

CHEMICAL RECYCLING OF PLASTIC PACKAGING WASTE: THE GERMAN APPROACH

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INTRODUCTION

The Packaging Ordinance, introduced in Germany in 1991, for the first time prescribes the principle of „prevention, reduction and recycling“, and holds manufacturers and retailers directly responsible for the disposal of the packaging they have put into circulation. Packaging from households and small businesses is no longer classified as „the household waste“ as such; it has to be collected separately. In 1991, Duales System Deutschland GmbH (DSD) was founded as a private dual waste management system responsible for the nationwide collection, sorting, and recycling of post-consumer sales packaging, and thus releasing companies from their individual take-back obligation. Initially founded by 95 companies from the retail trade and the consumer goods and packaging industries, DSD, as of today, has about 600 shareholders.

THE SYSTEM

The services offered by DSD are available to consumers all over Germany. Yellow bags and bins are distributed to households for the collection of light-weight packaging made of plastics, metals and composites. Glass is collected in color-coded bottle-banks set up close to residential areas. The packaging is then collected either at the curbside or from the containers by waste management companies contracted by DSD. These contractors are also responsible for the sorting of the contents of the yellow bag/bin. In over 360 sorting plants, the packaging waste is sorted into four fractions: Plastics, metals, composite cardboard, and other composites. The economically more efficient automated sorting is increasingly replacing manual sorting processes. The waste management companies then forward the sorted packaging to the guarantors. These guarantors have signed contracts with DSD in which they guarantee to accept and recycle the material fractions delivered to them. While the task of recycling aluminum, tinplate and composite sales packaging is handed over to industry, DSD is responsible for the collected plastics. DKR, a subsidiary, was founded to coordinate and organize the recycling of plastics packaging.

The principle of recovery and recycling and the Dual System have proved to be a success. In 1996, over 5.4 Million tons of post-consumer sales packaging were collected by the Dual System. This corresponds to 86% of the sales packaging from households and small businesses. Nine out of ten German households participate in the sorting. On average, each citizen collected 71.2 kg of used sales packaging in 1996. Out of the total quantity collected, 84% was sorted and forwarded to recycling. The individual figures for the different material fractions in 1996 are given in Table 1.

DSD's services are financed over the Green Dot trade mark. Fillers, manufacturers and retailers pay DSD a license fee for the right to mark their packaging with the Green Dot trade mark. This fee pays for the collection and sorting of sales packaging, and in the case of plastics also the recycling, as shown in Figure 1. The Dual System is thus financed exclusively by German industry. The costs for the „green dot“ costs are largely passed on to consumers via the product price. The license fees are calculated based on the material, the weight of the packaging, and the number of items being circulated in the German market. The fees for the different kinds of packaging thus take into account the actual waste management costs caused by these different kinds of packaging. The licensing fee for plastic packaging is by far the highest because, unlike with other materials, the costs of preparation and recycling are included in the „Green Dot“ fee for plastic packaging.

The Dual System not only meets the recycling quotas set forth in the Packaging Ordinance, but also effectively realizes the principles of prevention and reduction. To reduce license fees, manufacturers and fillers optimize packaging and packaging materials. The German environmental ministry estimates that the amount of sales packaging has dropped by 900.000 tons between 1991 and 1995. The recycling achievements in the packaging sector have become a model for an ecologically oriented economy in Germany. „Closing the loop“ is the basic concept in this economy and in the „Kreislaufwirtschaftsgesetz“ (Product Recycling and Waste Management Act), which came into force in October 1996 as an extension of the „Verpackungsverordnung“. Taking things one step further, this act, for the first time, makes all branches of industry fully responsible for their products, right through from manufacture to disposal.

PLASTIC RECYCLING

In 1996, approximately 800,000 tons of plastic packaging were used in Germany. Out of this total, 535,000 t were forwarded to recycling. The collected material is sorted into five fractions: EPS, bottles, cups, film, and mixed plastics. The composition of plastic packaging waste in Germany in 1995 is given in Table 2. The Packaging Ordinance requires that the collected plastic packaging be

materially recycled. Initially, material recycling was thought of in terms of mechanical recycling only. However, the extensive sorting necessary to separate the packaging waste in order to isolate relatively pure plastics was found to be too difficult and too expensive. With the introduction of the so-called „mixed fraction“ to reduce the sorting efforts, chemical recycling has come into play as a viable alternative to mechanical recycling. Today, most of the containers and films - mainly oversized items which consist of polypropylene and polyethylene - undergo mechanical recycling. The mixed plastics are prepared for feedstock recycling. Although contamination and heterogeneity are not a problem in the mixed plastics fraction, the material still has to be sorted to an agreed-upon specification (Figure 2) in order to be suited for feedstock preparation.

In the preparation process, which is crucially important for successful feedstock recycling, the pre-sorted material is converted into a homogeneous, pourable bulk material. This bulk material must be easy to transport, store and handle. DSD, together with the preparators and the feedstock recyclers, has developed a specification (Figure 3) to define a bulk material which is suitable for all the different feedstock recycling techniques available: The preparation process involves several shredding and separating steps and an agglomeration step to compact the material. Initially, preparation was based on a wet technique. Here, the material fractions were separated in a sink-float process. Although the output quality of the material was very high, this wet process involved intensive washing and therefore was expensive and questionable from an ecological point of view. DSD, together with the preparation plants, has developed an alternative dry technique, where the sink-float step is replaced by air separation and vibrating conveyors. Additionally, magnetic separators and eddy-current separators, as well as sieves, are used.

In a final preparation step, the material, which is now largely free of non-plastic components, is compacted. Depending on the type of machinery used for compacting, the final product takes the form of agglomerate or pellets. Compacting to an agglomerated or pelletized form is a very important step in the preparation. Before the material is compacted, it has a very low density ($< 60 \text{ kg/m}^3$) and would be very difficult to handle in subsequent feedstock recycling processes. The new dry technique has considerably reduced the costs of feedstock preparation, while the quality and consistency of the output material still perfectly meets the specification.

Preparation plants with a capacity of more than 10.000 t/y per line can operate economically. Currently, about 10 plants with a total available capacity of approximately 310.000 tons (output) prepare the mixed plastics for the feedstock recycling. This material is all produced according to the same specification regardless of the recycling process it subsequently undergoes. There are three main usages for mixed plastics as a feedstock: Liquefaction/ pyrolysis, gasification, and the blast furnace. Currently, about nine German plants are involved in the feedstock recycling of post-consumer plastics, with an available capacity that by January 1998 will be sufficient to recycle the prepared material, as presented in Figure 4.

CONCLUSION

With environmental issues becoming more and more serious, the demand for economically efficient and ecologically effective recycling technologies is rapidly increasing all over the world. Over the past five years, Duales System Deutschland has collected significant know-how in waste management, in the collection and sorting of household waste, and particularly in the crucial preparation of plastics for feedstock recycling processes. DSD is now actively exploring cooperation agreements with researchers and companies from other countries to develop economically competitive and ecologically superior alternatives to existing disposal methods.

Table 1. Recycling of post-consumer packaging in 1996

	<i>Packaging consumption</i>	<i>Quantity recycled</i>
Glass	3,148,740 t	2,686,639 t
Paper/cardboard	1,402,286 t	1,318,641 t
Plastics	791,816 t	534,953 t
Tinplate	374,598 t	301,789 t
Composites	560,860 t	444,753 t
Aluminum	44,415 t	35,926 t
Total	6,322,715 t	5,322,701 t

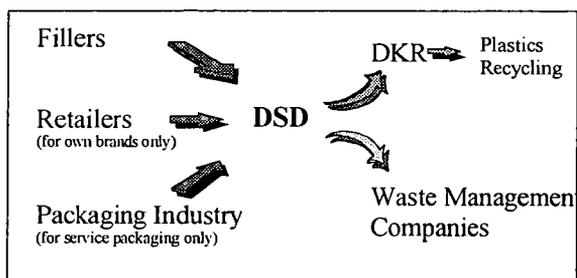


Figure 1. DSD-financing: Flow of payments

Table 2: Waste plastic collection: Quantities supplied for preparation in 1995

Fraction	Quantity (t)	% of Total
EPS	3,500	0.6%
Cups	10,000	1.9%
Bottles	53,000	9.8%
Film	143,500	26.6%
Mixed Plastics	330,000	61.1%
Total	540,000	100%

A Composition/ Description	Mixed Plastics from Plastic Packaging and Plastic Containing Articles
B Purity	Plastic Content > 90 (wt.) %
C Impurities	Total < 10 (wt.) % Metal < 3 (wt.) %
D Typical Impurities (from other containers and packaging)	Metal, Glass, Paper, Aluminium Coated Plastics, Cardboard Composites
E Typical Impurities (from other sources)	Rubber, Stones, Wood, Textiles, etc.
F Packaging	Bales (80 cm x 80 cm x 120 cm)

Figure 2. Product specification: Mixed plastics fraction

Granular Size	≤ 1,0 cm
Granular Fines (< 250 μ)	≤ 1,0 (wt.) %
Appearance	Pourable
Moisture Content	< 1,0 (wt.) %
Density	≥ 0,3 kg/l
Chlorine	≤ 2,0 (wt.) %
Ash (@ 650 C) Total	≤ 4,5 (wt.) %
Ash (@ 650 C) Metal	≤ 1,0 (wt.) %
Plastics Content - Total	≥ 90,0 (wt.) %
Plastics Content - Polyolefin	≥ 70,0 (wt.) %
Plastics Content - Engineering Resins	≤ 4,0 (wt.) %

Figure 3. Product specification: Mixed plastics agglomerate

Contractor	Consumption (t/y)	
	1997	January 1, 1998
KAB	80,000	80,000
BASF	20,000	20,000
Stahlwerke Bremen	80,000	80,000
Eko-Stahl	13,000	15,000
Thyssen	18,000	18,000
KHS	12,000	40,000
HKM	0	50,000
(Additional Capacity for Gasification)	(70,000)	(70,000)
Total	293,000	373,000

Figure 4. Feedstock recycling: Available capacities in German plants