The flow of paper in Germany

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1 Introduction

During the last fifteen years, Germany has experienced considerable changes in the sector of paper production. New legislative regulations such as the Packaging Ordinance, the voluntary agreement concluded between the graphical paper producers, processors and printing firms, and the state executive as well as technological progress with regard to recovered paper processing, de-inking and waste management have provided the main reasons for this.

2 Paper production and consumption

Under the order of the German Association of the Paper Industry (VDP), a model depicting the mass flow of paper throughout all stages of manufacturing, consumption and recovery had been elaborated by the company INTECUS for the old federal states in 1990 [1]. Starting from the year 1992, this model has been annually updated with the data for the whole country.

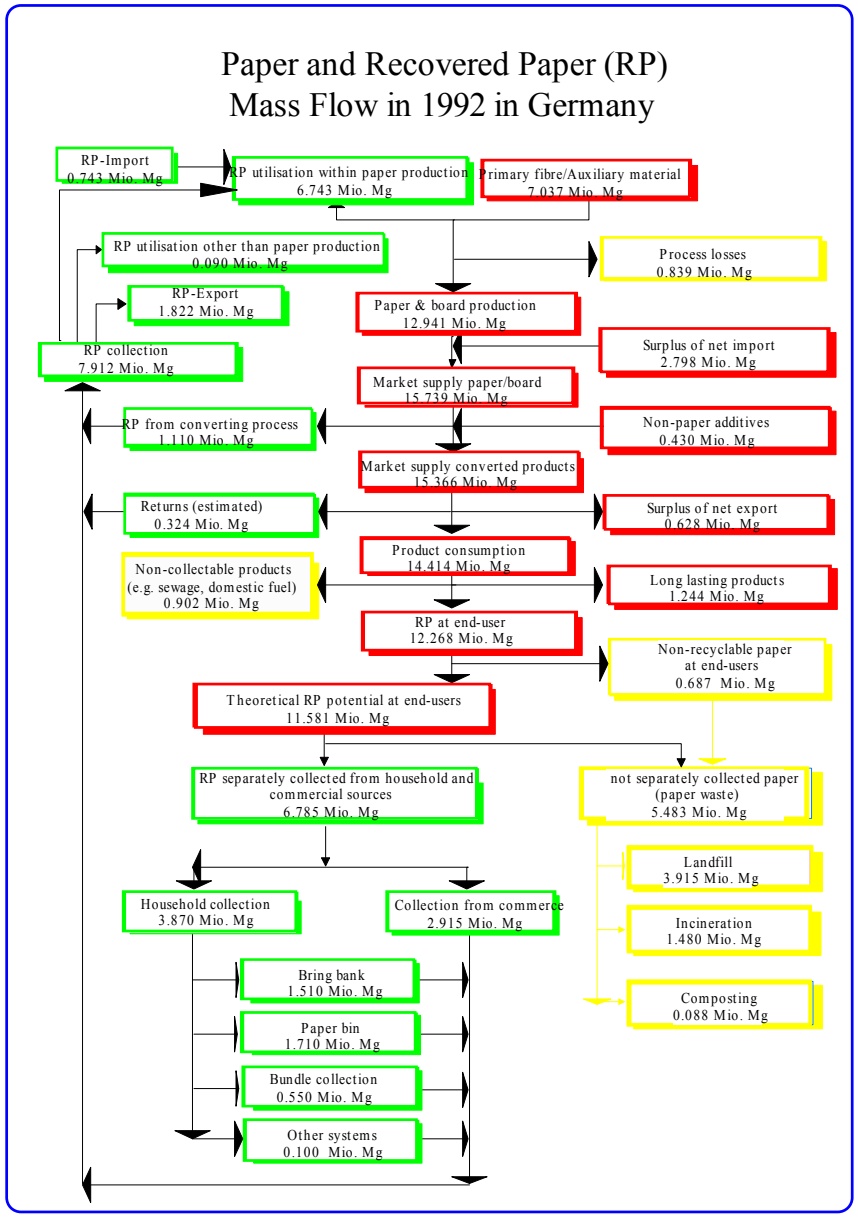
Fig. 1 shows the data of this balance for the years 1992 and 2003.

After a total production of 12.941 million Mg paper and cardboard in 1992, German paper production reached the amount of 19.310 million Mg in 2003. In comparison of the two balances shown in Fig. 1 certain developments can be noted. The market supply of paper and cardboard in the year 1992 came to 15.739 million Mg because of surplus imports amounting to 2.798 million Mg or 21.6 % of total domestic production. In the year 2003, Germany had for the second time after 2002 a surplus export of 0.484 million Mg. This means that over the years, the domestic market became independent from foreign supplies of paper and cardboard.

A look onto the entire paper flow shows that the successful exploitation of the used paper potential from German households and commerce is one of the main reasons for this achievement. While 6.785 million Mg or 55.3 % of the paper available at the place of the end users had been collected in 1992, this amount increased to 12.174 million Mg or 79.1 % of the used paper potential in the year 2003.

Waste disposal in 1992 still included 5.483 million Mg used paper, an amount that went down to 3.208 million Mg till the year 2003. In relation to the total quantity at the place of the end users this means a reduction of the paper disposed of as waste from 44.7 % to 20.9 % within the period 1992 to 2003.

In Fig. 2 the development of the collected recovered paper quantity from households and commercial sources is summed up and set into relation to the total used paper potential at the place of the end users. Through these figures the meaning of recovered paper collection as a raw material source for the paper industry becomes very evident.



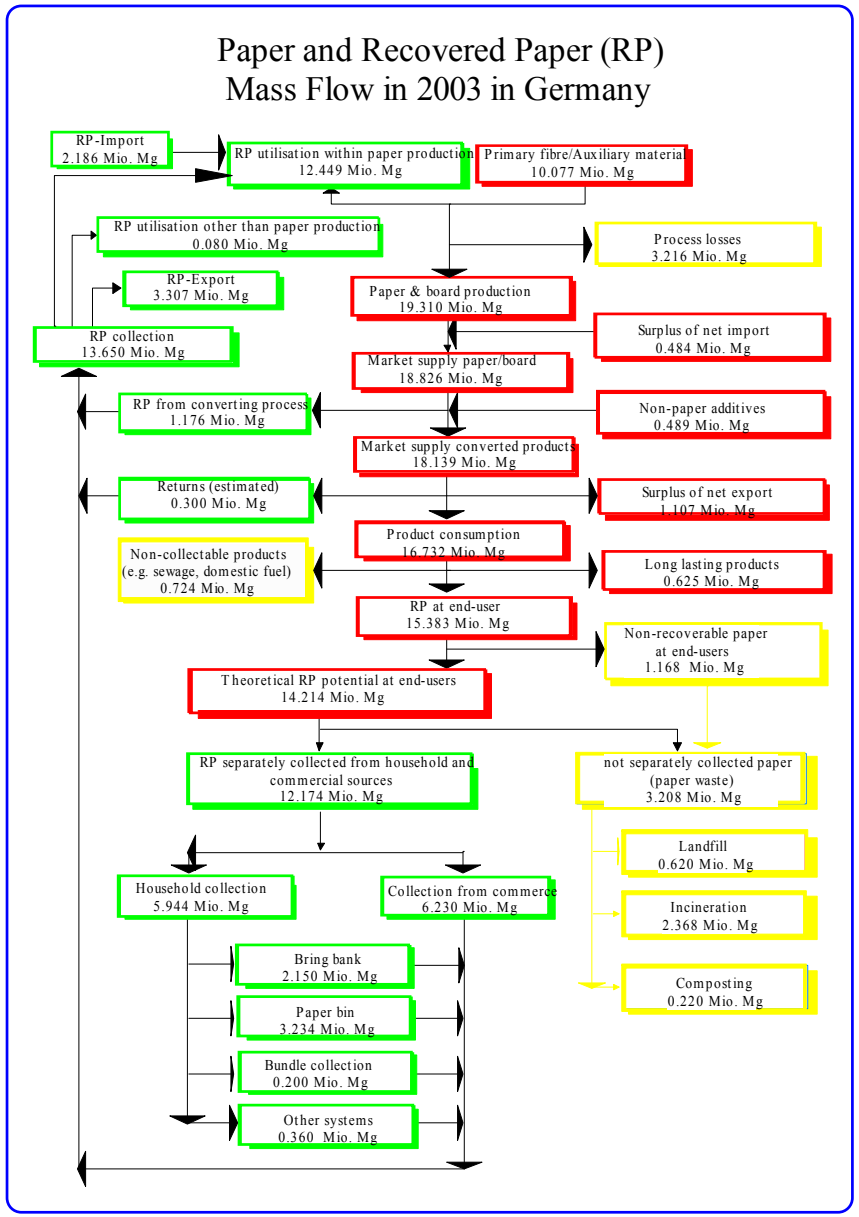


Fig. 1: Paper mass flow for Germany in the years 1992 and 2003

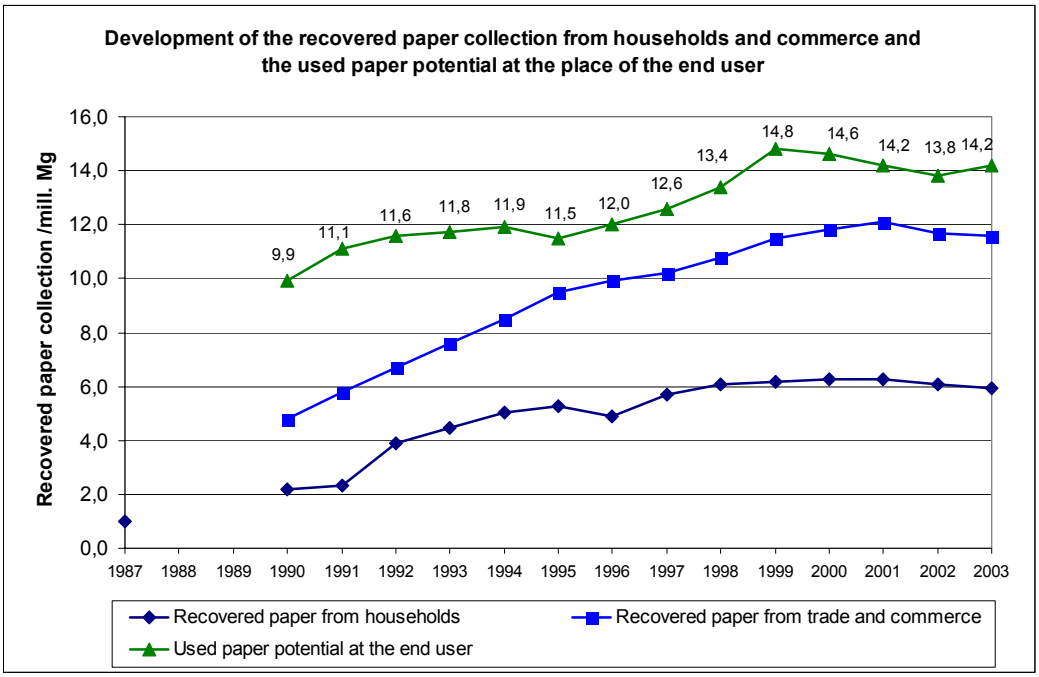


Fig. 2: Development of the recovered paper collection in a cumulative illustration of the shares from household and commercial sources in relation to the total used paper potential [3]

2.1 Paper and cardboard for packaging

With a totally produced quantity of 4.6 million Mg and a market supply of 6.08 million Mg, packaging grades have formed the second largest product group in 1992 while their manufacturing was done to 94.6 % from recovered paper (**Fig. 3**). Packaging grades still hold the second position of the product groups in 2003, total production however increased to 7.481 million Mg, while 7.658 million Mg were supplied to the market and the rate of recovered paper utilisation in production came to 93.2 %. What can be noted here is that in the period from 1992 to 2003 the total production of packaging grades grew by the factor 1.63 whereas the overall paper production had increased by the factor 1.49 only.

The net import has no significant meaning for the market supply with packaging products any longer. The resulting consumption of paper packaging in the country has thus come to the amount of 5.613 mill. Mg in 1992 and 7.004 mill. Mg in the year 2003. Reducing these amounts by the quantity of long-life products (as net amount) gives a total of used packaging paper at the place of the end users of 5.449 mill. Mg in 1992 and 6.916 mill. Mg in 2003, respectively. In the market segment of packaging paper these amounts equal to the total potential of used packaging paper available for collection from the end users in the respective years. From this potential 3.524 mill. Mg have actually been collected as recovered paper in the year 1992 and 5.734 mill. Mg in 2003. Disposed of via the waste collection were 1.926 mill. Mg in 1992 and 1.182 mill. Mg in the year 2003.

Additional amounts of paper come from the processing of the packaging paper and board and get almost completely returned into the manufacturing of paper and board products. In proportion to the total quantity of recovered paper utilised for paper production this gives a rate of return of 92 %. The corresponding amount remains permanently in the process circle of paper production, consumption and recovered paper utilisation, the so-called paper loop. About 10 % from the recovered paper utilised for paper production belong to the category of higher grades (e.g. graphical papers) which are, similar to primary fibres, needed as a reviver in the paper loop.

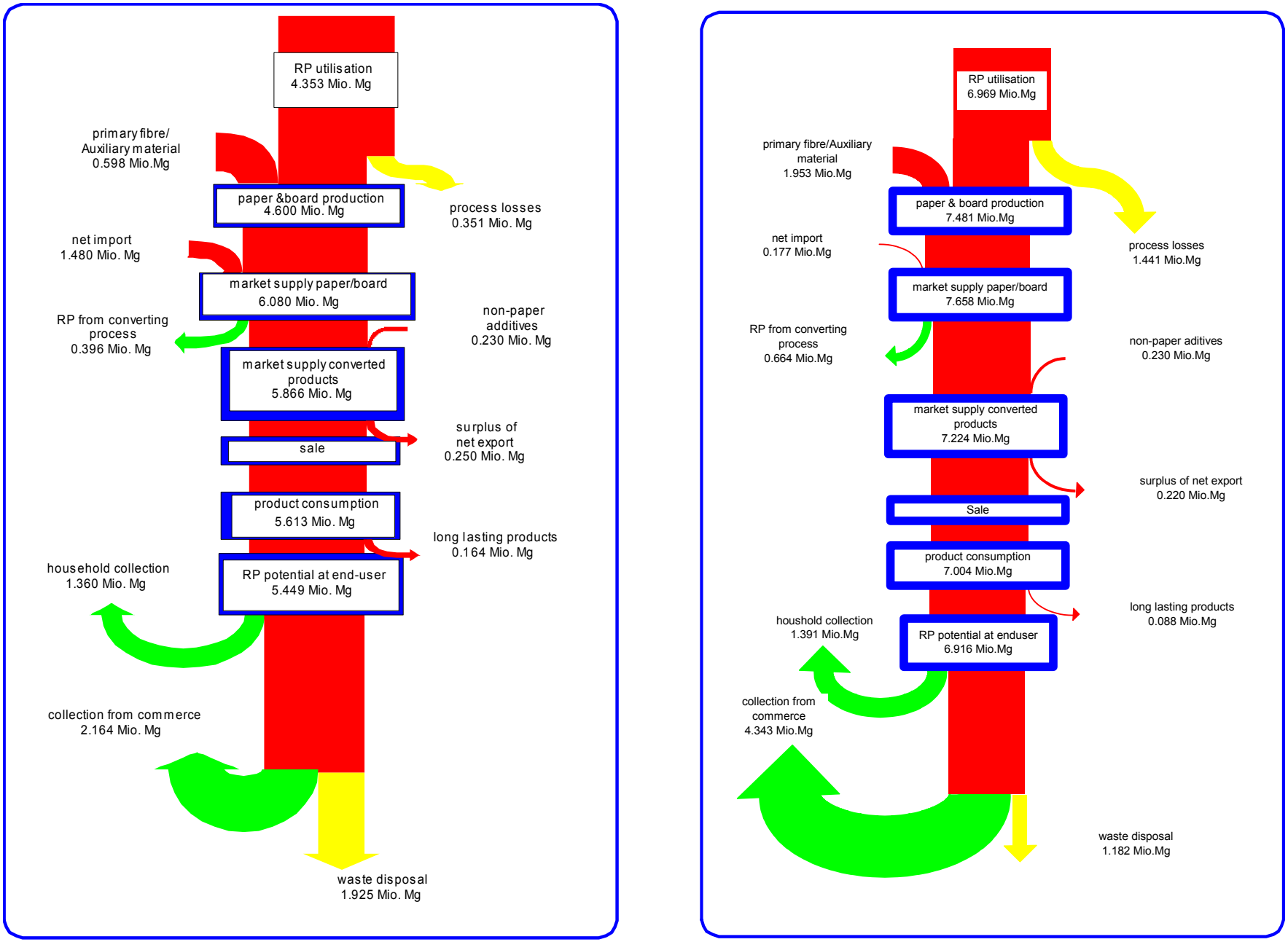


Fig. 3: Mass flow diagram for the product group of paper and board for packaging purposes in the years 1992 and 2003 [3].

2.2 Graphical papers

The product group of graphical papers is divided into the two main product grades of printing and writing papers, and administrative forms and office papers. Within the frame of the updating of definitions and data which has been taking place for many years now, it is possible to provide the amount of graphical papers only in the total sum.

For the production of 6.3 mill. Mg graphical papers in the year 1992, mainly primary fibres and a share of approx. 20.6 % recovered paper grades are being used. In the year 2003, graphical paper production has increased to 9.458 mill. Mg and recovered paper utilisation in this segment grown up to 43.3 % (see **Fig. 4**). LWC and SC papers and recycling paper from the entire spectrum of graphical paper production represent exemptions here.

The recovered paper utilisation mainly covers the segments newsprint and recycling paper which are grouped under the category of printing and writing papers.

Recovered paper within the segment of administrative forms and office papers is almost exclusively used for the production of recycling papers only. Basically this concerns paper qualities, such as copy paper and envelopes, where, similar to paper for newsprint, manufacturing is based to 100 % on recovered paper and the customers demands for brightness are somewhat lower.

Domestic production in 1992 could ensure the market supply with graphical paper only partly resulting in a surplus of net imports of 1.336 mill. Mg. In 2003 this situation had completely changed with the result of a surplus net export of 0.409 mill. Mg. Under consideration of auxiliary materials such as printing ink and adhesives and with the deduction of processing remains as recovered paper which goes directly back into paper production, a total of 7.458 mill. Mg of graphical paper products has been available at the market in 1992 compared to 8.775 mill. Mg in 2003. Further reducing this amount by the quantity of unsold returns and net exports of graphical paper leads to the quantity of domestic use which came to 6.849 mill. Mg in 1992 and reached 7.608 mil. Mg in the year 2003.

Through the deduction of a non-collectable portion which makes for example consideration of paper used for heating at home and the net amount of archives and long-life products, the total potential of used graphical paper at the end user can be established. In 1992 this has been an amount of 5.917 mill. Mg compared to 7.152 Mg in 2003. Within 1992, 3.046 mill. Mg or 51.5 % of the total quantity of used graphical paper have been separately collected while 2.871 mill. Mg were forwarded together with other waste materials to composting, incineration or landfill disposal. Separate collection in 2003 made up 6.21 mill. Mg or 86.8 % of the total potential in this product group already.

The successful evolution of recycling in the graphical paper sector within the frame of the voluntary agreement of producers, processors and editors since 1994 can be seen in Fig. 5. Particularly notable aside from the remarkable increase of the recycling rate from 64 % in the year 1994 to 81.7 % at the end of 2003, is the growing utilisation of recovered paper in this production segment which rose from 25.9 % in 1994 to 50.6 %. This development becomes very evident in the mass balance, too.

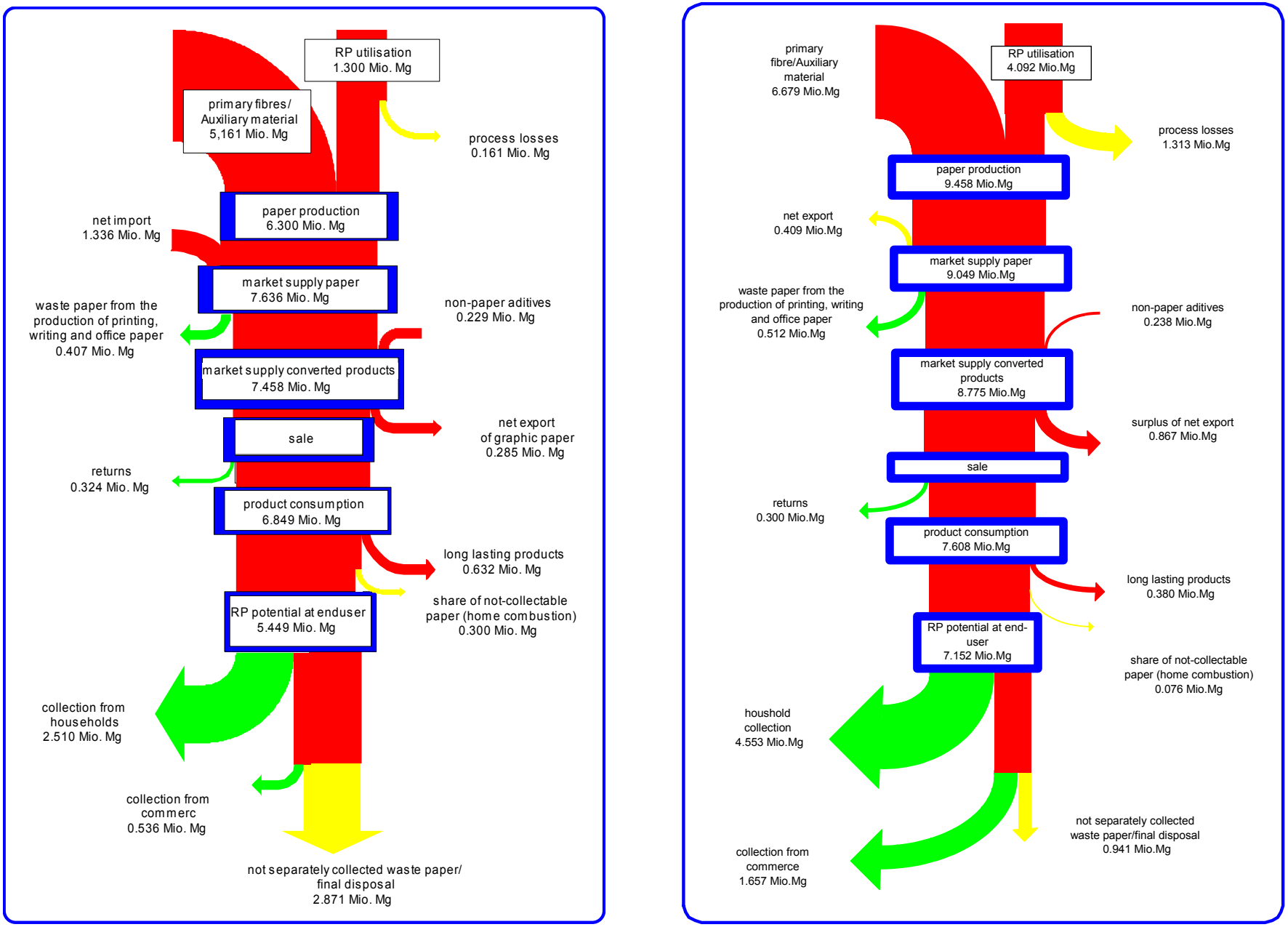


Fig. 4: Mass flow diagram for the product group of graphical paper in the years 1992 and 2003 [3].

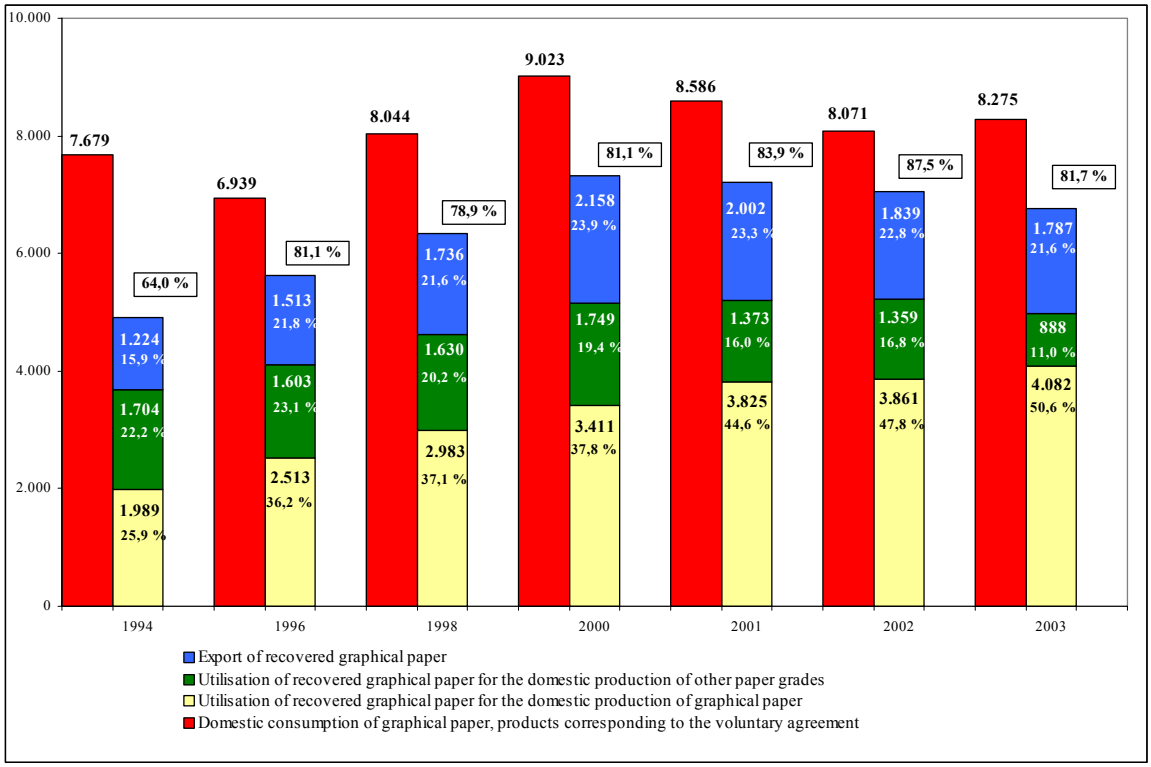


Fig. 5: Utilisation of used graphical paper and consumption of graphical paper products in the period from 1994 to 2003 in the meaning of the voluntary agreement as published from the AGRAPA [4].

2.3 Hygiene papers

Hygiene papers with a total production and consumption of 0.914 mill. Mg in 1992 and 1.053 mill. Mg in 2003 make up the smallest of the main product groups. Recovered paper utilisation in this production segment was 62.9 % in 1992 and increased to 75.5 % in the year 2003 (**Fig. 6**). Given the fact that hygiene paper production uses the pure fibres only, the discharge of production specific waste comes from the filler substances mainly and reached 0.319 mill. Mg in 2003 after 0.2 mill. Mg in 1992.

The input of primary fibres and auxiliary materials in relation to total production was 59 % in the year 1992 and 54.8 % in the year 2003, respectively.

In 1992 domestic market supply with hygiene papers had been guaranteed with even a marginal surplus of net exports, however, in 2003 this had changed into a small surplus of 0.019 mill. Mg of net imports.

Approximately 60 % from the total product use get disposed of through the sewage system and the rest by ordinary waste collection. Changes in the waste stream are marked by the growing consumption of tissue paper in kitchens and baths and for personal care purposes.

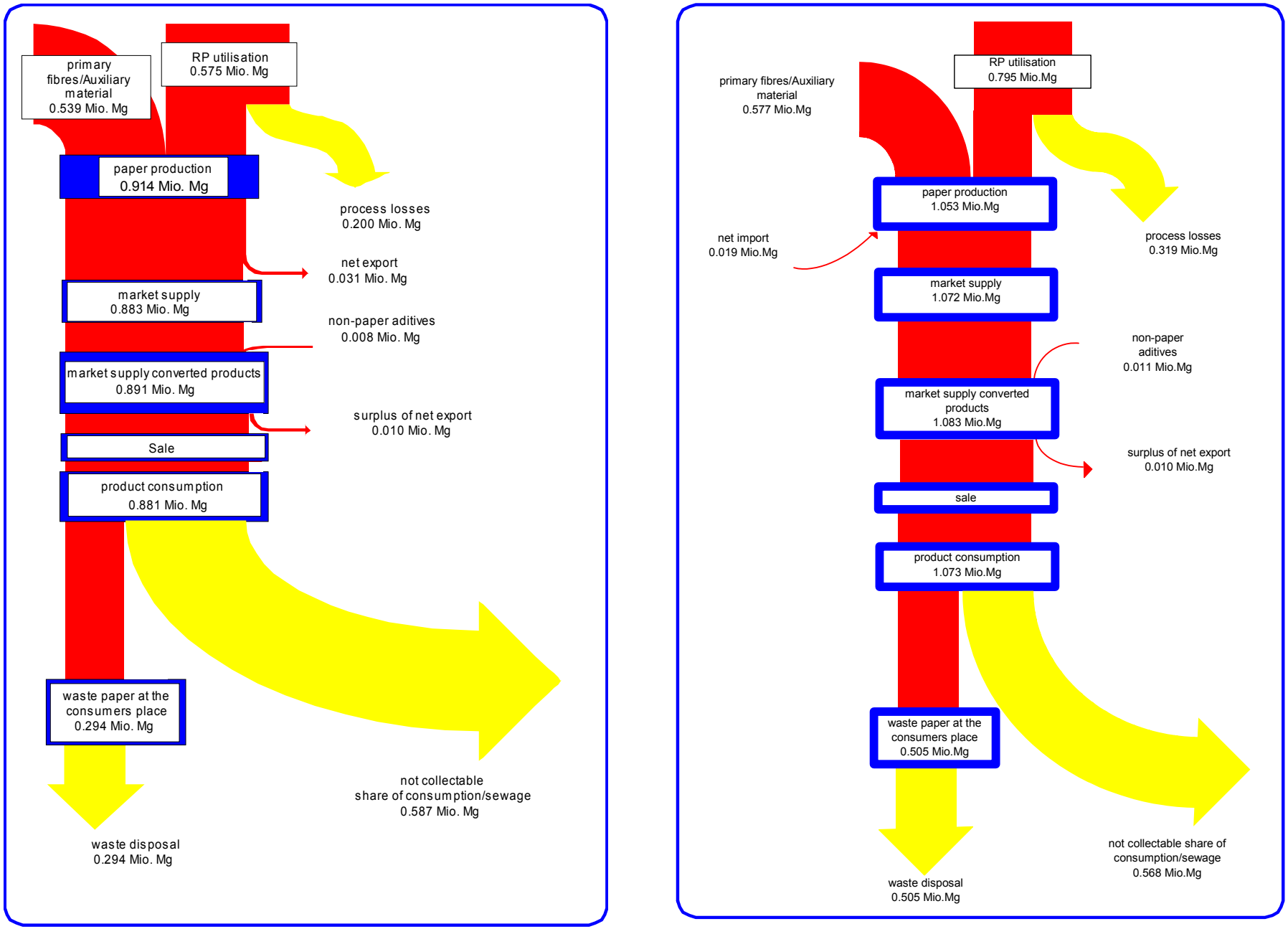


Fig. 6: Mass flow diagram for the product group of hygiene papers in the years 1992 and 2003 [3].

2.4 Technical papers

The production of technical papers reached 1.127 mill. Mg in the year 1992 and grew only slightly up to 1.318 mill. Mg. in 2003. Recovered paper utilisation in this product group also remained rather constant over the years and had a proportion compared to total production of 45.7 % in 1992 and 45.0 % in 2003). While in 1992 national production was not able to fully satisfy the domestic market with the consequence of a small surplus of net imports, nine years later this picture had changed into a surplus of net exports of 0.271 mill. Mg. The market supply that follows hereof reached the amount of 1.140 mill. Mg in 1992 and of only 1.047 mill. Mg in 2003.

Deducting from these amounts the quantity of long-life items in this product segment and the rather small non-collectable share gives the total used paper potential at the place of the end users which amounted to 0.608 mill. Mg in the year 1992 compared to 0.810 mill. Mg in the year 2003. A total of 0.215 mill. Mg which equals to 35.4 % of the potential in 1992 and 0.230 mill. Mg or 28.4 % of the potential in 2003 were collected through recovered paper collection, whereas 0.393 mill. Mg and 0.580 mill. Mg were disposed of as waste in the respective years.

3 Recovered paper quantities and ways for their utilisation

3.1 Recovered paper generation

The total recovered paper generation from the household collection has grown continuously until the year 2000 following which economic turbulences led again to a small decline of the amount up to a total quantity of 5.944 mill. Mg in 2003 (Tab. 1). In comparison this means a total increase by 2.074 mill. Mg or 53.6 % in relation to the year 1992, however.

Tab. 1: Evolution of the recovered paper quantity from household collection since 1986/87 [1, 3, 5, 6].

Year	Recovered paper from the household collection [Mg/a]
1986/87	994,000
1990	2,176,000
1991	2,320,000
1992	3,870,000
1995	5,260,000
2000	6,258,000
2003	5,944,000

Quantities and quality of the used paper disposed of with the residual waste of households have changed considerably over the years. Reached the amount used paper in the residual waste an average of 38 kg/cap*yr. in the year 1992, it had went down to 13.8 kg/cap*yr. in 2003 already. Also in the year 2003, the established proportions of used paper in the residual waste showed big differences in dependence from the region. The used paper amount disposed of in big cities and here in particular in the multi-storey housing areas via the residual waste collection traditionally comes to approximately 20-25 kg/cap*yr. (with the maximum being 42 kg/cap*yr.) whereas an average of 7.0 kg/cap*yr. (with the minimum being 4.8 kg/cap*yr.) is typical for counties and rural type areas [7].

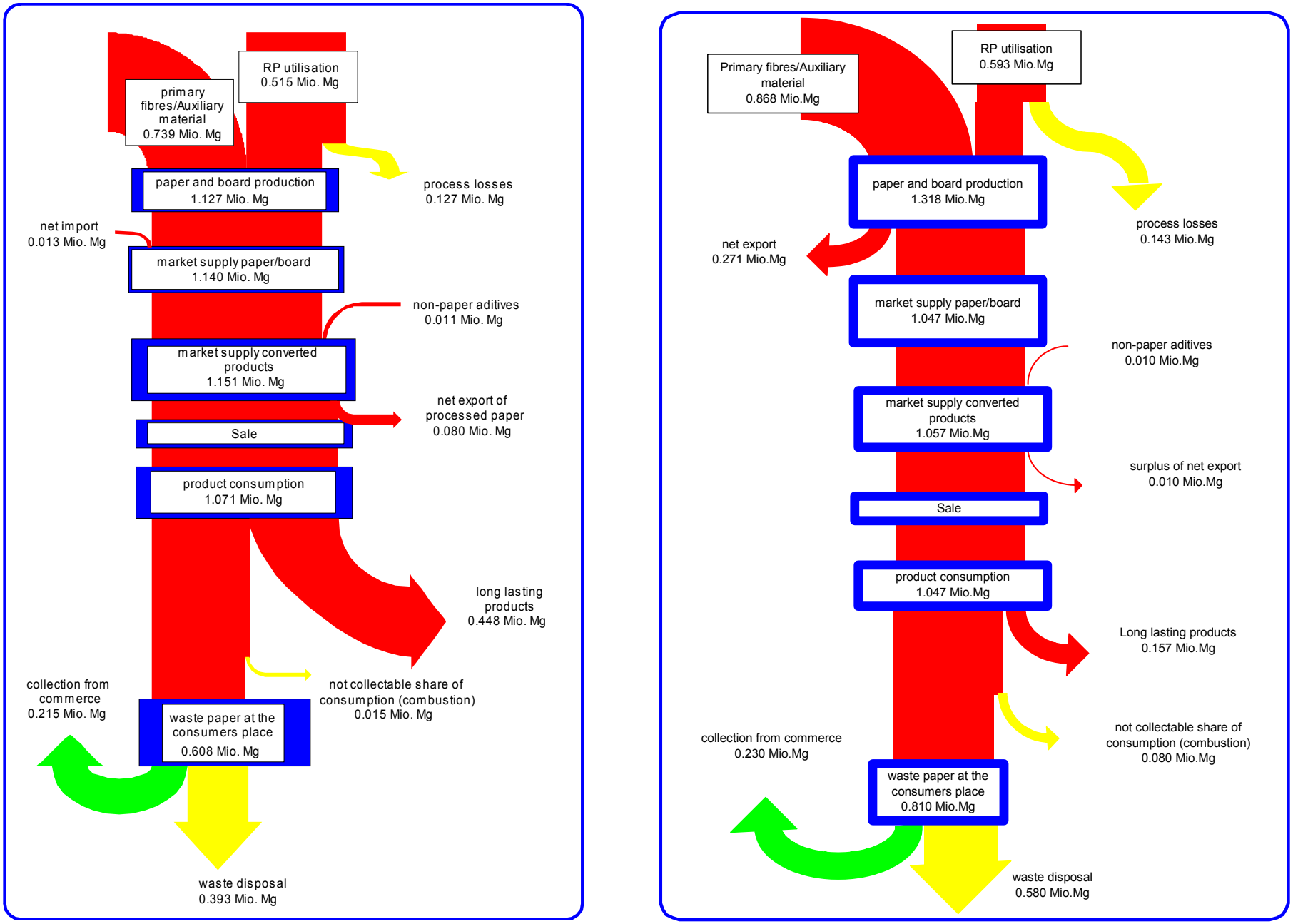


Fig. 7: Mass flow diagram for the product group of technical papers in the years 1992 and 2003 [3].

3.2 Recovered paper quality

Beside the mere quantitative perspective also quality aspects have to be considered as critically important for the intensity and achieved level of recycling. Through the recovered paper quality is determined how much material can potentially be recycled in paper production and thus be used to generate the different paper qualities.

3.2.1 Mixed paper collection

The quality spectrum of recovered paper from the mixed collection can be seen in Tab. 2. The data summarise the results obtained with the typical collection systems offered in form of pickup (such as the collection in bins from the kerbside, the "blue" bin - system) and bring arrangements (bring bank) as well as in the different dwelling structures (cities/county areas). Under the category "packaging" are summarised the packing with and without the green-dot licence mark, transport and wholesale packaging. The fraction of "graphical and other papers" is made up from graphical papers, books including book covers, waxed paper, gift wrappings, hygiene paper and similar paper products. Separately stated are wall papers and foreign matter, whereby the latter represents impurities which are not paper materials.

Tab. 2: Spectrum of recovered paper composition in the mixed collection[1]

Fraction	Minimum	Maximum
Packaging paper	13.8 %	39.7 %
Graphical and other papers	57.0 %	83.1 %
Wall papers	0.4 %	4.8 %
Impurities	1.6 %	3.6 %

An illustration of the resulting recovered paper quality is provided in Fig. 8.

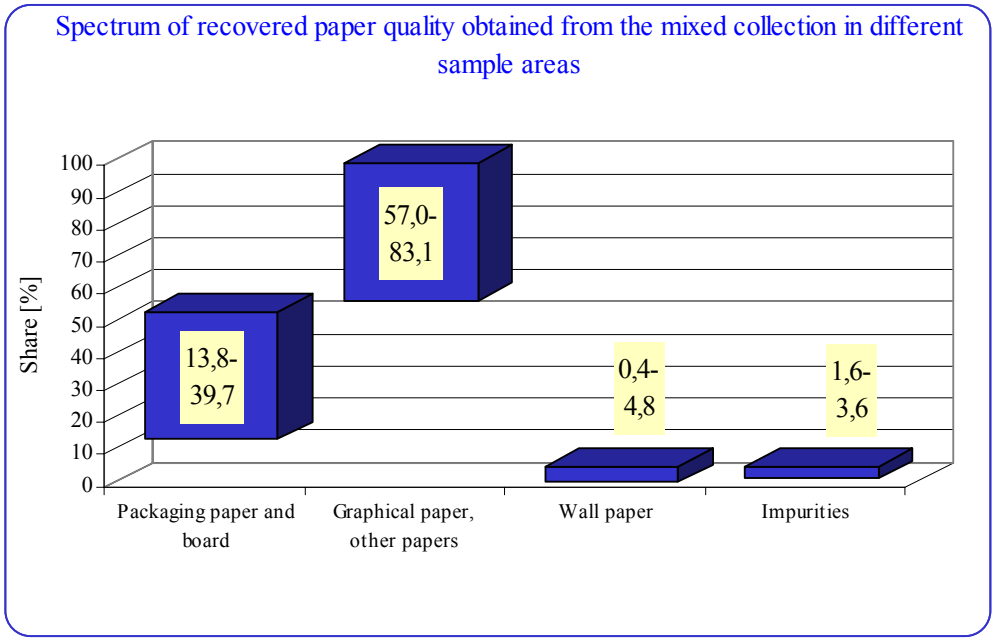


Fig. 8: Spectrum of recovered paper quality obtained from the mixed collection in different sample areas

[1] INTECUS investigations

3.2.2 Differentiated collection

Following the voluntary agreement initiated by the working association for graphical paper (AGRAPA) on graphical paper recycling and take back, intensified efforts were undertaken to enhance the separate collection of used graphical paper from households. As one of the various measures, a pilot project for differentiated recovered paper collection has been initiated.

The commitments made in context with the extension of the agreement by October 2001, consist of the following essential points:

Commitments from the side of the paper producers:

- to ensure the material recycling of graphical papers to be kept at a rate of 80 % ± 3 %,
- to use recycling benign fibres, filler substances and auxiliary components only

Commitments from the side of the converters, editors and the printing industry

- to make use of paper with recycled content
- to use recycling benign materials and auxiliary components in production

Commitments from the side of the paper importers and wholesalers

- to increase their engagement in the segment of paper with recycled content
- to increase the focus on products manufactured with recycling benign fibres, filler substances and auxiliary components.

3.2.3 Graphical papers

On the initiative of the AGRAPA, different collection arrangements have been investigated with regard to their effectiveness for a separate collection of graphical papers. Seen from the content of impurities the quality of the collected material can be illustrated for the different sampling areas as follows:

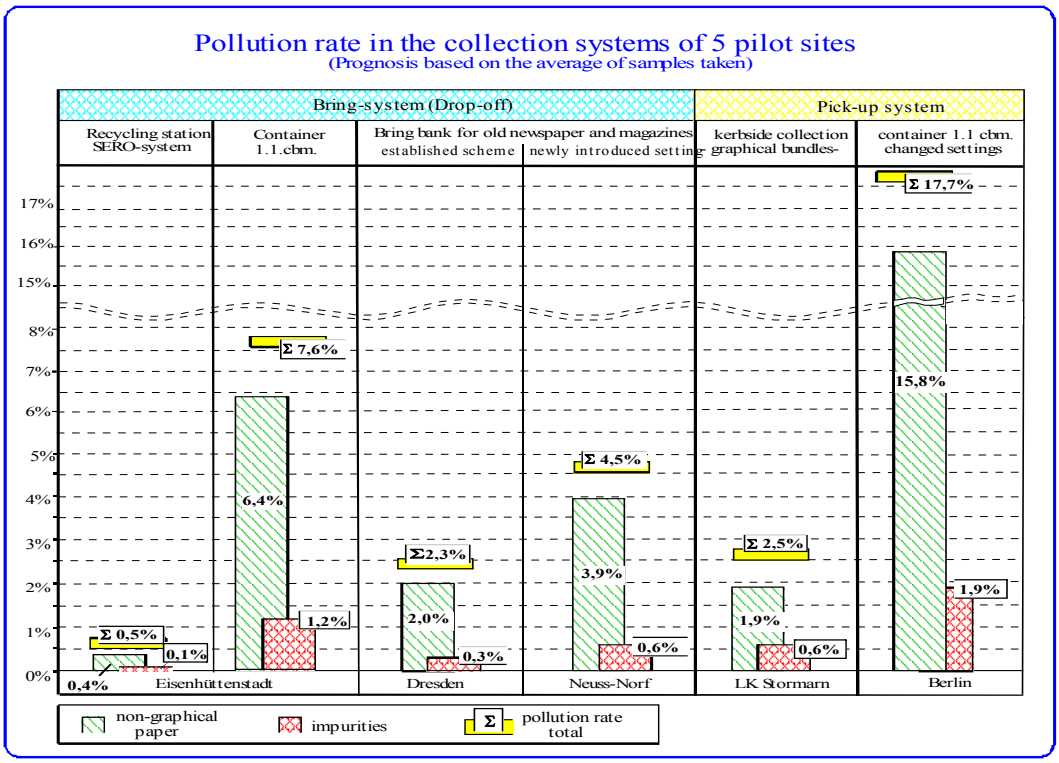


Fig. 9: Share of impurities in the collected graphical papers

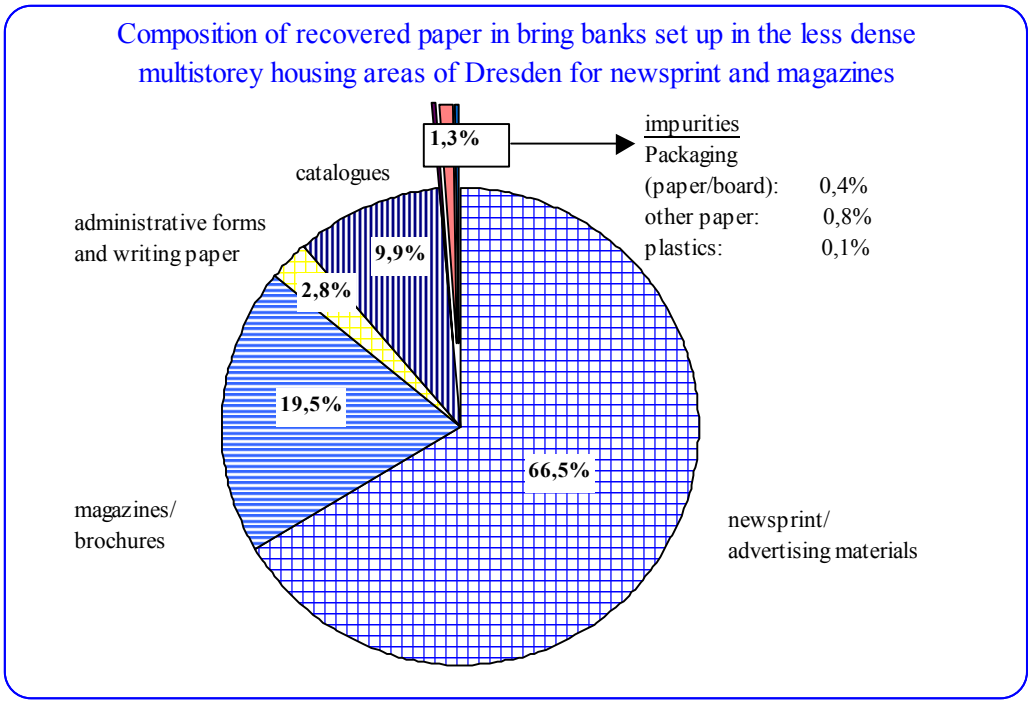


Fig. 10: Composition of the collected graphical paper in one study area

By far the best quality of the graphical paper collection could be obtained with the SERO-system (take-back station).

The high rate of impurities in the Berlin area must be attributed to the insufficient number and capacity of containers provided for the collection of non-graphical paper. This example gives a clear impression of the influence that unfavourable collection infrastructure and conditions can have on the collection result.

Comparing the quality of the collection in the SERO-system with the provisions made on the tolerable content of impurities in de-inking grades[2] for the paper industry brings to light that the SERO-system yields a much better result than what is foreseen in the agreement[3].

The results achieved by means of a drop-off arrangement (bring bank) in the city of Dresden also meet the said requirements without much problems. The quality obtained with the bundle collection from the kerbside came close to the limits. In the Berlin area, these limits were exceeded in consequence of the high proportion of non-graphical paper in the collected material.

The investigations of INTECUS [7] revealed that in selected areas the quality of the separately collected graphical paper is good enough to principally meet the requirements the paper industry has set forward for de-inking material. Such an example can be seen in Fig. 10.

[2] VDP, BDE, BVSE: Recovered paper; List of the German standard grades and their quality. June 2000.

[3] Non tolerable limit for impurities (unwanted paper grades and foreign matter) in single deliveries has been fixed at 3 %, within a month time the average overall content of impurities shall not exceed 2.5 % of the total mass

3.2.4 Non-graphical papers

The quality of the separate non-graphical paper collection within a differentiated collection arrangement shall be described on the example of the results obtained within the AGRAPA investigation in the area of Neuss-Norf.

About 75 % of the material collected after the adoption of the new collection arrangement were packaging paper and approximately 17 % graphical papers. The share of other papers (administrative forms and writing paper, books, hygiene papers) reached about 5 % while non-paper impurities comprised less than 3 % in total.

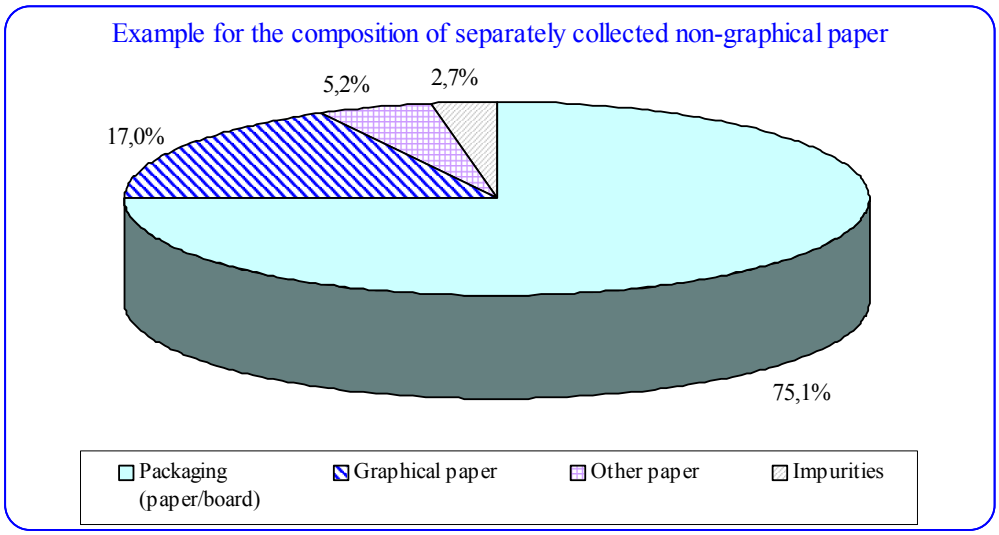


Fig. 11: Composition of the separately collected non-graphical paper - study area Neuss-Norf[4]

The above composition, which can be considered typical for this particular type of collection, can be significantly influenced through the following factors:

- system settings used for the graphical and non-graphical paper collection in the same area (joint installation or spatial division of the two different systems),
- frequency for the emptying of the system in a joint installation setting (if the capacity of one container system is exhausted because of too large intervals for its emptying, people will start to ignore the separate collection arrangement and make use of the container(s) for the other paper quality instead),
- kind of commercial activities in the area.

3.2.5 Bulk density

An important and cost-relevant aspect in the collection and transportation of recovered paper beside the quality is the bulk density of the collected material. Essential impacts are coming from the size of the containers used for collection (smaller container usually show a higher bulk density since users cut large-sized cardboard items into pieces), their design (open 1,100 lt.-containers leave the possibility for manual compression, not so bring banks with a feeding

[4] Technical University Darmstadt/IfP: Assessment of the properties and quality of recovered paper from differentiated collection in various ample areas – volume 7 Scientific investigations and attendance of the investigations for the differentiated collection of graphical papers, 2000.

slot), and the presence of commercial activities in the collection area (determining the share of graphical and non-graphical papers). The bulk density to some extent is varying very extremely in between the different collection areas. Following hereafter, some typical values for the bulk density of the differentiated and the mixed recovered paper collection will be provided.

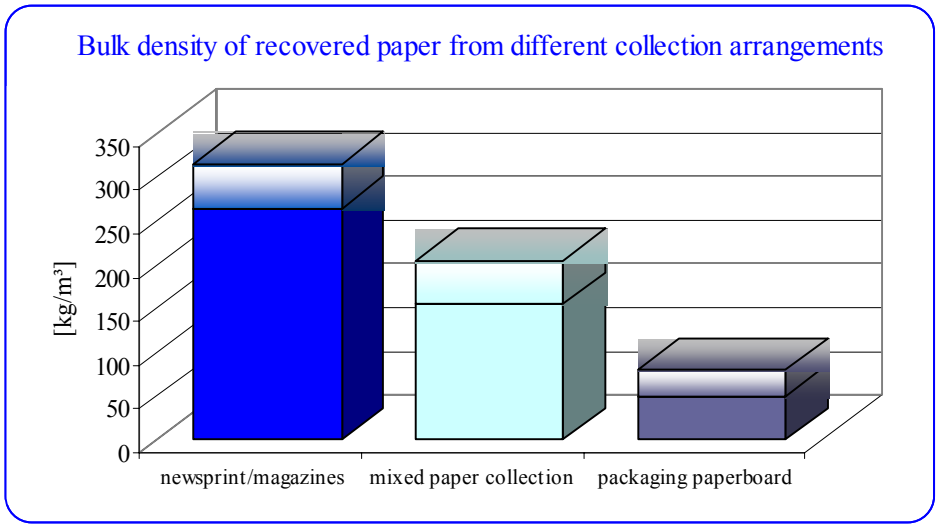


Fig. 12: Bulk density of material from the differentiated and the mixed recovered paper collection

4 Fields and quantities of recovered paper utilisation

A survey covering German paper manufacturers helps the German Association of the Paper Industry (VDP) [2] to establish the recovered paper utilisation in paper production. For the year 1992 the reported quantity amounted to 6.743 mill. Mg.

Based on the INTECUS study of 1990 an estimate of 90,000 Mg is being assumed as the quantity of recovered paper used in other branches of the industry. Until 2003 this amount remained unchanged in the overall mass flow balance. In a new study the Confederation of European Paper Industries (CEPI) commissioned in 2005 to INTECUS it has been found that the recovered paper volume used outside paper production has meanwhile reached the amount of 280,000 Mg annually [8].

Tab. 3 shows the utilisation of recovered paper for the main product groups of paper production in comparison of the years 1992 and 2003.

The utilisation rate has grown up from 52.1 % in the year 1992 to 64.5% in 2003. A deeper analysis of the data in Tab. 3 reveals that the desired growth basically took place within the product groups where already in the year 1992 the highest rates of recovered paper utilisation could be observed. Recovered paper utilisation in the product segment packaging grades has, for example, increased by approximately 2.6 mill. Mg. The use of recovered paper in the largest product group, graphical papers, rose by nearly 2.8 mill. Mg, an amount which also underlines that the growth potential in this segment is yet one of the biggest in comparison to the other product segments.

Tab. 3: Distribution of the utilised recovered paper across the different segments of paper production (in 1992 and 2003) [5]

Main product groups	Recovered paper utilisation [Mg/a]		Total production [Mg/a]		Rate of recovered paper utilisation in paper production [%]	
	1992	2003	1992	2003	1992	2003
Packaging paper/board	4,353,000	6,969,000	4,166,000	7,481,000	92.3	93.2
Graphical papers	1,300,000	4,092,000	5,784,000	9,450,000	18.1	43.3
Hygiene papers	575,000	795,000	828,000	1,053,000	54.9	75.5
Technical papers	515,000	593,000	1,095,000	1,318,000	38.6	45.0
Total	6,743,000	12,449,000	11,873,000	19,302,000	48.6	64.5

The possibility for a continued increase of recovered paper utilisation exists only in the graphical sector, given the fact that in all the other product segments technical limits of recovered paper utilisation have almost been reached. For graphical papers an increase of the utilised amounts of recovered paper will also be possible in the long term perspective.

5 Literature

[1] INTECUS: Analysis of the mass flows on the German paper market for the elaboration of a paper-specific recycling and disposal system. Study (in German) commissioned by the associations of the German paper and recycling industries, Berlin, May 1992. produced with the kind collaboration of Prof.Dr.-Ing. L.Göttsching and Dr.-Ing. H.-J. Putz of Technical University Darmstadt.

[2] Association of the German paper industry (VDP): Paper 2004 – Report of achievements. (in German)

[3] INTECUS by order of VDP: Elaboration of a fibre flow balance for the years from 1992 till 2003. (in German)

[4] AGRAPA: Annual reports for the years 1994 till 2003. (in German)

[5] Association of the German paper industry (VDP): Updates of the survey on recovered paper for the years 1990, 1992, 2003. (in German)

[6] INTECUS: Influence of the separate collection of recovered paper on the disposal costs for household waste in Germany. Study (in German) commissioned by the manufacturers of paper from recovered material, 1989.

[7] INTECUS: Multi-client study (in German): Success factors of the future – The collection and recycling of recovered paper from households, data analyses and recommendations. Produced with the kind collaboration of the attorneys office RAe Gaßner, Groth, Siederer and Co., Berlin, 2003.

[8] INTECUS: Study on the alternative utilisation of used paper outside the paper industry in CEPI member states. For Confederation of European Paper Industries (CEPI), Dresden/Brussels, 2005.