase the ink detachment if needed.

Another example is the installation of a multistage screen with minimal fibre losses or as a last stage in an existing screening system. The reliable operation of such 2 or 3 screens in one single machine (fig7 and 8) has been made possible also because flowmeters, pressure drop sensors and flow control valves exist.

For other stages it is much more complicated, like for bleaching tower when a retention time of more than one hour is really a limitation to on line regulation.

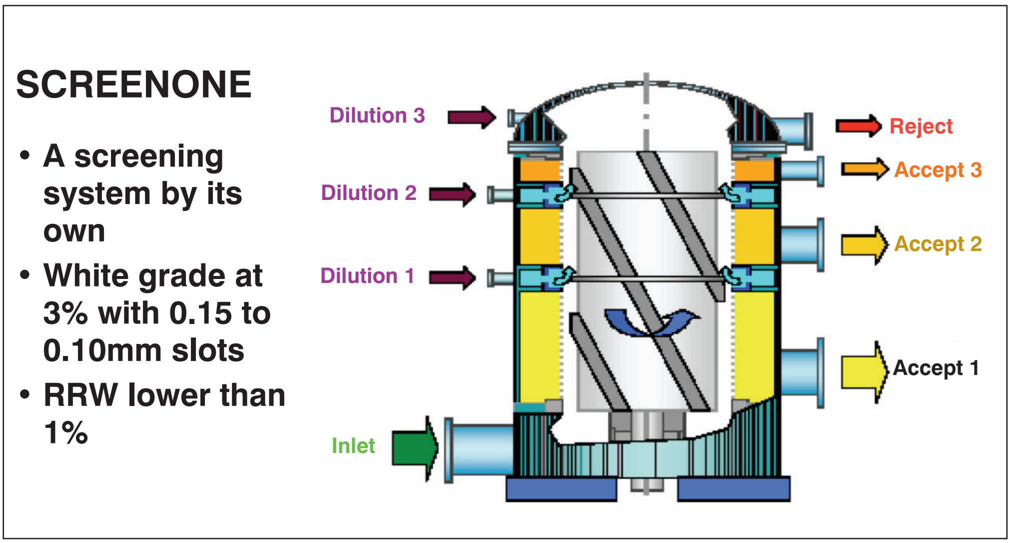


Figure 7: Screenone concept with Screenone

ENERGY COMPARISON	CONVENTIONAL SYSTEM	COMPACT SYSTEM WITH SCREEN ONE
PULPING DUMP SCREEN	Equivalent	Equivalent
HOLE SCREENING	15 to 20KW.h/T	0 KW.h/T
FINE SCREENING excluding feeding pump	17 to 25KW.h/T	7 to 12 KW.h/T
ENERGY SAVING in KW.H/T		25 to 35 KW.h/T
MONEY SAVING in €/year for 8€/100KW.h for a 300T/Dat system		200 to 300,000€ ROI < 1 to 2 year

Figure 8: Example of energy saving

Are all stickies well screenable?

Since decades the quest for stickies full removal is permanent. Initially, stickies were with light density and easily removed by lightweight cleaner like the Gyroclean. Meanwhile heavy stickies have appeared. The required technology is then fine slotted screens, particularly with wedge wire type basket for a compromise between fibre passage and stickies reject. The present situation is that stickies bigger than 1mm in diameter (so called Maxi-stickies) are correctly removed by fine slots. But stickies smaller than that (measured on a lab slotted screen of 0.15 or 0.08mm slots) are not well removed by industrial screens. Such “mini-stickies” are globally transported along the process line and send to the paper machine. (fig 9). This issue will be even more important when water closure ratio is high.

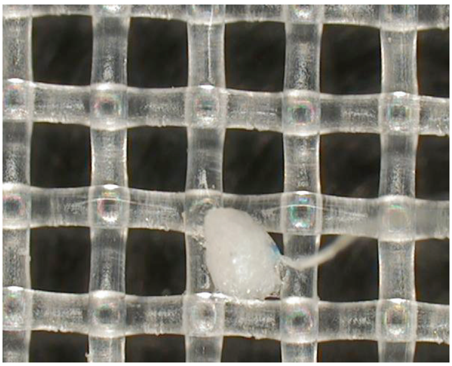


Figure 9: A sticky, small and painful (CTP)

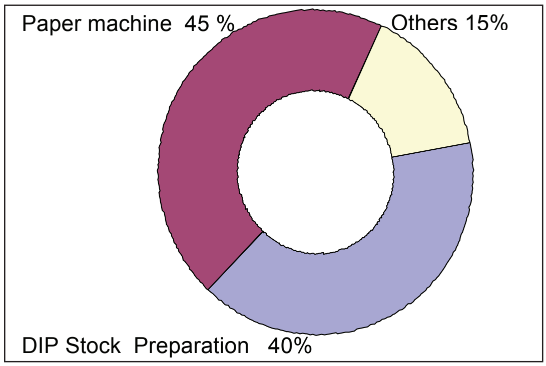


Figure 10: Share of mill energy consumption (kWh/T) for NP DIP

Conclusion

Up to now, it has been possible to find technological answers to the challenges of increasing “contaminant” content and request for high quality recycled stock. But the cost is high when looking:

- at energy consumption in kWh/T (fig 10)
- at production line complexity with 2 or 3 loops and drastic control of process water circulation
- at purchase and discharge cost of undesired elements like ash or fines
- and at the complexity of chemicals recipe introduced in the circuits with limited possibilities to remove it.

Recycling processes will have to be reconsidered as more compact, implementing the best added value on each RCP original component. Today the market is clearly oriented to the question “can we get the quality of virgin fibres from recycled fibres?”. To answer yes, the industry needs complexity and kW.

So, challenges and threats in Paper Recycling are numerous and exciting. There are reasons to be confident in our future, thanks to innovating spirit of our market and leading suppliers. In the future, the number of innovative solutions will increase and more countries will be able to drive the world up.

Future years in recycling processes will be more than ever in hands of innovating companies who know how to anticipate and to develop answers to new challenges and world moves.

Metso Paper Oy

"Limits of paper recycling" in Europe in the next 15 years.

Significant changes have happened during the last 15 years in world politics and economics. Our everyday life has been changed in many areas thanks to development of man's technological knowledge, especially in the area of IT- and communication sectors. In newsprint pages, magazines and books have been described, reported and speculated about the things happening around us. Some of these "documents" have been archived, some documents after fulfilling their task as a information carrier been recycled back to be prepared to do their job again. Business environment for pulp and paper industry has changed dramatically. Growth of unit size of paper manufacturing lines (larger & faster machines, DIP line capacity 300-600 => +1000 tpd) and huge papermaking capacity increase in Far-East area (China especially). There has been major growth of recovered fibre (RCF) utilization in printing and writing grades (major in newsprint grades, but also for SC B and LWC grades), tissue and packaging materials. As utilization of RCF has increased, there has been disturbing variation in availability and cost of RCF. This has caused occasional lack of fibre in certain areas. Inevitably, this has caused also deterioration of the recycled fibre quality. Some of these local and global trends were forecast and some have arisen as a surprise. However, in process language can be said that common for all "events" is that always there has been found "operating window" after voluntary or compulsory, minor or major tuning actions. The transfer from other operating window to another has been most successful in those cases where history and existing knowledge is used to create something new and not used to maintain old.

Depending on the paper grade (news, SC/LWC, fine paper, tissue), quality demand and cost of utilities, it roughly can be estimated that total RCF cost is ~200-300 €/t, mechanical pulp 280-350 €/t and chemical pulp + 500 €/t. RCF has been used and will be used in applications where it is quality and cost-wise justified (investment + operational costs vs. pay-back time). RCF can be either main component in paper furnish as is today for newsprint. Fastest paper machines produce premium quality newsprint from RCF. More and more are searched new applications where RCF is a part of the furnish mix to produce the desired paper quality. Based on discussion with some paper makers the challenge is, that when applying RCF on higher grade printing papers the challenge is to avoid "downgraded" image of printing paper. This requires development work and co-operation throughout the paper making technology chain up to printing house. In paper quality evaluation, focus should be on "quality of printing surface", not in furnish mix.

Cost has been for a long time the main driver in most of the development actions both for paper mills and technology suppliers. Though this trend reduces limited resources to develop new innovations, this focus will remain very probably also in future. The main factor for recycled pulp cost has been recovered fibre itself. RCF cost will be paid second time in reject handling. As the environmental regulations are becoming more and more stringent, new solutions for reject handling and disposal are required. This yields to question, how to ensure the RCF quality in future?

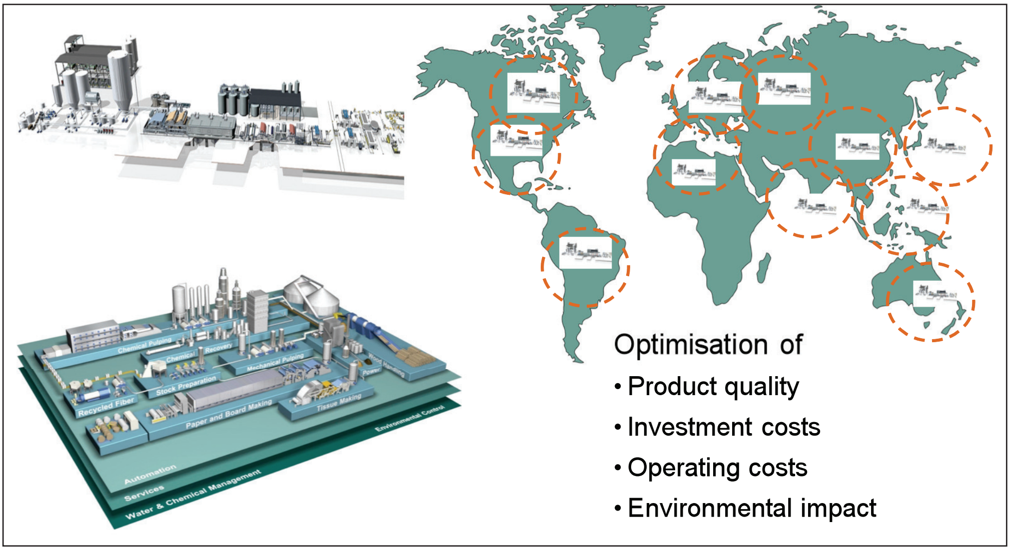


Figure 1: Depending on the markets RCF can be a sole or a part of the furnish components yielding the desired PM/TM/BM paper quality at minimum cost

From a quality and cost optimization point of view, it's obvious that existing RCF classification standards are insufficient. From the mill operational point of view existing classification standards specify very little or nothing at all that is related to paper making potential of specified furnish. RCF system is a "separation process" where impurities are separated from the material (fibre furnish, pigments) suitable for paper making. Tools ("in-mill", "over the fence") for good and stable raw material enable maximum yield with minimum environmental load. Hence, they must be further developed. This means development for waste paper collecting systems and sorting technologies. On the other hand, this creates potential for secondary products (e.g. energy fractions, as studied already in the 90's). This is a kind of version of RCF bio-refinery. There could be also some potential for better utilization of production unit synergies.

During the last 15 years we have seen a change in RCF ash (amount, quality) and fibre content (quality mec/chem, recycling degree), as well as increased load of sticky potential material. All these changes have challenged the target for high yield and affected the economy of RCF pulps. If raw material final ash is fixed (typically newsprint 12-16%, tissue $<$ 4%), then 1% ash removed will cause $\sim$1.3-2% loss in yield depending on the process and tool used to remove ash (flotation, washing).

This change in RCF composition has been a result of an increased recycling rate, but also a change in consumed and recovered paper grades. Changes in paper consumption, especially newsprint consumption and quality demands will definitely have an effect on a whole recycling system and operating window at the mill in future too. There are options to manage the increasing ash load in recycling system. Either filler recycling systems or PM/BM/TM technologies for high yield (increased ash contents) should be further searched. The challenge for filler recycling technology is the low cost of minerals used for paper making. For high ash loaded paper products, better integration of machine chemistry automation is required. A third option is to study further and increase utilization of high yield RCF at paper grades as a partial component. This means that the quality and cost focus must be in head-box instead of RCF storage. Correspondingly, this means optimization of total furnish quality, not partial optimization of one component. Further, this approach would enable a completely new process solutions. About ten years ago a Mid-European paper maker stated that the mills that can combine different fibre sources "in-mill" are in strong position both quality and cost-wise.

A major challenge for technology suppliers is to develop improved/innovative unit process technologies for RCF processing which improve selectivity and yield. Energy consumption will stay as one of the main issues. During the last 15 years major steps have been made in pulping (control of intensity, increased unit capacity), screening (narrow slotts, foils both in LC and MC range), cleaning (MC operation) and dispersion (fillings development for good dispersion and fibre development, reduced energy consumption).

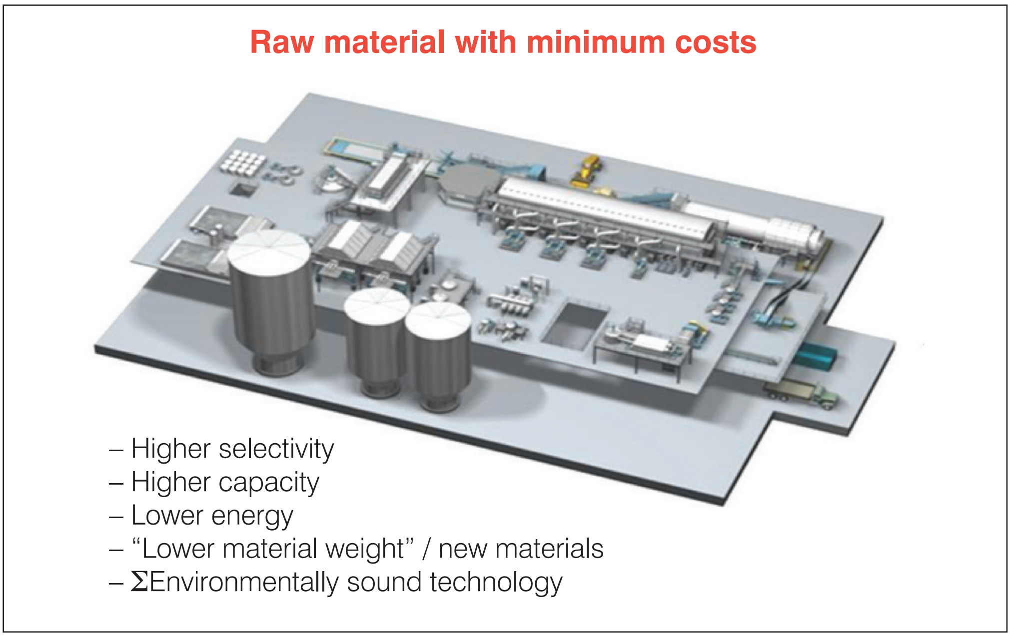


Figure 2: Cost reduction will be major driver for RCF development also in future

Further, work to search solution to decrease investment costs will continue. One road towards this is more simple equipment technologies with high capacity (€/tpd), i.e. larger systems and less equipment. Another road is a search for new lower cost materials which still give required performance in RCF process conditions. New intelligent approaches and combinations of technologies (machinery, chemistry, automation) should be applied instead of "reject recycling". Development of better unit processes and better system integration will enable "simpler" systems, e.g. "advanced" 1-loop systems when applicable.

As a summary the following assumptions can be made about the limits of paper recycling in Europe in the next 15 years.

- Good and stable quality of RCF availability must be ensured in future. This has an effect on RCF manufacturing cost and also the cost/quality of reject disposal:
  - RCF classification standards should be developed;
  - collection systems and/or development in-mill sorting systems.
- Cost reduction of paper making has been and will be driving force for RCF utilization:
  - for standard newsprint grades manufacturing this means aiming for higher yield by better selectivity. Improved unit processes and better integration of chemistry and automation will enable towards more simple process solutions.
  - for higher “eco”-grades key issue is availability of suitable high grade raw material. Unit process efficiency and selectivity must be also improved;
  - for higher grades, search for applicable combination of RCF and mechanical and chemical fibre will give advantages regarding the cost and product quality;
  - close co-operation through-out paper making technology chain up to printing house to specify the required quality of printing-surface.
- As history has shown, there will always be an applicable “operating window” when existing knowledge is used to create something new and not used to maintain old. Definitely, there are several new and also some older technologies and concepts (not been applicable when published) to reviewed and waiting to be applied. From technology point of view there are no seen limits for paper recycling.

Voith

Turning the Old into the New – Opportunities and Limitations of using Recovered Paper

Over the last several years, the use of recovered waste paper in the papermaking industry has steadily increased: Worldwide, the paper industry now has an average reutilization rate of approximately 50 %. At Voith Paper, we are dedicated to raising this average even further. Therefore, we are continually working on new technical innovations to make it a reality. But what can be done to make the use of recovered paper more profitable for quality-conscious paper manufacturers? And where are its limitations?

First of all, we should recognize that enormous regional and national differences exist concerning the use of recovered paper. In Finland for example, the reutilization rate is only 5 %, while in the USA it is 36 % and in Brazil it is 41 % (based on statistics from 2007). Central European countries such as Switzerland and Germany can serve as a role-model with reutilization rates of more than 65 %. In German paper mills for instance, recovered waste paper has now become one of the key raw materials for new paper products. In fact here, our goal for reutilizing waste paper in the cases of packaging papers, cardboard and newsprint has already been reached: With a reutilization rate of 97 % in 2008, these products set a new benchmark for recovered paper. Added to that, even graphic papers are produced with reutilization rates of 47% (2008). The lowest reutilization rates of 28 % are associated with specialized graphic papers. But even here, there have been improvements over recent years: In 2000, these products had reutilization rates of only 18 %.

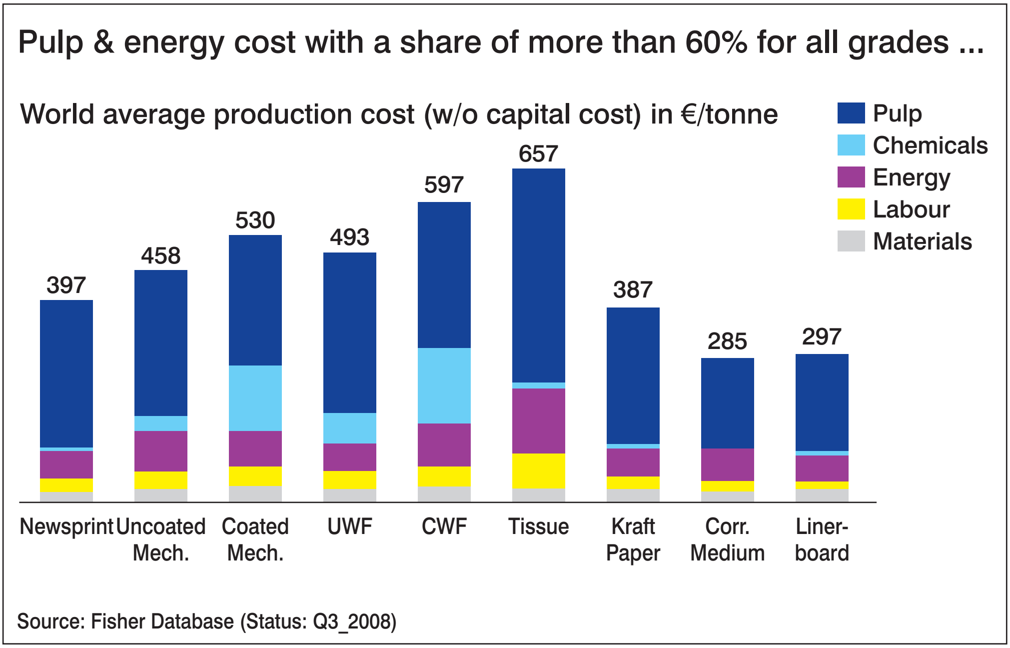
So, how was it possible to improve these reutilization rates so dramatically?

The improvements were due to significantly enhanced processing technologies. Compared to the past, there are, precise sorting machines and advanced fibre processing systems - which not only remove impurities from recovered paper but also optimally process recycled pulp. Voith Paper, as a leading system supplier for the paper industry, invests heavily in research and development to support this field and can now profit from its years of experience. As a result, we can offer the most advanced fibre pulp processing systems, which provide paper mills with the ideal fibre characteristics – such as through our innovative deinking process and combisorting systems. But for the successful use of recovered paper a second factor is important: Namely, the collection of recovered waste paper. Here, the paper manufacturer Steinbeis Temming in Glückstadt, Germany, is a prime example. Steinbeis Temming produces high quality copying paper made from 100 % recovered paper. Besides a new deinking process developed by Voith Paper,,the recovered paper is delivered pre-sorted and graded, which means it has an excellent quality.

Why Use So Much Recovered Paper?

It is well known, that the use of recovered paper pays off for paper manufacturers. Today, especially in the production of newsprint, plenty of paper mills use 100 % recovered paper. In many cases, even magazine grade paper (including uncoated paper and SC B) is often produced using 80 to 100 % recovered paper.

Voith Paper fully supports the increased use of recovered paper due to its many advantages. For manufacturers, cost savings are of course a key advantage. The use of recovered paper generally results in lower expenses for raw material and energy - two cost types which have a large impact on the overall production cost of paper and board producers. The below figure indicates for a number of important major grades that raw material and energy cost account for more than 60% of the production costs. This shows that the use of recovered paper has an impressive effect on the cost situation of the mill.



Beside the economic advantage, the ecological benefit has to be taken into account. Consumers' environmental awareness has strongly risen over the past. This is a key driver for paper consumption and the use of recycled fibres. Using recycled fibre, many grades of paper can be produced more ecologically and sustainably – which are key advantages that the paper industry, particularly the packaging sector, can exploit when competing with other materials. After all, paper is both renewable and recyclable. In some countries - especially in Western Europe – this unique environmental advantage is already a motivating factor for the increased use of recovered paper.

Across the paper industry, our experience shows that the use of recovered paper is indeed a sound investment – despite the special efforts it demands. The conversion of a production line for example, to accommodate the increased use of recovered paper, does represent an economic and technologic challenge for most paper mills. The product quality and productivity of a paper mill may fluctuate dramatically due to the varying finish of the recovered fibres. Often, such fluctuations are due to seasonal changes or long-term trends. One such example are changes in the reading habits across a particular region, which also changes the proportion of newsprint to magazine paper in the local stocks of recovered paper. For paper producers, this is an important production factor: Then, higher percentages of magazine paper significantly rise pigment levels at a paper mill, while the pigment levels for the production of newsprint paper are limited to 25 %. Up to now, this problem can only be solved through the addition of new fibres (TMP).

Quality Is Decisive

Typically, recovered paper stockpiles contain not only raw fibres, but also a wide range of other associated materials such as pigments, fillers and bindings - plus undesired impurities like paints, glue, metal, wood, glass and minerals. However, the decisive factor for the quality of recovered fibres is not only the composition of these associated materials – but the characteristics of the fibres themselves: What are their optical qualities such as whiteness and brightness? What are their mechanical characteristics such as strength and E-modulus? Which structure and chemistry do these fibres possess? And what shape do these fibres have in terms of length, thickness and twist?

The raw fibre found in recovered paper stockpiles may be mixed or well sorted, printed or unprinted. In household collections however, it is always a mixture of newspapers, magazines, packaging, cartons and undesired impurities. As a result, the raw materials need to be sorted – in some cases even by hand.

At this stage however, the collection of recovered paper, Voith Paper now sees the greatest potential for increasing the reutilization rate of recovered paper. That's chiefly because the current quality of recovered paper stocks simply is hardly good enough to produce many higher grades of paper. Plus, the quality of recovered paper stocks also varies greatly between countries, as well as between paper mills. For example, some paper mills use the remainder stock from printing plants – and thereby use recovered paper with a much higher quality than paper mills which depend on recovered paper from household collections.

While the state-of-the-art in paper machinery can without a doubt be further improved and elaborated, we at Voith Paper believe that the paper machine is not the main bottleneck in using recovered paper. Because with modern technologies it is already possible to produce high quality paper from 100 % recovered paper. What we do believe however, is that the real problem occurs long before any paper is even produced: Paper collection systems as well as sorting and processing techniques need to be dramatically improved.

Producing Different Grades of Paper

Viewing recycling from the standpoint of how it is used to produce different grades of paper can be very useful. Because here, significant differences exist in how recovered paper is currently used, as well as what its future potential may be.

Newsprint – in our opinion, offers little potential for increased reutilization rates in Germany or Western Europe. However, at paper mills in other countries there is still a strong potential for increasing the use of recovered paper regarding their technical equipment: For example the reutilization rate in Eastern Europe is only 10 % and in North America 30 %. With modern processing systems, the use of recovered paper could be increased greatly.

Uncoated magazine paper (SC) – in most cases already uses recovered paper as a basis for its production. Prime examples can be seen at numerous paper mills, such as: Schongau 9 (from UPM in Germany), Ettringen 4 and 5 (from Lang Paper in Germany), Maxau 6 (from SE in Germany), Laakirchen 11 (from SCA in Austria) and Steyrermühl 3 (from UPM in Austria). In Schongau and Maxau the production lines even use 100 % recovered paper.

But in these cases, problems can occur when high quality printing (PPS value) is desired, such as with SC A papers. That is because SC papers, which use a high percentage of recovered paper, tend to suffer from black glazing caused by cellulose fibres in the recovered paper. To solve this problem, a way must be found to selectively remove cellulose fibres from the recovered paper to prevent the black glazing effect. In addition, better cleaning systems during pulp processing, as well as the separation of wood-free from wood-based fibres would be required.

High quality, coated magazine paper (LWC) – can also be produced using high percentages of recovered paper – but only if the technical equipment is available and the quality of the recovered paper stock are adequate. For example, at the Leipa paper mill in Schwedt, Germany, almost 100 % recovered paper is used to successfully produce very high quality paper – for Lufthansa Magazine, among others. But here too, these quality differences could be minimized through improved cleaning systems during pulp processing and the separation of wood-free from wood-based fibres. Afterwards, the fibres could be precisely mixed to meet even the strictest requirements.

Uncoated woodfree paper (copying, writing, and printing paper) – is currently being produced by a few paper mills using 100 % recovered paper. With modern machinery and technology, the quality of this paper can be almost identical to papers produced from 100 % primary fibres. However, this also requires the use of well sorted, homogenous, recovered paper stocks. This clearly shows that using a uniform grade of recovered paper is the foundation for producing high quality paper products. And these same requirements are essential for producing wood-free, coated papers (graphic arts papers).

Outlook

To increase the reutilization rate of recovered paper in high quality grades of paper - such as wood-free, coated and uncoated fine papers – the delivered fibres need to be separated, depending upon their optical and structural characteristics. To date however, it has not been possible to separate white from brown fibres, nor old from new fibres (TMP). Nevertheless, Voith Paper will continue its research and development efforts in the field of renewable fibre processing and intensify its work involving recovered waste paper.

Thanks to the successes of the many paper mills, which Voith Paper proudly supports, we believe that our strategy is right - both economically and ecologically. Even for high quality paper, we have proven that high reutilization rates for recovered paper are indeed possible – and at the same time we have shown how they can bring tangible economic advantages to paper mills. In the near future, we expect to see significant new potentials for the use of recovered paper, which may vary depending upon the paper grades produced, the country and the quality of recovered paper in use.

Clearly, the future holds exciting challenges – such as developing individualized concepts for our customer's paper mills, as well as accommodating a wide range of special requirements. And it will be equally exciting to deal with the local regulations which individual countries will no doubt create over time. Because as governments begin to promote the use of recovered paper, they'll also increase the acceptance, as well as the demand for a new generation of paper products – which Voith Paper is helping to create: By turning the old into the new.

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The Limits of Paper Recycling

COST Action E48

The main objective of the Action was to develop scenarios describing the future use of recovered paper within the European paper industry in order to provide a better background for focused research activities in the field as well as to facilitate investment decisions.

The benefits of the Action are the sound base for targeted research, provision of necessary arguments in the discussion with governmental organizations, guidelines for the design of recycle-friendly paper products, guidelines for more effective, tailor-made collection strategies for used paper and a background for investment decisions.

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