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OCDE/GD(94)40

**RECOVERY AND RECYCLING OF PACKAGING MATERIAL
-- TRENDS AND INDUSTRY IMPACT**

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

Paris 1994

COMPLETE DOCUMENT AVAILABLE ON OLIS IN ITS ORIGINAL FORMAT

FOREWORD

This report on "Recovery and recycling of packaging material -- trends and industry impact" was approved by the Ad Hoc Working Party on Pulp and Paper of the Industry Committee in October 1993. It is made publicly available under the responsibility of the Secretary-General.

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PREFACE

This report was prepared by the Ad Hoc Working Party on Pulp and Paper of the OECD Industry Committee during the years 1992/93. The information contained in it was brought up to date in Autumn 1993.

The background to the report, like the Working Party's previous report on "Environmental Issues - Waste Paper", is the growing attention which the general public is paying to the environmental impact of packaging, including paper and paperboard packaging. Attention focuses not only on the "waste" impact which used paper and paperboard packaging material may have on the environment but also on preserving the natural forest resources. In response to this, governments in an increasing number of OECD countries intend to introduce regulations -- a small number have already introduced such regulations -- to deal with the issues involved, often setting targets for the recovery of packaging material and their recycling into the paper industry. However, knowledge about the implications of such regulations, in terms of their wider impact on the economy and the environment and of alternative modes of disposing of packaging material is often nonexistent or limited.

The intention of the report therefore is to draw attention to a number of issues involved in increased recovery and recycling of paper and paperboard packaging material, to identify and highlight particular problems that may arise or are difficult to evaluate in advance and, in this way, to provide a perspective which comprises environmental, economic, social and industrial issues related to present and, especially, future regulations in the area of recovery and recycling of paper and paperboard packaging material.

SUMMARY AND RECOMMENDATIONS

The continuing growth in world population, the current situation relative to the availability or renewability of resources, the ability of our planet to cope with the activities of man are all factors shaping public opinion and government action in relation to the environment. The concept of sustainable development is very much in the forefront both in many OECD countries and within the international institutional community. Trade and environment are subjects being discussed in many fora including the United Nations, the GATT, FAO and OECD.

The environmentalist community has also become more vocal in recent years, and many governments, often reacting to apparent public pressure, have been anxious to act quickly and to implement rules and regulations, particularly in the area of solid waste management. Paper and paperboard packaging is very much the subject in these deliberations. The issues and considerations are complex, and governments should carefully consider all the implications of enacting rules and regulations to ensure that they are appropriate for the circumstances and provide a net benefit to the environment.

The goal of reduced packaging consistent with functional performance is one that most industrial users and producers of consumer or packaged goods would support as packaging can represent an important cost factor in the production and sale of a product. Progress is evident in this area in many countries and industries. For example, the detergent industry has developed super concentrated products requiring much less product per use and therefore less packaging. Additionally, they have developed refill packages that fit the original box, once again reducing the overall packaging required. The market is the best regulator of how much packaging is needed. However, the desire to reduce packaging must be tempered by the need to ensure that the product is adequately protected so as to withstand travel and guarantee the shelf life of the product between producer and consumer. Also, most jurisdictions have specific regulations related to product labelling which can include: multilingual needs, quantity declarations, composition, health data or warnings, and country of origin. These requirements can, in part, dictate the size of the package.

The desire to achieve less packaging often is translated into targets for the reduction of waste to landfill and many of the targets put forward relate to reducing the weight or volume of packaging material going to landfill. While on the surface a weight reduction may be desirable, it may not be the ideal solution from a landfill or overall environmental perspective. A weight target can be achieved, at times, simply by switching to a lighter weight synthetic material produced from a non-renewable resource. While an immediate reduction in waste weight will result, the long term benefits are not so apparent.

The area of recycling and recycled products also requires careful scrutiny and several factors need analysis when regulations, guidelines or targets are being developed. Some of these include:

- The technical capability to produce a new product from the recycled material. It is, in most instances, technologically possible to produce an equal or lower grade of paper or paperboard from a specific grade of recovered paper. Although technical strides have been made in this direction, it is generally not possible to produce a higher grade paper from recycled fibre than from virgin fibre.
- The suitability of a recycled packaging material also deserves consideration. While recycled materials are acceptable in many applications, there are situations where strength properties or sanitary, health and safety requirements are paramount, where recycled materials cannot meet the technical requirements. This is particularly the case in pharmaceutical or medical applications and for most liquid or oily foods.

- The wood fibre has a limited life span because it deteriorates with each successive use. While it varies from grade to grade, the useful life of the cellulose fibre is estimated to be in the vicinity of six to seven reprocessing cycles, but it could be less. As a result, the addition of virgin fibre in the complete system is required. Fibre life or use can be extended by the use of fillers and additives but this adds to the production of sludge.
- The environmental impacts of recycling itself need also to be taken into consideration. There is a popular misconception that recycling is a 100 per cent closed process. This is not the case. For example, the difference of output in terms of recyclable fibre and by-products between a standard corrugated box with minimal printing and a laminated or coated paper package with sophisticated printing is considerable.

While research continues in the area of recycling processes, the body of knowledge concerning the overall consequences of recycling, especially from a "byproducts" perspective remains modest. The development of guidelines, targets, and legislation appears to be significantly ahead of the scientific information to determine the relative environmental impact of recycling.

The collection of used materials has also been the goal of regulators and is often seen as making a universal positive environmental contribution. This too requires scrutiny. Because a major portion of the packaging materials used are destined for the consumer, curbside recovery is required to recover these materials and curbside recovery is very cost intensive. The evidence to date suggests that in areas of high and very dense population recovery may be both environmentally and economically beneficial. However, studies undertaken to date suggest that in areas of lower density or sparse population, the costs of recovery often far exceed the cost of landfill or other disposal alternatives. Studies also suggest that some recovery programs may well have a net negative impact on the environment. The recovery activities themselves not only consume non-renewable resources but contribute to air and water pollution.

While there is no doubt that environmental protection, preservation and enhancement is a pressing concern, care needs to be taken to ensure that regulations and programs put in place will achieve the stated goals. All recycling and recycled products have, in the minds of many people, become a solution and other options for integrated waste management, such as conversion to energy, have been neglected, although there appears to be an increasing awareness and understanding of the potential for energy recovery as a complement to recycling. A surge of regulatory activity has taken place. Many OECD countries are enacting new rules and regulations at a quick pace. Most of the regulatory activity has been aimed at the supply side of the "problem" in areas of take-back provisions and recycled content requirements. Many of the targets or requirements are based on assumptions rather than on technically sound data. These types of actions are of particular significance to packaging materials in general and paper and paperboard packaging in particular. New regulations could well force major changes not only in packaging processes but also in the utilization of certain packaging materials, disrupt the flow of international trade, create surpluses and disrupt the markets for recyclable materials, add to product costs and yet still not achieve the desired waste management and positive environmental improvements really required.

The Ad Hoc Working Party recommends that:

- i) Governments should encourage industry to adopt voluntary solutions to the problems created by packaging waste and give market forces the opportunity to prevail before giving consideration to a legislative approach; they should also accord market forces as much flexibility as possible to determine the kind and amount of packaging being used between manufacturers and ultimate consumers. Close co-operation between government and industry will prove beneficial for assessing the contribution which industry, both manufacturer and consumer, can effectively make to overall environmental protection;
- ii) Governments, when setting up targets and regulations for the protection of the environment and which relate to recovery and recycling of packaging material, should ensure that a positive overall environmental benefit will result;
- iii) Governments should ensure that a) recovery and recycling regulations result in a net environmental benefit rather than in shifting the problems of packaging waste from one material to another and b) that all parties in the life cycle of packaging materials share the responsibility for the final disposition of the product;
- iv) Governments, in establishing targets and regulations for recovery should consider a) integrated approaches which, in addition to recycling, could include burning for heat recovery, composting and source reduction or landfill, and b) that recognition be given to the fact that paper and paperboard packaging is produced using a fully renewable resource;
- v) Governments should ensure that rules and regulations a) avoid reference to production and process methods [PPMs] as the benchmark, and b) provide complete information to the public on the net overall environmental benefits of the new regulations;
- vi) In recognition of the significant role packaging plays in facilitating international commerce, Governments should ensure that the development process for establishing rules and regulations be transparent, allowing for broad based consultations.
- vii) Industry should give due consideration to the environmental impact of the products they bring to the market throughout their life-cycle, including cost of collection and handling, recyclability, energy resource utilisation, compostability, and other uses.

* * *

The following terminology is used in this report:

- Paper and paper-board packaging: All products made of paper and paperboard to be used for the containment, the handling and the delivery of goods, from raw material to processed goods, from the producer to the user or the consumer. Disposables used for the same purpose are also considered as packaging.
- Sales packaging: Any packaging conceived so as to constitute a sales unit to the final user or consumer at the point of purchase.
- Transport packaging: Any packaging conceived so as to facilitate handling and transport of a number of sales units or grouped packagings in order to facilitate transport of goods and prevent damage.
- Recovery: Collection of packaging material for the purpose of re-use, recycling, export, energy recovery or composting.
- Recovery rate: The ratio of packaging material collected for re-use to the total consumption of packaging material.
- Recycling: Input of extracted secondary fibre/raw material for the manufacture of new products.
- Utilisation rate: The ratio of total recovered paper used for paper and paperboard packaging to the production of paper and paperboard packaging.
- Recovered fibre: Fibre extracted from recovered paper and paperboard to be used as a raw material for the manufacture of new products or for the manufacture of recovered paper market pulp.
- Packaging waste: Discarded packaging material excluding recovered packaging material.
- Waste management: Organised actions (collection, transport, and disposal) to manage the solid waste stream.
- Burning for heat recovery: Conversion by fire for the purpose of energy recovery.

- Incineration: Combustion for the purpose of ultimate disposal (without recuperation of heat/energy).
- Landfill: Controlled disposal in land.
- Board: Paperboard.
- Packaging material: Includes both primary paper and paperboard to be used in packaging (e.g., linerboard, folding boxboard) and the converted package (e.g., corrugated box, milk carton, folding carton).

I. INTRODUCTION

Government regulations regarding packaging material: Status and Implementation

The nature and strength of the concern of OECD countries about the impact of packaging material on the environment is reflected in the rules and regulations that exist in individual countries and especially, the mechanisms through which current and expected future issues are approached. Traditionally, recovery of paper packaging material has been a matter for the private sector and involvement of the public authorities was generally only for the purpose of setting the framework for the functioning of private initiative. Recently, however, the situation has shown signs of change in that governments in some countries consider introducing, or have introduced, obligatory regulations for the recovery and recycling of packaging material. These regulations generally provide for specific quantitative targets to be met for recovery and recycling (see the schematic presentation in Table 1).

Germany was the first country to introduce obligatory regulations for the recovery and recycling of sales packaging -- which includes paper and paperboard material -- and which has since had some (limited) experience with it. The main characteristic of this "Ordinance on the Avoidance of Packaging Waste" which came into force in 1991 is an obligation on trade and industry to take back a certain percentage of packaging materials. Trade and industry can, however, be exempted from this obligation, if a so-called Dual System for the collection of used sales packaging materials is organised instead of or in parallel to the existing systems of recovery, and if certain goals for recovery, sorting and utilisation are attained. These goals are that by 1995, 80 per cent of all packaging material be recovered, of which 80 per cent are to be recycled. Another country which has recently introduced a regulation concerning disposal of household packages is France. The guiding principle here is that manufacturers or importers of packed products are held responsible for contributing to the recovery of the packages which they bring onto the market. Producers and importers have to put at the disposal of households appropriate collection facilities or set up a deposit system, or instead, adhere to special organisations which are charged with recovering packaging material. The ultimate target is to recuperate 90 per cent of packaging material by the year 2000.

In Austria, an obligatory system will be introduced effective 1 October 1993. Following the German example, it will contain the obligation for industry and commerce to take back and recover packaging material free of charge. Like the German model, it will be a combination of stated objectives and measures; recovery is to be increased from 40 to 80 per cent by 1 January 2000, of which 80 per cent have to be recycled or re-used (incl. thermal utilisation). In Sweden, the government has presented to Parliament in February 1993, a bill involving, *inter alia*, the responsibility of producers for the recovery of waste in general. Currently, existing legislation provides for the promotion of recycling and the reduction of incineration and landfilling of unseparated waste.

Table 1: Recovery and Recycling of Packaging Material: Country Regulations

Country	Action	Objective	Timing
Austria	Ordinance on the avoidance and recuperation of packaging waste	Take back obligation of trade and industry. <u>Goal:</u> Recovery to be increased from 40% to 80% by 1 January 2000, of which 80% must be recycled or reused (incl. thermal utilisation).	To become effective 1/10/93
Canada	Various authorities exist at provincial level (see Annex 2) "National Packaging Protocol". Federal Government is examining legislative options in support of industry-led stewardship initiatives.	National Packaging Protocol: voluntary arrangement, but provincial authorities to introduce regulation if voluntary target not met. <u>Goal:</u> progressive reduction of the amount of packaging waste going to disposal: by 20% by December 1992, by 35% by December 1996 and by 50% by the year 2000.	
Denmark	"Action Plan"	Voluntary "action Plan"; recycling of 40% to 50% of all commercial waste by the year 2000.	
Finland	New waste law	Increase recovery from present levels by municipal measures.	Likely to pass Parliament end 1993
France	Decree concerning household packages	Take back obligation of producers and importers. <u>Alternative:</u> deposit system or adherence to special organisation. <u>Goal:</u> Recovery of 90% of packaging material by the year 2000.	1/01/93
Germany	Ordinance on the avoidance of packaging waste. Obligatory regulation	Take-back obligation of trade and industry. "Dual System" as substitute.	1/06/91
Netherlands	"Packaging Covenant"	Voluntary agreement concerning reduction, re-use and recycling of all kinds of packaging material.	
Norway	Revised Pollution Act	Pollution Act places responsibility on all parts of the production and distribution chain. Currently under negotiation is an agreement regarding corrugated board packages; <u>Goal:</u> to increase within two years, the recycling rate from 40% to 60%.	July 1993
Portugal	Voluntary arrangement	Reduction by weight and/or volume of packages made from composite material in urban waste.	

Spain	Decree of 1991	Decree concerns production, commercialisation and recycling of packaging material for liquid foods.	
Sweden	"Ecocycle Bill" presented February 1993	Reduction of environmental impact by diminution of solid waste and adaptation of products. Collection rate for paper and paperboard packages: 65% as of January 1997.	
United Kingdom	Producer responsibility	Introduce concept of producer responsibility for packaging, whereby retailers, fillers and manufacturers would deliver agreed targets for the recovery of used packaging. Industry leaders to report on actions taken and progress by end-October 1993. Industry's plans for meeting objectives invited before Christmas 1993.	Before end 1993
United States	In 1992, Congress considered but did not pass legislation mandating paper recovery targets. It is not expected that Congress will address this legislation in the next several years.		
EC	Draft proposal for a "Council Directive on Packaging and Packaging Waste" adopted by the Commission in July 1992 and amended in 1993 (see Annex 1)	No later than 5 years: 60% to be collected, of which 40% to be recycled; no later than 10 years: 90% to be collected, of which 60% to be recycled.	Awaiting approval of EC council.

Source: Country replies.

In the compulsory systems that exist in Member countries, the main aim, reflected in their particular provisions, is to ensure and increase the recovery and recycling of packaging materials; but there is often an implicit hierarchy with avoidance and re-use of packaging ranking higher, and burning for heat recovery and landfill ranking lower than recovery and recycling. Such compulsory systems as exist today establish a joint responsibility of the entire supply chain, i.e. from the producer of goods to the retailer, for the management of used packaging material ("from cradle to grave"), therefore replacing the traditional recovery systems.

In general, the situation in OECD countries, however, is characterised by the existence of voluntary arrangements or the absence of particular arrangements altogether. In some countries, voluntary arrangements between government, on the one hand, and industry and commerce, on the other, exist in respect of recovery of packaging material. For example, the Dutch Government has an agreement with industry concerning reduction, re-use and recycling of all kinds of packaging materials ("packaging covenant") which include paper and board packaging. The Danish Government has an action plan which sets the general target of recycling by the year 2000, 40 to 50 per cent of all household waste, and 50 to 60 per cent of all commercial waste. In Spain, a decree of 1991 concerning production, commercialisation and recycling of packaging material is in force. It will be adapted to take into account the present EC draft Directive on Packaging and Packaging Waste when it is adopted by the EC Council. In Portugal, voluntary arrangements exist aimed at reducing the weight and/or volume of packages made from composite materials in urban waste. In Sweden, the government presented an "Ecocycle Bill" in February 1993. Its aim is to reduce the environmental impact of products by reducing solid waste fractions and adapt products for re-use and recycling. The responsibility for this lies with the manufacturer. The bill sets collection targets and a timeframe, with the responsibility of manufacturers to be determined after consultation with industry. While for newspaper and magazine paper the target is 75 per cent by the year 2000, it is 65 per cent by January 1997 for paper and paperboard container packages. In Norway, a revised Pollution Act which came into force in July 1993 deals with the recycling of waste and places responsibility on all parts of the production and distribution chain; the environmental authorities may set specific targets for recovery of each material. An agreement with manufacturers is under negotiation regarding corrugated board packages; when fully implemented, it will increase the recycling rate for such material from currently 40 per cent to 60 per cent within a period of two years. In the United Kingdom, the idea of producer responsibility for packaging waste has been introduced. Under the initiative, producers (including retailers, fillers and manufacturers) will have to demonstrate that they accept responsibility for the packaging materials that they bring to the market when they have served their original purpose by demonstrating that they are committed to achieving recovery targets of between 50 and 75 per cent by the year 2000. Producers have been invited to report to Ministers by the end of October 1993 on what steps they have taken to ensure that a recycling infrastructure -- collectors and processors (especially for waste paper and board and plastics) -- continues to be available to them so that they could meet these recovery targets. If industry's plans are unlikely to meet Ministers' requirements, the Government has made it clear that it will consider legislating the producer responsibility concept. In some countries, (e.g. Ireland, Italy, Greece), no particular regulations for packaging material exist. The same is the case in Switzerland.

An EC Directive is in preparation which will apply to all EC Member states. A "Draft proposal for a Council Directive on Packaging and Packaging Waste" was adopted by the EC Commission in July 1992 and was recently amended. It sets targets for the recovery and recycling of packaging material which increase over time to attain, ten years after the setting up of collection systems, a collection rate of 90 per cent of packaging waste of which 60 per cent have to be recycled (for details, see Annex 1). Modelled on the EC provisions is a new "waste law" which the Finnish Government is preparing and which provides for specific regulations regarding recovery of waste material.

In the United States, the US Congress, in 1992, considered but did not pass legislation mandating paper recovery targets. It is not expected that Congress will address this legislation in the next several years.

In Canada, there is various existing or planned authority over packaging recovery and recycling at the provincial level (for details, see Annex 2). Voluntary arrangements ("National Packaging Protocol") exist the main goal of which is to reduce progressively the amount of packaging material going to disposal: by 20 per cent by December 1992, by 35 per cent by December 1996 and by 50 per cent by December 2000 (compared to the 1988 levels); the Canadian pulp and paper industry is a partner to this arrangement through an advisory body to Canada's Environmental Ministerial Committee.

The guiding motives behind recent Government regulations for packaging waste are of different kinds, but it appears that environmental concerns rank very high. These are termed differently, i.e. minimisation of waste destined for landfill, avoidance of environmental pollution; this is the case in Italy, the Netherlands, France, Austria, the United States and Canada. But there are also additional intentions, such as in Germany where paper and paperboard should be of a quality which can be recycled as far as possible and that it should be produced using recovered paper as far as possible; and that used paper should be recycled as far as possible. Fostering re-usable packaging and lightweight packaging material is an additional goal in Austria. In France the first objective is to control waste through the introduction of joint responsibility of the packaging industry, and the second to optimise the management of natural resources.

The problems that are associated with recovery and recycling of packaging material can be assessed more adequately when they are considered against the background of the quantities involved. Previous work of the Ad Hoc Working Party has provided a clear idea as to the quantities of total paper which are recovered, recycled domestically and traded internationally. The "sub-item" of packaging material is less easy to quantify since many countries do not collect data on packaging material separately. The data that have become available so far are contained in Table 2. They indicate extremely rapid growth of consumption of recovered packaging material by the paper industry over the last few years: in the seven countries for which comparable data are available, growth was in range of 30 to 63 per cent over the five-year period 1985 to 1990.

**Table 2: International trade and apparent consumption
of recovered paper and board packaging materials
(selected countries; 1 000 metric tonnes)**

	1985			1990			1995 (est.)		
	I	E	AC	I	E	AC	I	E	AC
Finland	22	71	283	55	50	461	140	35	550
Germany	130	638	2 395	157	978	3 462	n.a.	n.a.	n.a.
Norway	29 ¹	16 ²		33 ³	20 ⁴				
Portugal				17	2	170			
Spain	158	10	1 000	212	8	1 350	180	10	1 470
Sweden	90	23	279	119	25	364	20	170	430
Switzerland ⁵	107	161	449	139	237	617	n.a.	n.a.	n.a.
United Kingdom	30	40	1 100	40	80	1 500			
United States ⁶	5	1 331	7 166	10	2 478	9 695	n.a.	n.a.	n.a.

I = Imports; E = Exports; AC = Apparent Consumption

Source: Country replies.

¹ 1986.

² 1986.

³ 1991.

⁴ 1991.

⁵ Total recovered paper.

⁶ Data for import and export are those for old corrugated containers (OCC). Apparent consumption (domestic use) is calculated on the basis of recovery of transport packing and exports and imports of OCC.

Packaging Material: Technology, Usage and Recoverability

The term packaging covers a wide spectrum of materials and products made from paper and paperboard and other materials, (e.g. metal, glass, wood, solid plastic and plastic films) plus numerous combinations of them. It is worthy of note that paper and paperboard packaging, like wood, are the only kind of packaging materials produced from a renewable resource.

Paper and paperboard packaging materials can be broken down into the following main categories:

Corrugated Board

Corrugated board packaging consists of two or more layers of linerboard and an inner layer of corrugating medium. Both come in varying types, basis weights, and are made from virgin fibre, recycled fibre or a combination of the two. The strength of the corrugated board is influenced by the quality and length of the fibres, the basis weight of the linerboard and the medium, plus the size and frequency of the fluting when the corrugated board is produced. The primary use of corrugated board is for the production of corrugated boxes, also referred to as shipping containers or cardboard boxes. Corrugated board is also often used as a divider within a package or as a separator and padding for banding purposes in bulk shipping.

Corrugated board is predominantly used in its "natural" condition. However, for some special uses, plastic or wax coatings are applied to the linerboard, or foam pieces are laminated to the board, or plastic film liners are used to protect products from moisture. Although corrugated products are most often used as shipping containers, changes in retail operations have increased the use of corrugated boxes as the point of sale consumer package. These factors combine to make corrugated boxes one of the best candidates for recovering and recycling. In many countries corrugated boxes have been one of the first products to be recycled and primarily converted back into linerboard and corrugating medium. Also, corrugated boxes often achieve the highest recovery rate of all paper and paperboard products.

Boxboard

Boxboard, also referred to as cardboard, is produced in single or multi-ply construction, and can be made from virgin fibre, recycled fibre, or a combination, and can be bleached, unbleached, coated or uncoated. Boxboard is primarily used in the manufacture of folding cartons. It is also used to produce set-up boxes, cartons for liquid packaging, food service products (such as plates and cups), composite cans, spiral wound tubes, cores and drums. Folding cartons are used in a large number of packaging applications, including such items as dry cereal and cookie boxes, frozen food containers, cigarette packaging, beverage carriers, gift boxes, and boxes for pharmaceuticals and cosmetics. As the above list implies, a majority of the packaging produced from boxboard is utilized to package consumer goods and is most often used as a point of purchase package.

While many boxboard products utilize recycled fibre, the use of boxboard in packaging of foods and liquids, if the packaging is to be in direct contact with the product, regulations frequently call for the use of virgin fibre. Therefore, boxboard is often used in combination with other materials, such as foils and plastic films or coatings. The recycling of used boxboard packaging has often been difficult. As a consumer product package, boxboard packaging has been difficult to recover from households, and once recovered, to utilize it. Canada, however, is actively using this material as filler in new boxboard packaging.

Packaging Paper

Packaging paper is in a number of countries made from kraft paper. This paper can be a natural brown kraft, such as used in the manufacture of the grocery bag, or a white, treated, coated or laminated product for such items as multiwall bags for pet food that combines a glassine or greaseproof paper with a coated and printed outer ply for printability, and natural kraft inner plies for strength. Kraft paper comes in a variety of weights and strengths from the lightweight polyethylene coated paper used to produce a single serving sugar pouch through to the mid-weight sheet found in a small retail carry out bag or cookie bag to the very heavy weight sheet found in a cement bag or other multiwall shipping sack. Like boxboard, paper is often polyethylene or wax coated or laminated to foils and plastic films or vacuum metallised to manufacture a composite packaging material. Examples would include butter wrap, butcher wrap, specialised and multiwall bags, the outer wrap on cigarettes, as interleaving for meat and other products, or as labels for bottles, jars and cans. Like boxboard, paper packaging is most often utilised in relation to consumer products, either as a package *per se* or as a carry out medium to transport products from the store to the home.

Like boxboard, paper packaging is often difficult to recover since its final user is the consumer.

While not packaging *per se*, an additional consideration in the context of waste management is the substantial use of paper and paperboard, particularly in North America, for permanent uses, particularly in residential construction. For example, old corrugated containers are used in the construction of interior doors as a filler or spacer; recovered paperboard is used to manufacture gypsum wallboard for interior walls; and paper, usually asphalt impregnated, is used as sub-roofing material and as a backing for fibreglass insulation. Therefore, a certain percentage of paper and paperboard is not available for recycling.

II. IMPLICATIONS OF INCREASED RECOVERY AND RECYCLING OF PACKAGING

Cost of recovery, market prices and trade of recovered material

Introduction of compulsory recovery and recycling systems will affect the parameters that govern recovery, recycling and trade of packaging material. The question therefore arises as to the possible change in these parameters that may occur as a consequence of a switch from present, i.e. mainly voluntary and market-driven, systems to a compulsory recovery system. Except where a compulsory system is in place and where this question can therefore be answered on the basis of experience, an assessment can only be made in comparison with the present system, and this will of necessity be of a somewhat hypothetical/speculative nature.

Germany is a country which has some, albeit limited, experience with a compulsory system for the recovery of packaging material; it came into force in 1991. Its assessment of the evolution of recovery costs is that these will increase substantially because of the need to serve cost-intensive regions and locations. Increases in recovery costs are also expected in France, the United Kingdom, Finland, Sweden, and the United States. However, productivity gains -- for instance, a result of economies of scale -- may be reaped or innovations in the recovery system be introduced which would contain recovery cost or even lower them, and this latter effect is expected to occur in Norway. In other countries the situation differs: to the extent that the question has been looked into, the expectations in some countries are that recovery costs would remain stable (Netherlands, Austria).

As far as market prices of recovered packaging material are concerned, the assessment of the impact of increased recovery, whether voluntary or mandatory, varies very much between countries and is

considered difficult to predict. Interestingly, the assessment of Germany is that market prices of recovered paper and paperboard packaging material will increase, as a consequence of increased collection costs. A few countries tend to expect stability of prices (Austria, Portugal). Others (France, United States, Sweden, Norway, Finland) predict lower market prices, depending on the magnitude of the additional quantities of recovered packaging material which will come onto the domestic market. These may differ for individual grades of recovered material, depending, *inter alia*, on the level of recovery already attained. They may also be influenced by the quantities that are exported.

Consideration of costs and prices of recovered packaging and of the mechanisms to attain specific recovery targets, leads to the issue of possible subsidisation of recovery. In a system of voluntary recovery, subsidisation will tend to increase the volumes recovered, and this up to a point where the additional (marginal) recovery costs for additional volumes recovered are met by the level of the subsidy. The amount of the subsidy will thus be the parameter to determine what additional quantities are recovered. Naturally, locally isolated subsidisation, e.g. by a few municipalities only, will have a less significant volume effect nationwide than broader scale subsidisation. In the case of a compulsory system with prescribed recovery targets a mechanism will be required to compensate for the recovery costs incurred; these may be compulsory contributions by manufacturers or commerce (as in the case of the German and French Green Dot system) or straightforward subsidisation. Since compulsory recovery systems are usually nationwide, their total volume effect on recovery will tend to be significant. In order to avoid excessive downward pressure on domestic prices of the material recovered, minimum utilisation rates by the paper industry may be prescribed by the authorities and made a corollary of the compulsory recovery target (as in the case of Germany). The demand of the domestic industry will determine the price at which the recovery agency(ies) will be able to sell the recovered material; the recovery agency(ies) may also attempt to sell excess quantities abroad and at prices below the domestic ones (i.e. dump). Whatever the system, whether voluntary or compulsory, the extent to which subsidisation will impact on costs of recovery and on prices and quantities of recovered material may not be the same for individual grades and may well differ between them.

In line with the above considerations are the expectations of countries with regard to the impact of subsidies on recovery activity and trade flows. In Ireland, the paper industry sees the need for some kind of subsidy (in the form of recycling credits), to increase recovery; Italy expects that a significant increase in paper recovery is possible only if local authorities support selective recovery. As to the trade impacts of increased recovery of packaging material, it is generally expected that increased recovery in a great number of countries will cause increasing competition for export markets and price drops resulting in market distortion there. This effect is currently experienced severely by the Netherlands and, increasingly, in other EC countries which are being exposed to significant imports of recovered paper "at zero price" from countries with significant recovery activity; similarly, in Norway, attainment of the intended increase in the recycling rate of packaging material may fail because of the surplus of recovered material existing in other countries. More generally, and regarding the direction of recovered paper flows, it is interesting to note that countries which import significant quantities of recovered paper or are net importers of recovered paper, expect increased self-sufficiency and lower imports to result from their own increased domestic recovery (Italy, Portugal, Austria, Spain). The outcome then would be the simultaneous occurrence of, on the one hand, increasing competition for export markets from some countries and, on the other, reduced demand for imports in others.

Collective action and organised methods of recovering packaging

Government regulations regarding recovery and recycling of paper and board packaging material, in order to attain their intended goal, may necessitate collective action by the different actors, such as collectors and traders, packaging manufacturers, and the pulp and paper industry. This raises the question

of the impact of such collective action on the functioning of the market and especially of whether such impact may be negative. Naturally, the reply to this question, which translates a concern that the effects may indeed be negative, depends not only on the structure of the recovery system in place in individual countries but also on the possibility of having sufficient experience with them.

The only experience to date is that of Germany, since it is the only OECD country where an obligatory recovery and recycling system has been in place for some, albeit short, time. Here, it has been observed that the Government regulations distort the market nationally and internationally, changing the structure of suppliers, and leading to monopolistic concentration of merchant companies; when fully implemented, there is a risk that the total tonnage collected will not be in balance with national demand; there may also be imbalances for different grades. In France, the implementation as from 1 January 1993 of a decree concerning household packages and the preparation of a text relating to other kinds of packages are expected to cause a change in the nature of the market of recovered paper as well as modifications in the traditional recovery system; in the long run, downward pressure on prices of recovered paper are expected to occur as well. Similarly, concentration of the traditional recovered paper trade and the occurrence of recovery companies are expected in Finland as the result of the "waste law" mentioned before.

In those countries where recovery of packaging material is organised on a voluntary basis, negative effects are not generally considered to exist as long as the market price of the recovered packaging material is high enough to stimulate recovery. Pressure on the market price of recovered paper has been a severe problem in 1992 for such countries as the Netherlands. Due to the legislation on packaging material in other countries and the lack of enough recycling capacity, there is a significant export stream of recovered paper at "zero price" into the Netherlands. In the United States, the Federal government has not enacted legislation requiring recovery and recycling of paper and paperboard packaging or any other paper and paperboard material. Nevertheless, the industry has established a voluntary goal of recovery -- for domestic recycling and export -- of 40 per cent of all paper used in 1995. Since it was announced in 1990, significant progress has been made to meet this goal with more than 100 new US recycling projects up and running, under construction or publicly announced. On the supply side, existing and newly established collection systems, including numerous local curb-side and office recovery programmes, have generated usable recovered paper and paperboard to the mills.

A few countries where a compulsory collection system does not exist, are, however, developing ideas as to the conditions or the effects of such a system. For example, in Canada, the expectation is that a compulsory collection system would force industry to look at most effective ways of recovering fibre and of developing markets and infrastructures to serve them; joint ventures would occur; but collection costs are expected to be much higher than the value of the material collected. In Spain and Portugal, diverging effects are expected as a result of compulsory regulations: in the former, important increases in the availability of recovered material, with increased pressure on existing supplies, imports and prices; in the latter, an improvement in the quality of the packaging material collected due to improved sorting by grades. Industry circles in Italy, where compulsory collection of paper and paperboard products does not exist, hope that possible introduction of such regulations would not interfere with the existing collection systems and not lead to competitive distortions in the market of recovered packaging material; if this could be achieved, co-operation between those involved in the implementation of the regulations would make it possible to ensure rational development of recovery and recycling of paper.

Factors affecting the use of recycled materials

Specific regulations regarding the use of recycled packaging material for new packaging material do not exist in some countries (Netherlands, France, Austria, Ireland); but at the EC level a list of acceptable

raw materials and chemical additives in paper and board packaging materials that come into contact with food is under development.

In other countries regulations exist which have an effect on the use of recovered material in the production, in particular, of food packages. For example, in Germany, the Federal Health Office (Bundesgesundheitsamt) has over many years in the past issued recommendations concerning the manufacture of materials and articles that come into contact with food. Recommendations XXXVI, XXXVI/1 and XXXVI/2 cover the manufacture of paper and paperboard for food contact, of paper for cooking and filtering purposes and paper and paperboard for baking purposes. Recommendation XXXVI on "paper and paperboard for food contact" permits recovered paper as raw material, but excludes the use of a few low-quality grades. In Italy, a decree of 1973 guarantees purity of food packages; a later decree (1989), based on an EC directive, requires that all liquid packages must clearly indicate the material used in the manufacture of these packages. In Norway and Finland, recycled paper and board can in general not be used for direct packaging of foodstuff. In Spain, a decree was issued in 1990 concerning materials that come into contact with food; it contains general regulations to pave the way for the subsequent compilation of schedules of substances and materials whose use remains authorised. Some regulations exist in Greece for packages for food, drinks and pharmaceutical products. Restrictions on recycled content in food packaging exist in Canada. This is also the case in Switzerland -- where it also concerns packages for children's toys. In the United States, the use of recovered packaging must conform to all regulations of the US Food & Drug Administration (FDA) that apply to food packaging materials; recovered materials may be used as long as they contain no poisonous or deleterious substances that migrate to the food at a level above the limits established by the FDA. The situation in the United Kingdom is characterised by the fact that there is no legislation which bans the use of recycled materials for food contact use, but the producer of the packaging material has to prove that it can comply with legislation in terms of transfer of constituents to foodstuffs that could endanger health.

There do not appear to be technical limitations in principle to the recycling of recovered paper in papermaking since technological progress is advancing. From a strictly technical point of view, every kind of paper and paperboard product can theoretically be produced using recovered material. There are, indeed, numerous paper and board grades that are made from recycled fibre. However, there are a number of technical problems which tend to put limits to the use of recycled fibre, in particular, when certain performance characteristics are required. These relate, in the first place, to the quality, especially lack of uniformity, of the fibres obtained from the recovered paper material -- lack of uniformity causes the final product to have the characteristics associated with the use of the lowest paper grade. Further, the presence of contaminants, e.g., "stickies", sets technical limits. The increasing use of packages made from composite materials is another problem. Very importantly, recycled fibre loses strength in the recycling process and this causes diminished strength of the final product. In other words, to obtain the same physical strength properties using recycled fibre, the basis weight of the product must be increased.

It must, however, be noted that the rapid technological progress during the last few years has overall expanded recycling possibilities. Progress took the form of more sophisticated technology for the cleaning of recovered paper material before it comes onto the paper machine, of development of multilayer production technologies which allow a more efficient distribution of recycled fibre in the different layers of the final product, the introduction of dedicated control systems, of new coating technologies which allow to overcome the drawbacks which result from fibre dishomogeneity compared to virgin fibre, and, finally, the continuous evolution of papermaking know-how, especially with respect to obtaining specific performance characteristics of the final product.

In addition to technical factors there are economic factors which affect the use of recovered paper. They can be listed as follows: cost of recovered paper (and its most important component, i.e. cost of collection and transportation, especially in sparsely populated countries or regions); costs of preparing

recovered fibre for recycling, especially cost of sorting by grade; cost of machine adaptation, e.g. retrofitting of virgin fibre mills; loss of recovered fibre in remanufacturing; cost of disposing of sludge; loss of self-generated energy. All these costs have to be weighed against the market demand and price for the products manufactured with input of recovered fibre.

Regarding the scope for further substitution of secondary fibre for virgin fibre, the Ad Hoc Working Party has in its previous work ("Environmental Issues -- Waste Paper") drawn up a picture of the present situation of the use of such fibre in different paper grades. In packaging, it was found that the share of secondary fibre is in many countries between 50 and 90 per cent of the furnish -- with this proportion, however, being lower in countries with significant forest resources, such as Sweden, Canada and the United States. These rates may increase further in the future; for example, in the United Kingdom it is felt that in corrugated board further substitution for virgin fibre material could be made from the present level (which is 70 per cent).

Packages made from composite material, briefly mentioned before, pose particular technical and resulting economic problems in recycling and therefore warrant some special consideration. Composite packages are packages made from a combination of paper or boxboard and other materials, such as plastics, metals, and others. Their importance in total packaging material varies between countries at the present time, (e.g. 8 per cent Germany, France and Italy; 2 per cent, Canada; 1 per cent, Portugal), but they are considered to increase in the future. Worth noting in this context is the fact that in one country, i.e. Finland, the Environment Authorities have issued a recommendation that composite packages be reduced in view of the difficulties inherent in recycling.

The problems associated with composite packages in the recycling process are twofold. The first is that, since such kinds of packages are generally used for products like fats and liquids, the recovered packages can be contaminated. Recycling of packages so contaminated requires a particular decontamination process to avoid other recycled material being affected. The other is the separation process. This implies, first, the need to separate composite packages from other, full cellulosic fibre based packages, ideally already at the stage of collection -- which is very rarely done, except in the United Kingdom where the "Alliance for Beverage Cartons and the Environment (ABCE)" has set up a recovery scheme for used milk and soft drink cartons -- and, secondly, the need for separating the various composite materials from each other.

In composite packages, separating different kinds of materials from each other requires a very sophisticated and costly technique. Different approaches are in use or are being tried. In the United States, some firms de-poly milk carton converting scrap, and in Canada, a technique to eliminate polycoat from juice boxes is being studied; but its introduction will depend on the possibility to reap economies of scale. However, composites are often not used at all for recycling; they tend to be disposed of in landfill or incinerated. But research is under way in a number of countries. In Germany, research concerns used liquid board packages; in the United Kingdom, the ABCE mentioned before has set up a trial plant to assess the economics of processing composite cartons to recycle the aluminium and plastic lining as well as the cardboard. In the Netherlands, TNO carried out some research in previous years to delaminate composites. In the United States, a pilot project is under way to recycle aseptic cartons composed of different layers of paperboard, plastic film and foil. In Sweden, tests are run to recycle milk cartons and to assess the willingness of local populations to separate and collect composite packages.

Consumer and user attitudes

Over the last few years, there has evolved an almost generalised positive attitude of the public towards packaging material that is made from recycled material, and this on the part of both the industrial users of

the packages and the final consumers. In a number of countries, user and consumer attitudes towards such packages are described as "very positive", "generally favourable", "rather positive", or "acceptance without problems", "well received", "significant increase in interest for recycled paper and paperboard packaging".

The reason for this positive attitude is the increasing environmental consciousness of users and consumers themselves. For example, in Italy, it is reported, the attitude of package users is clearly influenced, in addition to technical factors (i.e. related to product characteristics), and economic factors (i.e. related to the costs of alternative packages) by those of environmental image, i.e. the image conferred upon producers who use recycled material for their products. But there can exist some discrepancy between what users and consumers say and what they actually do. For example, in Canada, it was found that the generally positive attitude of consumers towards recycled packages is not always reflected in their action. And in the United States, surveys have confirmed the existence of a conflict between what consumers say they prefer (namely recycled packaging) and what they actually do (i.e. make purchases based also on other factors, especially cost). Consumers' stated preference for recycled goods does not necessarily translate into purchases of these goods: for packagers, the most important decision is whether the packaging material is suitable to meet the required performance characteristics of the package, and the users look for packaging that serves their needs at the most reasonable cost. In many countries, despite increasing environmental-consciousness of producers and consumers, service performance and cost play the important role in their choice. And also, in a forest-rich country like Finland producers feel that more use could well be made of packaging material made from virgin material.

Trade effects of transborder regulations for recovered material

Compulsory regulations for recovery and recycling of packaging material will not only tend to interfere with the hitherto established market mechanism but it may also, due to increased availability of such material, impact on the quantities and prices of the recovered paper exported and imported and generate second-round effects on the prices and the recovery activities in other countries. This is one aspect. Another is the fact that recently, Governments have set up regulations dealing with transborder shipments of waste material. One is the "Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal" of 1987 and the other the 1992 OECD Decision on "Control of Transfrontier Movements of Wastes Destined for Recovery Operations". Both are also relevant for international trade in recovered paper which, a matter that is largely unknown, is an important commodity in international trade. The question arises as to the effects which these international agreements may have on the transborder movements of packaging material.

The Basel Convention was designed to address the problem of transborder shipments of hazardous waste. However, the Convention does not distinguish between hazardous wastes and non-hazardous ones (e.g. paper and paperboard), nor between shipments bound for final disposal and those intended for recycling. Another feature is that the Convention would prohibit countries that had ratified it from trading with those that had not ratified it. Some of the negative effects of the Basel Convention have been rectified by the OECD agreement which covers wastes for recovery and which provides positive lists categorising wastes according to the level of control that should be established over their crossborder shipment. Recovered paper and paperboard is included in the "Green List" of materials which are considered safe and can, therefore, be shipped using existing commercial procedures. The OECD agreement only applies to trade among OECD countries.

The expectations which countries have with respect to the impact of these two conventions on international trade in recovered paper vary greatly. While some countries (Germany, United Kingdom, Spain, Ireland) consider that there will be no particular problems at least in the immediate future, or even positive ones (Italy), others see negative effects evolving (France, Austria). Some countries underline the

need for maintaining free trade in recovered paper and paperboard (Netherlands). However, special problems may arise for countries which export significant quantities of recovered paper to non-OECD countries, such as the United States, where the share of such exports is as high as 73 per cent. Delay or failure to adhere to these conventions may cause problems for the export activities of the countries concerned. Such is currently the concern of the United States paper industry where significant negative impacts on US exports of recovered paper to non-OECD countries are expected if OECD modifications are not incorporated in the Basel Convention prior to its ratification by the US Congress.

Environmental aspects of packaging recycling

Like recycling of any paper material, that of packaging is not free from generating new types of environmental impacts; these are mainly related to the sludge which is generated in the recycling process and which needs to be disposed of. The Ad Hoc Working Party has in a previous activity ("Environmental Issues -- Waste Paper") discussed these matters and set them against the background of the overall environmental impact of increased recycling of recovered paper. In the following, a few additional considerations will be presented which relate to the recycling of packaging material. However, before that, one would have to note that paper and paperboard packaging, just as paper and paperboard in general, in the state in which it is collected, generally contains non-paper and paperboard materials of various kinds which need to be sorted out before the first recycling stages proper can begin. They include substances such as plastic, strings, staples, wires, and many others. In terms of weight these amount to between 10 per cent (France) and 12 per cent (United Kingdom, here representing some 216 000 tonnes) of the paper packaging material recovered. The presence of such unwanted substances is expected to rise in the future as packaging recovery intensifies. They need to be disposed of after being sorted out.

The real environmental problems arise, however, from the generation of "byproducts" in the recycling process, in particular, of sludge; these byproducts consist of broken fibre, of fines and ink, of semi-solubles such as starch and coatings, and of non-solubles, such as fillers. Their environmental impact needs to be taken into consideration. When recovered paper and paperboard is recycled, the difference between the amount of the recovered packaging material and the quantity of the final product depends very much on the product being recycled and the process being utilized. The difference between output of recyclable fibre and undesirable byproducts -- for example, between a standard corrugated box with minimal printing and a laminated or coated paper package with sophisticated printing -- is considerable. The environmental question arising in the context of increased recycling is one of the additional quantities especially of sludge that will be generated in the future and need to be disposed of. Precise quantitative information on this is not available in many countries. The following are examples of the quantities of sludge generated in countries by recycling of paper. In the United Kingdom, 72 000 tonnes of sludge are generated at the present time; in Austria, 80 000 tonnes of sludge are produced annually; in the Netherlands, about 50 000 tonnes; for Canada, the quantity of sludge produced through the use of recycled fibre in the manufacture of packaging is approximately 200 000 tonnes dry weight. In the United States, the percentage of sludge resulting from de-inking varies significantly depending on the paper grade but, on average, represents about 20 per cent of the paper produced from the de-inked grades.

These sludges are disposed of in various ways, such as burning for heat recovery, soil conditioning (in Switzerland, this is prohibited as from 1993), composting, concrete making, landfill and production of building material. The prevalent way of disposing of sludge from chemical pulp mills as well as from recycling plants is to dump it. Some pulp mills press the sludge to dewater it before sending it into the bark boiler for heat recovery; the heat value, however, is low and the content of heavy metals in the roundwood and bark in the ashes will be enriched when burning it together with the residues of chemicals and clay. The de-inking plant sludge, usually of unknown composition, is still most often deposited but it is believed that in the future incineration under controlled conditions will replace landfill which means

that the waste material must be sorted according to its content of noxious components in fillers, additives, colour print ink, etc. In many instances, though, sludge from recycling plants adjacent to newsprint and board mills are burnt for heat recovery, the ashes used as road and building material. Some countries like Germany, Canada, Sweden and Switzerland allow the use of black sludge as soil conditioner but farmers are often hesitant because of the risks of contamination of the soil; in Canada an analysis of heavy metals content is prescribed before spreading the sludge and in Switzerland, as mentioned before, this outlet is prohibited as from 1993.

Future trends in domestic recycling

Current trends suggest growing pressure for recycling. The growth in recycling depends on a variety of factors: the increase in demand for products with recycled fibre content, the nature of new recovery and recycling regulations, the competitive evolution of the paper industry and the development of technology.

The available quantitative information suggests the following developments in future input of secondary fibre: In Spain, the paper industry expects to raise sharply the intake of recovered paper, for three reasons: the existence of a trade deficit in recovered paper (500 000 tonnes) which could be filled by domestic supplies; cheaper input of recovered fibre to become available through increased recovery; and the strength of overall growth of paper demand. Increased selective recovery of paper in Portugal is expected to lead to higher input of recovered packaging material -- and less dependence on imported recovered material (which was 45 000 tonnes in 1990). In Austria, some 220 000 tonnes of packaging material are expected to be recovered from household waste annually as the result of the obligatory system which will be introduced on 1 October 1993. Sweden and Norway expect increases in packaging material recycling -- in the latter, the recycling rate for paper and paperboard packaging material is expected to rise to 50 per cent from the current 46 per cent. And the Finnish paper industry intends to recycle all paper and paperboard packaging material that is recovered in the country and, beyond that, also utilize imported recovered packaging material.

As to the situation on the North American continent, the Canadian industry has committed itself to diverting from landfills all the paper that can be recovered on an economic basis. As a result, recycling capacity in Canada will increase by 75 per cent between 1991 and 1994. In the United States, where the paper industry has set itself the goal to recover for domestic recycling and export 40 per cent of all paper and paperboard consumed by the end of 1995, there are reasonable expectations that the growth of paper and paperboard consumption by 1995 will lead to increases in recovery by some 11 to 12 million tonnes relative to the 1988 levels. Although US projections on the amount of additional paper and paperboard packaging material that would be recycled in 1995 are not available, it should be noted that corrugated material is the largest component of packaging material. Currently, corrugated box recovery stands at some 59 per cent and is expected to be in the 60 to 65 per cent range in 1995.

Future trends in landfill

In discussing future trends in landfill, just as in domestic recycling, an important characteristic of countries, or of particular regions in a country, has to be borne in mind which is the density of the population. Differences in population density of regions and countries impact significantly on the intensity with which packaging material can effectively be recovered as well as on the cost with which this is economically sustainable. It is therefore necessary to make a distinction between countries (or regions in a country) with different population densities, because different criteria will apply when targets are set for recovery and recycling and when the results are assessed.

One important parameter in the pressure for recovery of packaging material is availability and cost of landfill -- in addition to recycling in the domestic market which is examined later. The most important means of disposing of waste paper at the present time is, indeed, landfill; in many localities, landfill is often necessary if adequate recycling structures are not available. In the OECD area, between 35 and 60 per cent, depending on countries, of all paper and paperboard consumed currently ends up in landfill with the trend being downwards. Landfill sites are becoming increasingly scarce, putting additional pressure on the search for alternative modes of disposal of paper. With a very few exceptions, the increasing scarcity of landfill sites is a characteristic feature of all OECD countries.

For example, for Germany it is reported that less landfill space will be available in the next few years and that landfill will be concentrated on a smaller number of locations. In France, the law of 13 July 1992 concerning disposal of waste provides, by the year 2002, for the closure of 6 700 traditional landfill sites which absorbed the ordinary household and industrial waste without special treatment, and their replacement by 160 waste treatment facilities. The law provides for some support to municipalities which agree to set up waste treatment facilities on their location. In Austria and Switzerland, the possibilities for further landfill sites are virtually exhausted and no additions to the existing ones are foreseen. Opposition to new landfill appears to be particularly strong in Greece where municipalities do not accept any additional landfill activity, not even of the most modern technology, and many landfills will have to stop operating soon.

In some other countries, the requirements for future landfill sites appear to be rather modest. This is the case in Norway, where the need for new landfill sites is expected to be small; in Finland, landfill areas are expected to decrease, and in any case no longer to increase as has been the case in the past. But the question of future requirements of landfill sites is naturally open or cannot be answered in cases where more stringent recovery systems are expected to be introduced and where the precise provisions are not yet known.

This overall picture of growing scarcity of landfill sites should not, however, mask the fact that there are a few countries where the situation is different; and this is not necessarily a function of the size of the country or a region within a country. In a small country like Ireland, availability of landfill space does not present a problem and additional landfill space will come on stream as required. In a big country, such as the United States or Canada, the assessment of the future availability of landfill opportunities appears to have changed recently. There is an increasing awareness that not all regions of the country are facing landfill shortages and that greater flexibility exists in siting modern, environmentally sound landfills than had previously been recognised. Increased recycling, somewhat greater reliance on burning for heat recovery, composting and the recent economic slowdown have actually reduced the amount of refuse flowing to certain landfills in the United States. It appears that the United States will be able to site sufficient landfill capacity to meet its needs during the decade of the 1990s and that those needs will be tempered by increased recycling and greater reliance on waste to energy and composting. The same holds true for Canada, where the potential also exists to increase the capacity of existing landfill sites in certain regions of the country.

Difficulty to site landfills and increased efforts for recycling will lead to smaller quantities of packaging material being sent to landfill; this trend is increasingly likely within Europe as the measures contained in the EC Packaging Directive begin to take effect. In France, the goal is to put at most 10 per cent of used packages in landfill by the year 2002. In Sweden and Finland, an absolute decline in the tonnages going to landfill is expected, due to increased recovery and also of likely reduced use of packaging material.

III. ALTERNATIVES TO RECYCLING AND LANDFILL

Burning for heat recovery, composting, methanol gas and fuel generation

The information available on alternatives to recycling and landfill of packaging material suggests that no OECD country has regulations or standards pertaining specifically to burning of packaging material, nor to composting and methanol/ethanol fuel generation. One province in Canada, Ontario, has banned burning for heat recovery and will not currently allow packaging waste residue from a paperboard-to-ethanol process to be used to make the ethanol plant self-sufficient in energy. Regulations concerning burning for heat recovery that are in force in OECD countries relate to burning of household waste and not specifically of packaging material. They set limitations to the emissions from burning waste as laid down in national legislations on air emission control. They vary greatly with regard to contents and implementation. Lack of information on norms does not permit comparisons to be made here of the requirements imposed on combustors for municipal solid waste; the question of whether burning for heat recovery of low grade, often non-recyclable paper and board and packages, would be subjected to other emission limits is a matter of interest and is addressed later. No regulations exist pertaining to composting of packaging material or methanol gas recovery from such material.

At federal level in the United States, the Clean Air Act, as amended in 1990, and the new Source Performance Standards for municipal waste combustors have set rules for waste incineration. They apply if more than 30 per cent of the fuel is derived from municipal solid waste and also if the fuel is composed of pellets made of recovered paper and board.

Little information is available on standards for composting and methanol gas recovery; this seems to indicate that procedures for turning non-recyclable waste into useful products are not very frequently applied or are tried in pilot plants only. Other information tends to confirm this assumption. This may suggest that composting plants and methane gas recovery systems must comply with existing laws and regulations governing pollution controls and effluent limitations. Moreover, some countries have regulations on the use of compost -- like manure -- on various soils/sites and for different applications; the risk is also seen of contaminating the soil with residues from de-inking plants containing, *inter alia*, heavy metals (Netherlands). In Canada, the industry-supported Paper and Paperboard Packaging Environmental Council (PPEC) has instigated the commercialisation of composting of waxed corrugated containers. The end product meets Ontario guidelines and the Council is now working to add boxboard as compost.

Site selection for waste-to-energy and composting plants in, or close to, suburban industrial or residential areas, is reported to be politically difficult in practically all OECD countries. Though no country appears to have any formal obstacle to building burning plants provided these meet the air emission limitations, and though an increasing number of cities and municipalities intend to set up such installations in order to bring down the waste mountain, they are almost without exception likely to run into local opposition (the "NIMBY" syndrome). Even in countries with a high percentage of municipal waste burnt with energy recovery like Switzerland (80 per cent) and Sweden (55 per cent), public opinion tends to become increasingly negative and to conjure up the risk of emissions of toxic substances. Factual data about the harmless nature and for some substances, infinitesimal quantities of emissions from plants built according to best available techniques seem so far to carry little weight for the residents in areas "threatened" by a burning plant. In Spain, however, the energy plan covering the period up to the year 2000 provides for an increase in the amount and use of energy from renewable sources including fuel from solid urban waste. Public opinion in Spain is also particularly worried with siting of burning plants and extra efforts on information would be required. In general, enhanced information activity will be necessary in countries to inform the public of the enormous progress that has been made with waste burning in recent years¹. Particularly in Germany, but also in other densely populated areas in Europe and North America,

intense public debate may be necessary before concessions can be obtained. However, despite local opposition an increasing number of municipalities are going ahead with such plans. It is noted that numerous US communities as a first choice will try composting plants but resort also to burning for lack of alternatives to solid waste disposal because of the high cost of shipping waste over long distances to interstate landfills. Rising tipping fees in areas where landfill capacity may be inadequate within a foreseeable future are another incentive to reconsider the advantages of composting and burning for energy recovery and to inform the public that these methods are economically viable and constitute environmentally positive options to ordinary landfills of low-grade packages and municipal waste.

In the United States, because local municipal solid waste management systems vary in terms of their comprehensiveness and economics, alternatives to recycling as a means to prevent landfilling are gaining increasing acceptance. For example, many paper companies are moving rapidly to utilise recovered paper not suitable for recycling as supplement fuel in their boilers. Several long-term studies are being conducted by the US Department of Energy, electric utilities and a major oil company concerning the burning of pelletized non-recyclable paper and municipal waste in utility coal-fired boilers, and converting non-recyclable paper into ethanol.

A statement from NCASI (National Council of the Paper Industry for Air and Stream Improvement) in the US says that burning of non-recyclable paper in pulp and paper mill boilers should pose no particular environmental concern; similar reports from consulting firms in other countries confirm the experience of industry that non-recoverable paper and packages used for energy generation bring substantial environmental benefits.

The information available shows that in the opinion of some legislators and of part of the public, burning for heat recovery has a low priority as a way of disposing of recovered packages and paper. While for some countries the prime objective is re-use and recycling, others do not subscribe to this as long as life cycle analyses have not demonstrated the superiority of recycling over burning for heat recovery. Despite much opposition, the EC draft Directive on Packaging and Packaging Waste, too, gives a clear preference to material recycling, implicitly setting limits to the amounts that may be burnt (i.e. 30 per cent, unless it is proven that the environment stands to gain from an increased rate of burning).

In Sweden, studies have been made using a holistic approach reasoning in terms of natural cycles; these come out in favour of all products originating in forests. They show that recovery of fibre for new paper and board products is just one of several alternatives to the use and re-use of forest products (fibres and stored energy). Just as it is natural to recycle paper as long as the fibres are unbroken, versatile and clean, it is considered equally natural that the package should be recovered in the form of heat when economic or environmental reasons do not justify the cost of recovering the worn-down fibre ("The eternal cycle of nature")².

Alternatives to recycling -- A matter for research

In view of the growing concern about the environmental impact and of the unknown overall effects of new regulations in this field some OECD countries have undertaken studies on the consequences of plans to reach specific goals for the recovery and recycling of packaging material. For example, the United Kingdom has undertaken a thorough independent assessment of the effects on business (but also on consumers and local authorities) of the proposed EC Packaging Directive. For a few regions in Italy, some effects have been analysed, together with the problems of municipal waste in general, but no conclusive evidence for the various packaging materials (paper and board, plastics, etc.), has come forward.

In the United States, numerous studies have been conducted by federal, state and local agencies and others with a stake in paper recycling issues, but there is no known public study which comprehensively addresses the associated economic and environmental costs and benefits of recycling and other waste management options.

Such studies as were conducted in some countries focused on specific matters for which more insight was sought. For example, in France, a study showed that the cost of recovery can be expected to rise following the minimum limits proposed for the recovery in combination with a general fee on waste. In Germany, an assessment of the structure of the market of recovered paper, the volumes involved and the way it is likely to develop in the next years has been undertaken by non-governmental institutions including the pulp and paper association. The UK departments for industry and environment have undertaken a study on the use of economic instruments to promote recycling, especially with a view to packaging material. The study estimated the cost of achieving the government's target of recycling 25 per cent of domestic waste by the year 2000.

The environmental benefits and economic costs of Government mandated recovery and recycling of packaging material meet with increasing public interest and so does the question of the costs and benefits to the environment of alternative modes of disposal of paper and board packaging material. Studies (often called "life cycle analysis") have been initiated in the past few years by a number of university institutions and consultancy firms. Such studies are complex and the assumptions underlying them are the subject of considerable debate, often because the findings raise doubts as to the viability of high ambitions to recycle packages. It would seem, however, that such studies give rise to a number of methodological questions. It has been stressed that a potential weakness of life cycle studies is the tremendous amount of data required; in addition to data, they also involve value judgements. Notwithstanding, such studies may be useful in guarding against extremist suggestions for possible modes of protecting the environment.

In Sweden, a study was conducted by the Packaging Research Institute and published in 1991 under the title "collection of consumer packages". Its starting point is the law of 1990 requiring increased sorting at the source by households to raise the rate of recovery also of materials other than those already commonly collected like newspapers, corrugated boxes, glass, cans, etc. In line with the "cycle-of-nature" concept the goal of that law is that deposition and burning of unsorted municipal waste shall in practice be discontinued by the end of 1993³. The report concluded that from an economic as well as an environmental point of view, collection of paper and board packages from households should be limited to urbanised areas with at least 50 000 inhabitants. Consequently, only 60 per cent of the population of Sweden would be included in a source collection system of packages and those living in the countryside preferably would have to send their packaging material together with other household waste for use as fuel in the nearest district heating plant, or, if that is not feasible, to a dump area. Irish experience confirms that sparsely populated areas do not generate enough material to support the costs of a collection agent even with heavily subsidised prices on packaging material.

Also in Sweden, studies and trials have been undertaken about the cost per tonne of fibre collected for recycling. A major dealer in recovered paper, in collaboration with a board mill, is collecting in separate containers, milk cartons and other plastic-coated packages as well as corrugated boxes and board material⁴. By the end of 1993, experience will indicate the cost and quality of the recovered fibre, and to what extent it can be mixed into the furnish for liner and fluting as well as whether plastics and aluminium components can be economically recovered. Also, the general opinion that re-use is better than recycling which takes precedence over burning is questioned in a study by the Chalmers Institute of Technology in Sweden. The preliminary findings indicate that the quality of the fibres do not justify the cost and that the mode of disposal most beneficial to the environment would be to burn these kinds of packages together with the municipal waste or separately in industry boilers for steam-power generation, thereby replacing fossil fuel and reducing the CO₂-load on the atmosphere.

There is little information available to give guidance as to whether other modes of disposal of packaging material than recycling receive greater consideration, or indeed, have been under study in terms of life cycle analysis. In Canada, NAPP (National Packaging Protocol) is developing guidelines on life cycle analyses and it has been largely left to industry to assess alternative cost factors. Practically all countries intend to reduce to the magnitude of 10 to 15 per cent the volume of waste going to landfill. Only a few countries seem prepared to state openly that the next best disposal method is burning for heat recovery, but many work in that direction despite public opposition. There is nowadays abundant evidence that burning of municipal waste in modern plants with the best available technique meets the most stringent emission limits; for most pollutants the emissions are lower per MWh than in the case of coal, oil and even peat-fired plants and the emissions of CO₂ are comparable to those of wood.

In Sweden, the Board of Environment Protection has stated that waste burning for heat recovery represents no problem from an environmental point of view; this view is not shared by the public. Nourished by the dioxin debate some years ago, burning has remained in disrepute and made authorities overlook that dioxins and other hazardous compounds in the waste actually are destroyed when the waste is burnt under optimal and controlled conditions and that chlorinated substances are greatly reduced compared to the uncontrollable dioxin emissions from spontaneous fires in landfill.

In some countries, composting is considered an alternative to recycling, but no specific information is available. In the Netherlands, composting of recovered paper is, however, in contradiction with the provisions of the waste act. For Sweden, it is reported that in the past decade, ten plants were built to treat some 200 000 tons of household waste by separation and composting. An energy-rich refuse derived fuel (RDF) is produced in addition to a compost fraction. The RDF, in pellets or other form, have been difficult to market. In the United States, solid waste composting is emerging as an important part of integrated waste management plans in more areas of the country. When combined with other solid waste management alternatives, composting has the potential to significantly increase the amount of material diverted from the municipal solid waste stream. Currently, 21 mixed waste composting facilities are operating in the United States, another one is under construction and 35 more are in the advanced stages of planning. In 1990, only nine facilities were operating. A number of individual paper companies are participating in the Composting Council. This organisation, which includes composters, academics, public officials, consumer products companies and environmental groups, was established principally to develop standards for compost products, work toward defining compost products as recycled materials and to serve as an information clearing houses.

IV. INDUSTRY IMPACTS OF INCREASED PACKAGING RECYCLING

The significant increases in the recycling of recovered packaging material by the paper industry which are foreseen in some countries in the next few years will have an important impact on the activities and the operation of the pulp and paper industries. The following discusses three issues which are relevant in this regard: the evolution in processing capacities over the next few years, research efforts, and the possible impact on the "structure" of the industry.

Table 3 contains some information on the evolution of the production capacity for the processing of recovered packaging material as well as of other recovered paper. The information seems to indicate that the capacity increase is slightly lower than that for the other kinds of recovered paper. They also show that the foreseen increase in capacity for processing of packaging material is lower than the foreseen recycling of packaging material, most likely because of the fact that more packaging material is already recycled. But one has to bear in mind the impact which government policies and the uncertainties associated with the future direction of government policies may have on the future evolution of capacities. Current government policy initiatives, as was mentioned before, are aimed at "reduce, reuse and recycle".

Reduction of packaging, however, will result in a reduction of demand and therefore the need for recycling capacity. This makes forecasts of future capacities difficult and unreliable.

Table 3: Capacities for processing recovered paper and paperboard packaging and other paper (selected countries; 1 000 metric tonnes)

	Recovered paper and paperboard packaging			Other recovered paper		
	1985	1990	1995 (est.)	1985	1990	1995 (est.)
Finland	130	120	150	153	331	400
France ¹		2 209	3 297			
Germany		3 800	n.a.		2 000	n.a.
Italy	2 900	2 865	2 940			
Portugal ²		+40				
Spain ³	1 500	1 800	2 025			
Sweden	800	100	1 500	800	1 100	1 500
United Kingdom	1 500	1 800	2 200	680	1 290	1 650
United States ⁴	8 352	11 138	14 336 ⁵	6 980	9 467	12 576 ⁶

¹ All recovered paper.

² Additional capacity 1985 to 1990.

³ All recovered paper.

⁴ Recovered paper consumed in US paper and paperboard manufacture.

⁵ 1994.

⁶ 1994.

Increased recycling of recovered paper, in particular of packaging material, has prompted the pulp and paper industry to make efforts to master the technological problems associated with it. In most countries relevant research and development activities are under way. Such activities mainly concern the treatment of recovered paper, the preparation of the paper furnish, the behaviour of the furnish on the paper machine, the required quality of the final product, and ways to dispose of the sludge. Research is usually undertaken by industry itself, occasionally with the assistance of academic institutions, and often also supported financially by the public authorities in view of its environmental dimension.

In Germany, academic institutions such as the Technische Hochschule in Darmstadt (Institut für Papierfabrikation) and the Papiertechnische Stiftung in Munich carry out relevant research. In the Netherlands, TNO is undertaking research on a variety of matters, such as stickies, regeneration of secondary fibres, re-use of sludge, and others. Similarly, in Finland, large-scale research on stickies and wax is underway in the Finnish Central Laboratory and is partly funded by the Ministry of Environment. In the United States, four of the 23 academic institutions with pulp and paper programmes have been identified as domestically recognized "centres of excellence" in recycling technologies and another five have ranked this field as "high in emphasis" in their research program. These "centers of excellence" are facilities staffed with professionals who have demonstrable evidence of their pre-eminent standing in their specialized field and who have access to state-of-the-art equipment. The facility is recognized by the extent to which it has an influence on the industry's technology, reflected also in the industry's reliance on it for specialized technological information. These institutions are conducting research in such areas as removing contaminants from recovered paper and using lower qualities of recovered paper to make higher qualities of paper and paperboard. In addition, the federal government's Forest Products Laboratory has expanded its programs on recycling. In Canada, the industry-supported Paper and Paperboard Packaging Environmental Committee (PPEC) has instigated the commercial development of new hot-melt glue formulations and has also developed new markets for boxboard collected at curbside.

Public support to industry for such research is given by various bodies and in different ways. Incentives are available in the United Kingdom via the Environmental Technology Innovation Scheme which is a programme of grant assistance for pre-competitive, industrial research in the environment field. Industry research activities in Italy are in certain cases sponsored (50 per cent of cost) by the EC Commission; such projects are mainly aimed at promoting recovered paper and board utilisation by improving stock cleaning, especially in the refining phase; another area of research is recycling of sludges. In Spain and in the Netherlands, the government offers assistance through its various R&D programmes. In Spain, this takes the form of credits or outright grants under two programmes administered by the Ministry of Industry: the Environmental Technology Infrastructure Plan and the Industrial Technology Development Plan. In the United States, Congress passed a National Energy Bill which allows for funding industrial R&D into gasification of non-recyclable paper in solid waste. And in Canada, PPEC has funded research to make composting a viable alternative to recycling; it is currently working on a feasibility study to convert paper and paperboard material into the alternative motor fuel, ethanol.

Finally, there is only little knowledge available on the possible impact on the structure of the industry and, especially, whether there will be changes in the location of paper and paperboard mills. This question appears to be rather of a hypothetical nature at the present time. Alterations to already existing processes in the mills are expected to be only of a marginal nature. On the other hand, in the future, the setting up of new mills may, however, reflect the changing -- regional -- pattern of raw material supply. In sum, immediate impacts on the structure of the pulp and paper industry will be marginal; sustained ones, however, may occur in the longer term.

Annex 1

EEC

1. The EC Commission adopted a "Draft proposal for a Council Directive on Packaging and Packaging Waste" on 15 July 1992; it was amended in 1993. The proposal must go through the normal legislative process leading to final approval by the Council before entering into force. It would be reasonable to expect this process to take at least 18 months.
2. Recovery (récupération) is defined in the proposal as meaning "any of the applicable operations provided for in Annex II B to the Council Directive 74/442/EEC on waste".
3. The rules as far as takeback or similar obligations are concerned are defined in Article 5.1 of the draft Directive:

"Member States shall take the necessary measures to ensure that, within five years from the date by which this Directive must be implemented in national law, systems are set up to:

- a) provide for the return of all used packaging and/or all packaging waste from the consumer or waste stream or other final user in order to channel it to the most appropriate management alternatives;
- b) ensure that the used packaging and/or packaging waste collected is effectively reused or recovered, including recycled.

These systems shall ensure the coverage of imported products under non-discriminatory procedures and conditions including the tariffs imposed for access to the system and shall be designed in such a way that there are no barriers to trade or distortions of competition."

4. The pulp and paper industry was consulted during the drawing up of the legislation. It is for the Member States to decide how and to what extent the pulp and paper industry should be involved in the implementation of the legislation.
5. The legislation is likely to result in increased supply of certain grades of waste paper as a secondary raw material for the paper industry. It should also lead to more uniform prices for these grades of waste paper in the EC.
6. The following target is set in Article 4 of the draft Directive:
 - "no later than five years from the date by which this Directive must be implemented in national law, 60 per cent by weight of the packaging waste output should be removed from the waste stream for the purpose of recovery. Within this general recovery target, and with the same time limit, 40 per cent by weight of each material of the packaging waste output should be removed from the waste stream for the purpose of recycling, and has to be recycled;

- no later than ten years from the date by which this Directive must be implemented in national law, 90 per cent by weight of the packaging waste output will be removed from the waste stream for the purpose of recovery. Within this general recovery target, and with the same time limit, 60 per cent by weight of each material of the packaging waste output shall be removed from the waste stream for the purpose of recycling, and has to be recycled."

The Member States shall take action to promote the reuse of recycled packaging waste in the production of packaging.

Within the limits set out above, burning is a valid form of recovery subject to processing for the purpose of energy recovery having a minimum inferior calorific value of 13 MJ/kg.

Annex 2

CANADA

Every Province has its own packaging rules

Quebec: Currently has regulatory authority for content and composition of packaging, 3Rs infrastructure development, prohibitions and deposits. Is planning amendment to cover standards and codes and waste reduction work plans.

New Brunswick: Standards and codes and 3Rs infrastructure development for beverage containers exist. Looking at comprehensive packaging legislation.

Nova Scotia: Current regulations cover standards and codes, 3Rs infrastructure developments, prohibitions and deposits for all packaging.

Prince Edward Island: Has authority over one-way packaging, infrastructure development, prohibitions and deposits on all packaging.

Newfoundland: No current regulatory authority over packaging but intends to introduce enabling legislation this year, including that specific to beverage containers.

Yukon: Has Environment Act covering waste prevention, reduction and recycling. Currently working on regulations. Also targeting beverage containers.

Northwest Territories: No current plans to implement packaging reduction legislation. Has deposit/return system for alcoholic beverage packaging.

Ontario: Now has enabling legislation covering standards and codes, content and composition, 3Rs infrastructure development, and data collection for all packaging (Bill 143).

British Columbia: Currently covers infrastructure development and deposits for beverage containers but is drafting comprehensive packaging legislation.

Alberta: Has authority over standards and codes, content and composition, 3Rs infrastructure development and data collection for all packaging.

Saskatchewan: Existing legislation covers infrastructure development, prohibitions and deposits for beverage containers. Plans to introduce comprehensive packaging bill shortly.

Manitoba: Recently agreed to industry funded model collection from curbside in exchange for "level playing field" regulation for importers.

Federal: In the process of examining legislative options.

NOTES AND REFERENCES

1. It is perhaps understandable if noisy and ill-smelling installations designed for the purpose of destruction of the waste, supplied by heavy trucks and smoke stacks with black fumes and downfall of unburnt substances and fly-ash over the surroundings have left a negative impact on the minds of people; it is regrettable that the enormous advances in the techniques of waste burning are not realized as well as the fact that new plants often have lower specific emissions than corresponding condensing power or steam supplying plants based on fossil fuel.
2. In the cycle of products, a package is a refined biofuel as compared to the tree/pulpwood from which it is made. When it has served its function, its heat content can be utilised which, in turn, will reduce the consumption of oil and release the carbon dioxide absorbed during the lifetime of the growing tree. The cycle of nature can start again, a condition for a sustainable system, the only one that can continue to supply food, raw materials and energy, without adding to the greenhouse effect. In this biological system, the forest is by far the most important element, producing the fibre while absorbing in the photosynthesis the CO₂ released by burning biofuel of all sorts. Unlike fossil fuels exploited after millions of years in the ground, this natural cycle does not add to the rising CO₂ content in the air, the main reason behind global warming. The forest derives its energy from the sun. By a process of photosynthesis, solar energy is converted together with carbon dioxide and water into "fuel" for the growth of trees. This process makes the forest into a renewable source of raw materials, the main products of which are wood fibres and energy. Wood fibres are used for manufacture of paper products. If the used products are recycled as waste-paper, the fibres can be used several times. If paper waste is burned, the liberated energy can be put to good use. Paper is a biofuel which can reduce the need for fossil fuels such as oil and coal. Regardless of whether paper waste is burned or is allowed to decompose on a refuse dump, it will emit carbon dioxide to the atmosphere. The forest, however, recaptures the carbon dioxide for reuse in the photosynthesis process. The circle is thus closed and a new cycle can begin.
3. The study estimates that the households consume a total of 130 000 tons of paper packages (excluding corrugated boxes), of which some 50 000 tons are so contaminated or greasy as to make them unfit for recycling, the collection potential would be just over 60 per cent of all paper packages. Moreover, practical experience tells that the households possibly would set aside for separate collection 50 per cent of the packages which means that the recycling rate would be about 30 per cent (50 per cent of 60 per cent collection potential). The cost of recovering these packages rises very steeply with declining density of population. Estimated at 1 000 SEK/tonne in large cities, the recovery cost per ton in thinly populated areas would be more than the double. The load on the environment in the latter areas in the form of energy input in MJ and of emissions of NO, CO₂ and HC are seven to ten times higher per tonne of packaging recovered.
4. The packages are chipped, dissolved and the plastic separated. The fibre, good for mixing to a limited extent into plasterboard will be very expensive, the recovery cost only being 1 200-1 500 SEK/tonne, or considerably more than ordinary recovered fibre. In a two year practical experiment engaging the residents in two other cities, liquid packages are kept separate by the households for processing in a pilot plant connected to a board mill.