POTENTIAL BENEFITS OF RECOVERED PAPER SORTING BY ADVANCED TECHNOLOGY

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Quality is the major prerequisite for extending the use of recovered paper (RP) as a raw material for paper and board manufacturing. Several studies related to furnish quality focus on recovered paper from household collection, which is the main source with potential for further increasing the recycling rates. The first part of the paper analyses the role of household collection for future development of paper recycling and trends of RP quality in Europe. Many studies have demonstrated that an extended household collection is always detrimental to RP quality. Without the adequate actions of all actors from the recycling chain, quality decrease could jeopardize the sustainability of paper recycling. In this context, many researches on the improvement of recovered paper quality are being carried out in Europe. A representative example for this research field is FP7 project – SORT IT (Recovered Paper **SORT**ing with **I**nnovative **T**echnologies), whose objectives of RP quality improvement and expected benefits are analysed briefly in the second part of this paper.

Keywords: recovered paper, recycling rate, recovered paper sorting, sensors, sustainability, life cycle

ROLE OF PAPER RECYCLING IN SUSTAINABILITY OF PAPER INDUSTRY

Eco-cycle of papermaking fibres

The pulp and paper industry has an important part to play in the future of sustainable development in Europe, due to the facts that: [1-3]

- economically, industry generates wealth – €80 billion for the economy and €21 billion in value and wealth creation; also, it employs more than 250000 people and provides indirect employment to 1.8 million people;
- socially, paper plays an important role in the society, providing essential, everyday products that contribute to the quality of our life; it is also an important driver for education, knowledge, democracy and culture;
- environmentally, paper is based on renewable raw materials and stores carbon, thus reducing greenhouse gases; it is produced with more than 50% of renewable energies; paper products can be then recycled, extending their life cycle and minimizing the use of landfill; when they can no longer be used or recycled, it is possible to convert them into a renewable energy source.

All these assets are parts of the virtuous eco-cycle that helps make the paper industry one of the most sustainable in Europe. Figure 1 presents[4] hypothetical recycling loops of a paper mill integrated with a pulp mill (kraft chemical wood pulp production) and a plant for recovered paper processing. The sun drives the eco-cycle of papermaking fibres: with water, nutrients and carbon dioxide, photosynthesis transforms solar energy into wood fibres in growing trees; this endless process means that the forest is a renewable source of raw material that provides wood fibres to produce pulp and paper, and energy as a biofuel; *once consumed*, *most forest-based products start a new life as recycled material or biofuel*. The carbon dioxide released by burning the biofuel is essential for the growth of wood – in this way, the eco-cycle is closed and balanced.

Recycling of used paper and board products is, of course, an important part of the paper industry strive towards full sustainability. In Figure 1, the main recycling loop includes: paper and board (p&b) production, p&b converting, recovering of used p&b products, preparation of recycled fibre pulp by processing of recovered paper (RP) and feeding it in a new production cycle.[5] For the industry, recycling and virgin production are complementary – one could not exist without the other, at least not at the present production volumes in Europe. Recycling helps keep the sourcing of virgin fibres at volumes where forests can be managed sustainably. Virgin fibres are essential in the renewal of the recycling loop, but are also needed for the manufacture of certain paper grades.

Environmental and economic assets of paper and board recycling

Paper and board recycling reduces municipal solid wastes, which would otherwise have to be landfilled or incinerated, thus impacting negatively on the environment.

On the average, in 1995, each European citizen generated 460 kg municipal waste. This amount rose to 520 kg per person by 2004, and a further increase to 680 kg per person is expected by 2020, corresponding to an increase of almost 50% in the following 25 years.[6] In Europe, the content of recovered paper and board in municipal waste decreased substantially in the last decade, but it still represented 20% of the total municipal waste (dry matter). On landfills, where large quantities of recovered paper still end up, the decomposition of paper produces methane, a greenhouse gas with a 21 times higher heat trapping power than that of carbon dioxide. Any increase in greenhouse gas emissions during the manufacture of paper and board from recovered paper is more than outweighed by emission reductions on landfills.[7]

Compared to paper made from virgin fibres, paper made from recovered paper uses less energy, reduces carbon dioxide emission and the volume and loading of effluent.

Energy consumption. Depending on its grade, manufacture of paper may use more or less purchased energy, in the form of fossil fuels, and electricity. Energy is needed to manufacture both virgin paper and recycled paper, but much less energy is needed to produce paper grades from recovered paper. By replacing virgin chemical pulp with recycled fibres in paper manufacture, paper industry accounts for about 28-70% energy savings.[8]

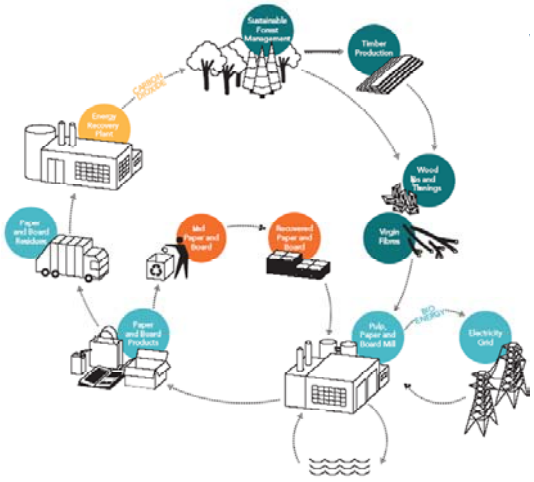

Figure 1: Recovering and recycling loops in an integrated paper mill

Air emission. Carbon dioxide (CO_2) emissions from the pulp, paper and print industry account for 0.7% of the total EU emissions in 2006. Although fuel combustion increased by 32% in the EU countries between 1990 and 2006, the CO_2 emissions increased by only 8% in the same period. This was mainly due to a shift from liquid and solid fuels to gas and biomass.[9] Replacing virgin chemical pulp with pulp made from recovered paper has a positive effect on the reduction of CO_2 emissions in

the paper industry sector. Every ton of pulp made from recovered paper saves 5-6 cubic meters of wood. At the same time, a lower consumption of energy in producing paper from recovered paper pulp results in a considerable reduction of carbon dioxide emissions.

Water emissions. The wastewater volume is a significant environmental measure, as it indicates both the amount of fresh water needed in production and the potential impact of wastewater discharges. In a pulp and paper mill, there are several process water recycling circuits and a common circuit for effluent treatment. Roughly, the volume of effluent is equivalent with the fresh water consumption. On the average, the production of virgin cellulosic fibres from wood requires substantially more water and yields wastewater with significantly higher levels of pollutants than the production of recovered paper pulp. The specific water consumption is lower by 10-30%, and average emissions are considerably reduced when paper is produced from recovered paper by applying the best techniques available.[11] Water emissions in producing recycled pulps depend on the recovered paper grade and processing technology. Generally, the volume and loading of effluent are higher in processing graphic recovered paper grades by deinking.

The manufacturing costs of paper based on recycled fibres are lower, compared to those of virgin fibre paper, for the following reasons: recovered paper prices are lower than those of wood as a raw material for virgin fibre pulp; manufacturing processes request simpler equipment and lower investment costs, consume less energy and water, and have a lower environmental impact.[12]

Due to its low price, recovered paper is a very attractive fibre raw material for paper and board manufacturing. Therefore, until recently, a low manufacturing cost was the most important driving force for substituting virgin pulp with the recycled pulp obtained from recovered paper processing. The benefits of substituting recycled for virgin fibre are generally greater for higher grades (especially for paper made from chemical pulp) than for lower grades, such as newsprint, liner and fluting for corrugated boxes, and hygienic paper. Actually, the use of recycled fibre pulp in producing high grades is limited to about 10%, the main causes of this limitation being the high quality demand for fibre pulp quality and the quality decrease of the recovered paper available for recycling.[13]

Limits of paper recycling and further development

The theoretical limit of paper and board (p&b) recycling rate is around 81%, since 19% of the paper products are not collectable or recyclable for technical reasons.[13] A study performed in the framework of COST Action E48 – "Limits of Paper Recycling"[14] estimated the maximum limit of p&b recycling rate in Europe at 75%. An increase of the p&b recycling rate from the actual level – from about 66% to 75% – will be progressively more difficult because:

- developed countries with high consumption *per capita* and high environmental consciousness reached a collection rate of 72-74.5%, close to the maximal limit;[14]
- recovered paper quality decreases as the collection rate continues to increase;[15,16]
- all easy sources (industry and trade) have been tapped, an increase in recycling being possible from small sources, with high spreading and contamination, mainly from household collection.[17,18]

At a European level, a rough estimation of the different sources indicates that 50% of the recovered paper is collected from industry and trade, 40% from households and 10% from offices,[19] although these percentages can differ greatly among countries, as well as the collection systems employed. The first, high quality and easily collectable sources are well-exploited. The future potential for a collection increase clearly lies in households.

The diagrams in Figure 2 evidence[20] an increasing trend in the export of recovered paper and it appears less probable that this trend will change, due to the high demand of the Far East countries, some of which depend largely upon recovered p&b imports, in the absence of fibre resources of their own. Furthermore, an increasing competition for the utilisation of used/recovered p&b for non-papermaking purposes was noticed. The obvious impacts of these developments *are increasing prices and deteriorating qualities of recovered p&b*, but there have been no severe bottlenecks in supply yet. Thus, a further increase in recovered paper supply to European paper mills could come mainly

from "other recycling/recovery and final disposal", by increasing and improving household collection. The revised Waste Directive created the framework for making this happen by setting an obligation to collect recyclables separately and by prioritizing recycling over incineration.[21]

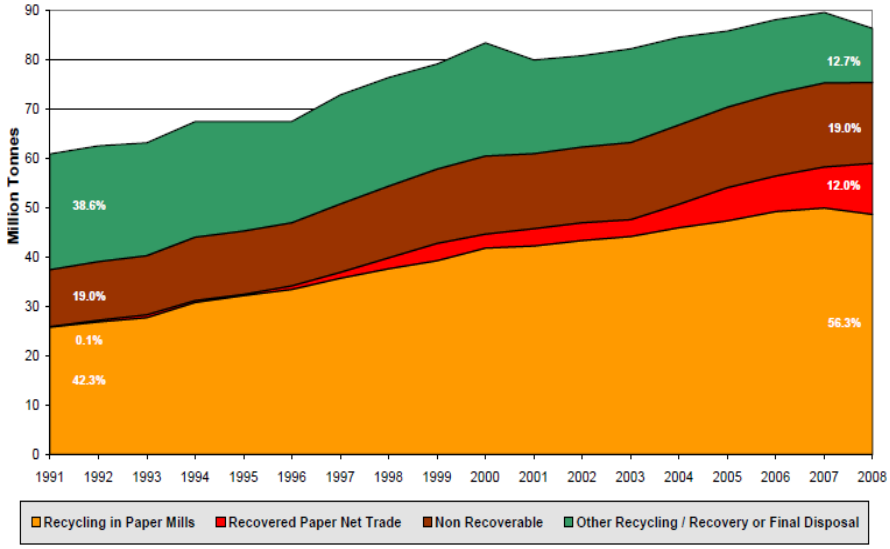

Figure 2: The routes of paper and board consumed in CEPI countries

NEEDS AND BENEFITS OF RECOVERED PAPER SORTING

Trends of recovered paper quality and its impact on recycling sustainability

Quality of recovered paper from household collection

EN 643 defines the quality of the recovered paper and board grades most commonly traded in Europe. The quality of recovered papers and boards is defined by: moisture content, unusable material content (including non-paper components and paper and board detrimental to production) and the possible variety of papers entering their composition.[22] Unusable materials consist in "non-paper components and paper and board detrimental to production". The standard specifies that, in principle, recovered paper and board should be supplied free of unusable materials, for specific grades, a certain proportion of unusable materials being agreed upon by purchaser and supplier – referred solely to elements described as "paper and board detrimental to production".

Quality is the major prerequisite for extending the use of recovered paper as a raw material, and the major threat – if sufficient quality cannot be assured. A considerable amount of research related to furnish quality is carried out in Europe, most of it focusing on the recovered paper from household collection. However, it is generally accepted that an extended recovered paper collection from households is always detrimental to recovered paper quality and many studies support this conclusion. A survey on the influence of various household collection systems on recovered paper quality in the Netherlands concluded[23] that the total non-paper components content of household recovered paper rose from 3.26% in 2003 to 3.89% in 2007.

The main products of household separate collection are mixed recovered paper (RP) grades, usually grades 1.01 and 1.02, which are described in EN 643 as follows:[22] grade 1.01 – provided directly by selective collection, consists of mixed paper and board, unsorted, with unusable materials removed; grade 1.02 – mixed papers and boards of various qualities (sorted) containing a maximum of 40% newspapers and magazines. Currently, grades 1.01 and 1.02 contain more than 50% graphic papers (newsprint, magazines and other graphic papers), and an important fraction of packaging paper and board.[24-26] Both grades are characterized by a large variation of the graphic/packaging ratio, as well as by a high content of unusable components.

The recovered paper quality is defined in relationship with its origin (industry, trade, offices and households) and with its

utilization in producing different paper grades (graphic, packaging, household and sanitary, others). As a function of their utilization, the different recovered paper grades could be grouped into: deinking RP grades – for the production of graphic papers and household and sanitary papers; packaging RP grades – for the production of case materials (corrugated board components), boxboard and other packaging paper and board.

Generally, mixed grades (1.01, 1.02) are sorted to obtain more homogenous and higher quality grades (deinking grade 1.11 and packaging grade 1.04), traded at higher prices. Unfortunately, today's sorting technologies cannot overcome the low and variable quality of recovered paper input. As documented below, the trend of quality decrease for mixed grades is translated into both deinking and packaging grades obtained by mixed grades sorting.

Quality trends of deinking grade 1.11

EN 643 definition: *sorted graphic paper for deinking from households, newspapers and magazines, each at a minimum of 40%*; *the percentage of non-deinkable paper and board should be reduced over time to a maximum level of 1.5%*; *the actual percentage is to be negotiated between buyer and seller*.

A study[27] carried out by ASPAPEL (Spanish Association of Pulp and Paper Manufacturers) and REPACAR (Spanish Association of Recovered Paper Dealers) on the quality of recovered paper grade 1.11 has shown the following: the average total of unwanted materials is around 7.28%, of which 6.14% are paper and board detrimental to production and 1.14% is non-paper; more than 80% of the paper and board detrimental to production (non-deinkable) represent grey and brown board; the board from the total of unwanted materials is made up by around 40% brown board, 30% grey board and 30% other boards. The main conclusion of the study is that selective collection has increased very rapidly in Spain in the last years, while RP quality has declined: in 2005 and 2006, the average total of unwanted materials was between 5-6% while, in 2007 and 2008, it increased up to 7-8%. Large variations of the grade 1.11 quality have been recorded at Holmen Paper Mill in Madrid in the last years, resulting in difficulties in optimizing the runnability of deinking lines and the efficiency of the whole recycling process.[28]

The quality decrease of grade 1.11 was confirmed by a study concerning the Ingede Member Countries, where similar average contents of unusable materials, but a larger variation range, were reported.[29] The study evidenced the following quality trends: increasing content of unusable material, unusable material consisting mainly in non-deinkable p&b, grey and brown board (OCC) representing more than 80% of the non-deinkable p&b content.

Quality trends of grade 1.04

EN 643 definition: *supermarket corrugated paper and board*; *used paper and board packaging, containing a minimum of 70% corrugated board, the rest being solid board and wrapping papers*.

In Germany, a study[24] on recovered paper grades for packaging has shown that commercial grade 1.04 supplied to paper mills can include recovered paper from a single source (supermarket, household sorting) or from many other sources – supermarket, other trades and household (sorting of mixed grades). For this reason, the quality of grade 1.04 may vary within large limits, as a function of the source and collection system.

Several studies of the SORT IT project[30] evidenced the following composition ranges for grade 1.04: non-paper components from 1.5 to 3%; non-recyclable paper and board from 3 to 6%; graphic papers from 5 to 30%, which does not correspond to the grade definition; corrugated board from 40 to 75%. The following quality trends of packaging grade 1.04 were noticed: increasing content of graphic papers; graphic papers consisting mainly of newspapers and magazines, but also of some office papers, which leads to high contents of mineral fillers (ash) and short fibres (hardwood and mechanical pulps); an increasing content of non-paper components, mainly plastic materials.

Impact of RP quality on paper recycling sustainability

The quality of the recovered paper grades supplied to paper mills impacts the sustainability of paper recycling by influencing different parts of the paper recycling chain, mainly the processes, resources, consumption and emissions in the paper mill. There is always a certain level of

recovered paper contamination, but it has to remain between the accepted limits, which depend on the produced paper grade and technological level of the paper mill. This limitation is due to the fact that the use of recovered paper as a raw material involves a complex process with multiple stages for the treatment of recovered paper, to separate and eliminate the contaminants and, finally, to obtain recycled pulp of constant quality. A global view on recovered paper processing is presented[30] in Figure 3. Essentially, recovered paper processing involves a multi-stage decontamination system, operating at various intensities, dictated by the paper grade produced and by the grade and quality of the recovered paper.

Various solid wastes (rejects and sludge) with different composition are eliminated in each stages of recovered paper processing, for obtaining the requested quality of recycled pulp. The total amount of rejects and sludge determines the processing yield, which is directly related to the quality of the recovered paper. If the papermaker decides to maintain a constant level of yield, the quality of the final recycled pulp will decrease with the increase of recovered paper contamination. Instead, if he decides to maintain the cleanliness of the recycled pulp, he has to decrease the yield. For a given quality of recovered paper, a higher cleanness level of recycled pulp means a lower yield of recovered paper processing and higher fibre losses with rejects and sludge. For example, if the contamination level of the RP stock entering the screening plant is of 4%, the total rejects could be of 8-10% (on dry basis) or higher.

The low quality of recovered paper and, respectively, the high volume of solid waste generated in recovered paper processing and/or low quality of recycled pulp, represent a serious problem for papermakers, from both economic and environmental points of view:

- *the low yield* of recovered paper processing (ratio between recycled fibre flow to paper machine and recovered paper flow in the processing plant) results in: direct economic impact, due to the increase of fibre raw material cost per ton of recycled paper; environmental impact, associated with increases in the wet waste volume generated in RP processing, as well as with energy consumption for wet waste management, as a function of the end-of-life solution selected;
- *the low quality of recycled pulp*, associated with the increase in the content of short fibres, ash and stickies, originating from recovered paper contamination, can produce: economic impact, due higher costs of energy, chemicals or virgin fibres necessary to keep the quality of the end product constant; environmental impact, due to the higher energy and water consumption and associated emissions.

Improvement of recovered paper quality by advanced sorting

Current status of recovered paper sorting

The non-paper contaminants and non-recyclables derive from converting/printing processes and utilisation of paper products. Hence, they are to be considered as to the collection of secondary raw material. The method of collecting has a direct impact on recovered paper quality. At present, it is recognized that there is no optimal collection system that can be considered as universal, because it depends on social and economic factors, different at regional and even local level. That is why, the recovery strategy has to include a sorting process, allowing the separation of the different components of recovered paper and its classification as EN 643 grades.

Sorting is the very first stage after collection, when non-paper, paper and board that are non-recyclable or unsuitable for the grade have to be removed. Practically, the method and intensity of sorting determine the quality (the type and content of different contaminants) of the recovered paper supplied to the paper mill. The main aims of sorting are: reduction of the content of unusable materials in recovered paper and increased homogeneity of the raw material supplied to recycling in the paper mill; provision of tailor-made recovered paper grades for the best possible re-use in paper and board products.

Basically, three main sorting strategies are in use: manual, semi-automatic and automatic. Despite the new technological developments, sorting of recovered paper in Europe continues to be mainly a manual, labor-intensive process, requiring only an inclined conveyor and a speed-adjustable sorting belt.[31] Generally, statistical data on this topic are lacking. However, a rough estimation of how much of the collected paper and board in Europe is sorted is based on specific questionnaires addressed to

representatives of the countries participating at the SORT IT project.[32] The results have shown that only 41.8% of the recovered paper consumption in SORT IT countries is sorted and, like in other references,[15,31,33] manual sorting is confirmed as dominant (Fig. 4).

In the survey on the general parameters influencing the future competitiveness of paper recycling in Europe, the partners of COST Action E48 were asked to rank the importance of different means in improving paper collection efficiency in their country. The general results, expressed as average levels of 19 countries, show[15] that advanced sorting of recovered paper is, after the collection system, the second most important area for extending the limits of paper recycling in European countries (Fig. 5).

Benefits of advanced sorting

Concept and objectives of advanced sorting technology (SORT IT project)

Previous analysis leads to the conclusion that better sorting could increase the effectiveness of recovered paper use in the paper and board manufacture. However, studies have shown that the sorting costs and the lack of advanced sorting technology are important obstacles to more intense sorting.[34,35] The project SORT IT (Recovered Paper **SORT**ing with **I**nnovative **T**echnologies, FP7, Theme Env. 2007.3.1.3.2.) is an example of the researches initiated at a European level, aiming at overcoming such obstacles.

The concept of new sorting technology is based on the development of new and improved sensors and new physical separation devices – such as robots. New sensors are concerning an extended wave range of near infrared spectroscopy, image analysis and color measurement, which enable the introduction of new sorting criteria based on the chemical composition of papers.[36]

The purity and quality of the fibrous raw materials have a significant influence on the economy and eco-efficiency of recycling. In this respect, the main objective of the SORT IT project is to enable sustainable and cost effective paper recovery from separate collection streams with a yield of ≥95% and purity ≥98% in wanted materials.

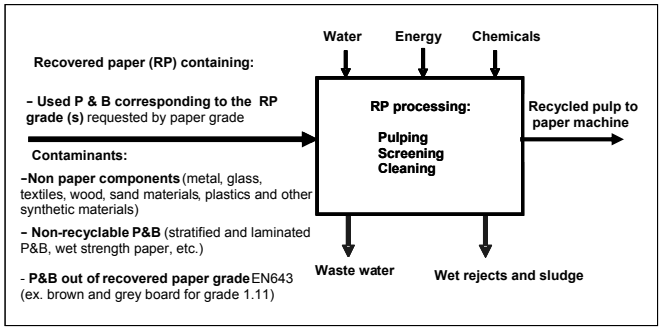

Figure 3: Inputs and outputs of the recovered paper processing system

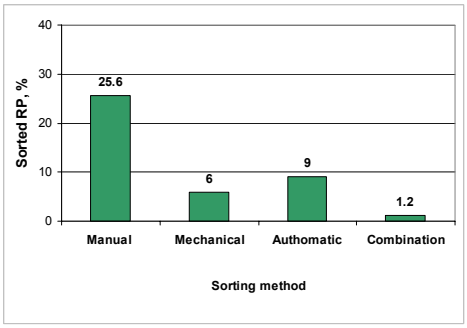

Figure 4: Distribution of recovered paper volume, processed by different sorting methods

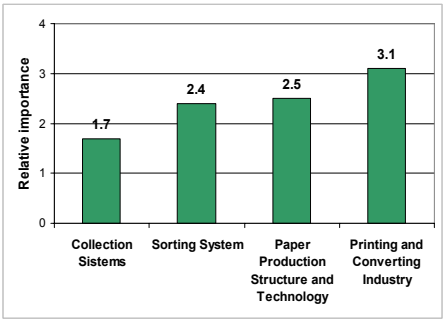

Figure 5: Average relative value of influence factors for extending the limits of paper recycling (values between 1 – the most important and 4 – the least important)

Background for evaluating benefits of the new sorting technology

The new sorting technology will be evaluated at an industrial scale for both packaging and deinking recovered paper grades. Full-scale trials will include two cases for producing and recycling recovered paper (RP): producing of RP grade 1.11 and its recycling in the newsprint paper mill; producing grade RP 1.04 and its recycling in the packaging paper mill. The environmental, economic and social impact of the reference (current technology) and innovative sorting technology will be evaluated by applying the principles of Life Cycle Assessment (LCA). In this respect, the first step of LCA study was to define reference and new technology systems that will allow the assessment of their changes as to the environmental and economic behaviour. Figures 6 and 7 show simplified flow diagrams of the current technology for producing newsprint and, respectively, packaging paper from 100% recycled fibres.

In the case of packaging production, current sorting consists mainly in the removal of non-paper contaminants, relatively large pieces of metal, textiles, plastics, glass, etc. For this reason, most of the unusable paper and board (liquid packages, laminated board, etc.), as well as graphic papers (paper and board not corresponding to grade definition) are transported to the paper mill, where they will be separated in the processing plant. In the case of newsprint production, current sorting is a little more advanced and important parts of brown paper and board are separated as grades 1.04 and 1.02. However, previous analysis has shown that grade 1.11 contains 4-7% of non-deinkable paper and board.

The main indicators characterizing the effectiveness of sorting are: *sorting yield* → the ratio of the amount of wanted material in "accept" to the amount of wanted material in input; *recovered paper purity* → the ratio of the amount of wanted material in "accept" to "total accept". The scheme of Figure 8 defines the yield and purity for sorting of mixed recovered paper (grade 1.01) to obtain grades 1.11 and 1.04 (case studies of the SORT IT project). Grade 1.02 is not defined in this scheme because it is a mixed grade whose composition depends on the yield and purity of the main streams (1.11 and 1.04). Current sorting is characterized by low yield in the wanted material (for packaging paper in grade 1.04; for graphic papers in grade 1.11) and low purity of "accept" (high content of non-paper components and graphic papers in grade 1.04; high content of brown packaging papers in grade 1.11).

Figure 9 presents the flow diagrams for a new sorting technology, connected with both paper production systems. An advanced sorting system will achieve a better separation of non-usable materials (non-paper components: plastics, metals, glass, textiles, synthetic paper etc.; paper and board detrimental to production – wet-strength papers, laminated papers, plastic coated papers, etc.) before entering the paper mill, as well as more accurate classification of the recovered paper grades (separation of paper and board not corresponding to grade definition).

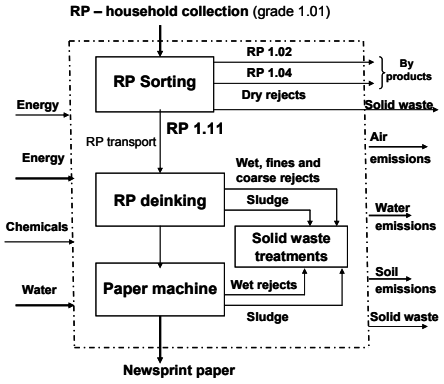

Figure 6: Flow diagram for newsprint paper production of 100% RP grade 1.11 – current sorting

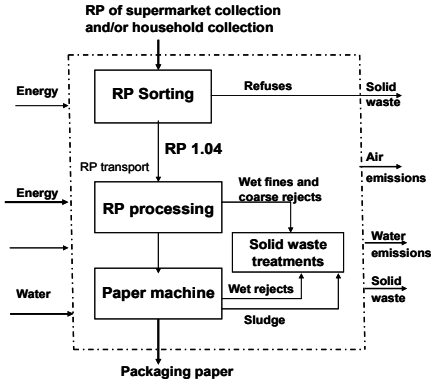

Figure 7: Flow diagram for packaging paper production of 100% RP grade 1.04 – current sorting

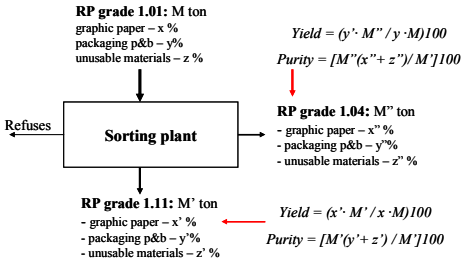

Figure 8: Model for calculating sorting indicators (sorting of mixed RP grade 1.01)

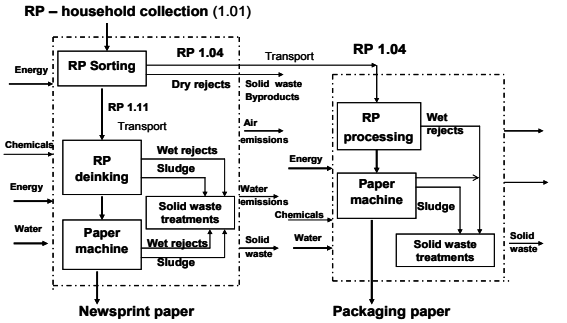

Figure 9: Flow diagrams for production lines of newsprint and packaging paper based on 100% RP, grades 1.11 and 1.04, obtained with new sorting technology from household collection (grade 1.01)

The better identification and separation of recovered paper components will result in an increased yield (≥95%) and purity (≥98%) of both main streams (grade 1.11 and 1.04) and will eliminate the secondary stream of grade 1.02. These improvements, resulting in several benefits along the paper and board recycling chain, will be briefly commented below.

Expected benefits from the innovative technology at the sorting plant

- Advanced sorting will achieve a high yield of wanted material and a high purity of each recovered paper grade, which will contribute to a *better exploitation of recovered paper resources and an increase of the recycling rate.* Current sorting of household collected paper and board (grade 1.01) produces a low yield and low purity for both grades, which means: RP grade 1.11 will contain packaging paper and board, grade 1.04 will contain graphic paper, both grades presenting a relatively high content of non-recyclable materials. Besides an inadequate quality of basic grades, an important amount of good fibres from graphic and packaging paper ends up in grade 1.02, used for inferior grades of board.
- The new technology will achieve constant sorting parameters and automated quality control of recovered paper. These achievements will prevent loading rejects and related costs and environmental impact, contributing to the improvement of the company profile.
- Comparatively with manual and mechanical sorting, the automatic sorting plant provides a better working environment and needs a smaller number of qualified personnel, which could contribute to lower costs and improved social relationships.
- The new sorting system is designed to separate different fractions of rejects, such as: plastics, unwanted paper and board, metals and a mixture of unusable materials as final rejects. This will allow *better solutions for exploiting rejects and minimizing waste stream*, since contaminants will be in a dry state and gathered in a high amount at the sorting place.

Expected benefits from the innovative sorting technology at the paper mill

A high purity of sorted recovered paper means less unusable material delivered to the paper mill, which results in direct and indirect benefits.

- Direct benefits comprise the *reduction of transport costs and related emissions*, as well as of *the costs with fibre raw material* (the paper mill pays unusable material at the price for recovered paper).
- A part of indirect benefits are related to the volume of contaminants to be eliminated in the processing plant as rejects and sludge. A lower amount of unusable material in the recovered paper fed to the processing plant means lower amounts of rejects and sludge, which could lead to the following benefits:
  - *reduction of fibre loss* since, in wet processing, a part of the fibres are loosed by contaminants, generally the amount of rejects separated in RP processing being 2-3 times higher than the contents of contaminants in recovered paper;
  - *reduction of energy consumption and handling costs for wet waste management* (wet rejects and sludge need treatments to reduce the water content before their use or disposal, which involves energy consumption, transport, etc.);

▪ *higher effectiveness of RP processing plants* – recovered paper processing plants are complex, involving various unit equipments, their practical design aiming at operating at various decontamination intensities, which allows to take off the fluctuations of RP quality and to obtain the requested quality of recycled pulp. Uniform and better quality of recovered paper can improve the effectiveness by reducing the energy and deinking chemicals consumption and costs for equipment maintenance.

● Other indirect benefits could result from the improved and uniform quality of recycled pulp fed to the paper machine. The new sorting technology aims at removing all non-paper contaminants and most of unusable papers, and at providing the quality control of recovered paper composition by the demand of the paper mill. This will result in a more uniform quality of the recycled pulp, which can lead to:

▪ *reduction of papermaking chemicals consumption*, mainly strength additives for packaging paper and shade/optical dyes for deinking grades;

▪ *better runnability of the paper machine*, which involves energy reduction and higher productivity. Low and, especially, variable quality of recovered paper leads to variable quality of recycled pulp obtained in the processing plant. This variability, transferred to the paper machine, could result in paper sheet breaks and production loss, lower quality of end products and their downgrading.

CONCLUSIONS

Recovered paper and board is a very important fibre raw material of the European paper industry; with a 66.6% recycling rate achieved in 2008, Europe was breaking world record levels of paper recycling. However, a further increase of recovered paper supply to European paper mills could come mainly from household collection, as the industrial sources of good quality have already been tapped.

Many studies have evidenced a clear trend towards a higher contamination of recovered paper grades, resulting from sorting mixed recovered paper grades from household collection. The most important trends are an increasing packaging paper content in deinking RP grade 1.11 and an increasing graphic paper and non-paper components content in packaging RP grade 1.04.

Grade classification and definition of recovered paper quality are achieved by sorting. However, only about 50% of the recovered paper consumption in Europe is sorted, manual sorting being the dominant method used. In this context, researches related to quality improvement of recovered paper focus mainly on new automated sorting technologies and online quality control.

The research project SORT IT aims at developing an automatic sorting technology that will allow sustainable and cost-effective paper recovery from separate collection streams with a yield of ≥95% and a purity of ≥98% in wanted materials.

The implementation of the new sorting technology will result in several benefits along the paper and board recycling chain:

● at the sorting plant, the main benefits include: a better exploitation of recovered paper resources and an increase of recycling rate; prevention of loading rejects involving additional costs for two-way transport and related environmental impact; improvement of working environment, use of more qualified personnel, yet at lower costs, due to a drastic reduction of personnel number; better exploitation of rejects and minimization of waste disposal;

● at the sorting mill, the main benefits comprise: reduction of costs with fibre raw material, due to fewer contaminants paid as recovered paper and to the reduction of fibre losses with rejects and sludge; reduced energy consumption and handling costs for wet waste management; higher effectiveness of RP processing plant, resulting in energy and deinking chemicals reduction; improvement in the quality and uniformity of recycled pulp, resulting in the reduction of papermaking chemicals consumption and better runnability of the paper machine.

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