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EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY

ADVISORY BROCHURE

COST Action FP1003 - BioMatPack
Impact of renewable materials in packaging for sustainability
- development of renewable fibre and bio-based materials
for new packaging applications

End-of-life solutions for fiber and bio-based packaging materials - key aspects and opportunities

This brochure is intended for packaging manufacturers and is designed to give a short overview of the present end-of-life (EOL) solutions for bio-based packaging materials. It addresses current standardization, legislation and socio-economic aspects related to renewable packaging in Europe. It provides insight into the performance of the existing EOL technology in relation to bio-based packaging materials and emphasizes the main challenges that still need to be tackled in order to achieve efficient recovery of bio-based materials.

Introduction

Efficient end-of-life (EOL) options play an important role in developing sustainable packaging solutions because they contribute to waste reduction, thus having a positive environmental impact, whilst providing economic and social benefits.

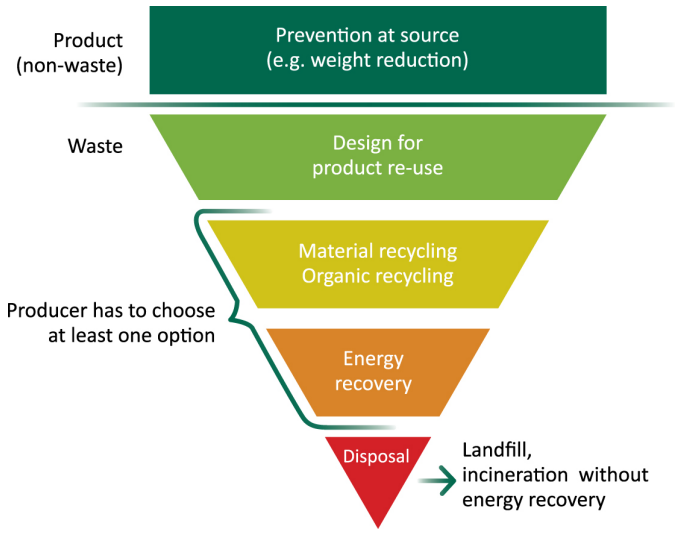
In the EU, recycling, organic- and energy recovery are viewed as beneficial EOL scenarios for packaging made of paper, board or bioplastics, hereafter referred to as bio-based packaging material. According to the CEPI 2050 Roadmap[1], the core strategy is to get the highest possible value from resources like wood, virgin/recycled fibres, and non-fibrous raw materials. Much research has been conducted on biomaterials for packaging applications, but there are still open questions in the context of EOL which have to be resolved.

Legal / Political Aspects

The **EU Waste Framework Directive**[2] lays out the waste policies to be adopted by the Member States. According to the Directive, each Member State shall promote and encourage re-use, recycling and incineration with energy recovery, in this order of preference, with the aim of reducing the amount of waste that is committed to landfill. These steps form the waste management hierarchy (Figure 1) which is legally binding except in cases that may require specific waste streams to depart from the hierarchy.

Therefore, waste should no longer be considered as garbage or rubbish that belongs in landfills but as a secondary raw material with a potential for re-use, recycling or at least for energy recovery. Additionally, all Member States have an obligation to set up separate collections for paper, metal, plastic and glass by 2015.

Managing the packaging stream at the end of its life cycle is currently regulated in the EU by the **Directive on Packaging and Packaging Waste**[3] which requires the Member States to set up return, collection and appropriate recovery systems. The Directive also stresses that it is enhanced producers responsibility to ensure that the environmental impact of the packaging and packaging waste is reduced as much as possible throughout its life cycle. Moreover, it sets a target of 60% material recovery from used packaging. It is therefore necessary to enable material and organic recycling as preferred EOL options for bio-based packaging solutions.



Prevention	Reduction of the quantity and of the harmfulness for the environment of materials and substances contained in packaging and packaging waste.
Re-use	Any operation by which packaging is refilled or used for the same purpose for which it was conceived.
Recycling	Reprocessing in a production process of the waste materials for the original purpose or for other purposes including organic recycling.
Organic recycling	The aerobic (composting) or anaerobic (biomethanization) treatment, under controlled condition and using micro-organisms, of the biodegradable parts of packaging waste.
Energy recovery	The use of combustible packaging waste as means to generate energy through direct incineration with the recovery of the heat.

Figure 1. Waste management hierarchy

Notes

[1] Confederation of European Paper Industries CEPI: The Forest Fibre Industry – 2050 Roadmap to a low-carbon bio-economy, 2011
[2] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives
[3] European Parliament and Council Directive 94/62/EC of 20 December 1994 on packaging and packaging waste
[4] "An introduction to Packaging and Recyclability", Nov 2009, PRAG: Packaging Resources Action Group
http://www.wrap.org.uk/sites/files/wrap/Packaging%20and%20Recyclability%20Nov%2009%20PRAG.pdf
[5] DIN EN 643:2014-05 Paper and board - European list of standard grades of paper and board for recycling
[6] EN 13432:2000 Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging, November 2000
[7] European Bioplastics, FAQ, August 2013, Available at: http://en.european-bioplastics.org/press/faq-bioplastics/
[8] Compostable plastics 101, An overview of compostable plastics sponsored by the California Organics Recycling Council,
Available at: http://compostingcouncil.org/admin/wp-content/plugins/wp-pdfupload/pdf/8095/Compostable%20Plastics%20101%20Paper.pdf

Definition of Packaging Types

This brochure addresses EOL options for packaging materials made from renewable fibers and bio-based polymers that are used in bioplastics or as coatings for paper-based packaging materials. These materials are currently present in the packaging market as both fiber-based and non fiber-based solutions, with each group having a number of different material and design variations (Table 1).

Table 1. Classification of bio-based packaging materials according to their EOL options

Bio-based packaging solutions			
Fiber based (comprising mostly fibers)	Conventional paper and board		Present as a mono component.
	Paper and board laminates and multilayers	Type 1	Containing conventional non-biodegradable coatings/layers (e.g. aluminum, oil based plastics).
		Type 2	Containing only biodegradable coatings/layers (starch based film, PLA).
Non fiber-based (comprising mostly bio-polymers)	Biodegradable plastics		Plastics that are both bio-based and biodegradable, such as PLA and PHA or PBS
	Non-biodegradable plastics		Bio-based or partly bio-based ("drop-ins") but non-biodegradable plastics, e.g. BIO-PE, BIO-PET

Technical Aspects

In Europe the definition of suitable end-of-life option of packaging products is regulated by a group of homogenised norms under the umbrella of the Norm **EN 13427**. This specifies both the requirements in production to minimize waste as well as the design for valorisation through recycling or energy recovery for all materials. In order to select the EOL option, the use of packaging, potential contamination and the main material component must be taken into account. Furthermore, chemical additives and multi-layer components should be selected in order to minimise any constraints to material recyclability as highlighted in the norms and relative CEN reports.

Material recycling: how to design a recyclable packaging?

The recyclability of a package essentially results from its design. Even though the current ecodesign regulation does not apply to packaging, there are some principles that are appropriate for all packaging products when considering designing for recyclability[4].

- Use only a small number of packaging materials
- Use mono materials wherever possible
- All content easily extracted
- Constituent materials easily separated
- Exclude additional items that can contaminate waste stream, e.g. plastic labels, cut out window
- State the material and recycling message, clear instructions about separating different materials

Packaging that is made of **paper and board** is inherently recyclable and therefore has a comparatively high utilization rate; an average of 76 % in Europe. However, contaminants introduced during production, converting and usage, such as plastic and wax coating, labels and adhesive joints, non-paper components or wet strength additives can cause problems in the recycling process. The main parameters affecting the recyclability of paper and board are **repulpability, sticky potential (removal of adhesives) and non-paper components**. The recently released European List of Standard Grades of Paper and Board for Recycling[5] has enhanced the number of products accepted in the paper recycling stream but nevertheless stipulates stricter limits for non-paper components and unwanted materials in all paper grades. Moreover, it has grouped most of difficult to recycle products in category 5.

In order to avoid cross-contamination the collection of paper and board based packaging should be separate from other waste streams. However, in some areas the collection is comingled together with glass, plastics, metals, which results in higher sorting costs to produce a material of adequate quality.

Concerning the material recyclability of **bioplastics** a differentiation between "drop-ins" and true biopolymers is necessary. For bio-based and partly bio-based non-biodegradable plastics (known as "drop-ins"), such as bio-based PE, PP, PET the conventional recycling together with petroleum-based plastics is the usual EOL option. The "drop-ins" need to be clearly differentiated from the true biopolymers, which are bio-based and biodegradable, such as PLA, PHA, PBS, and consequently act as contaminants in the petroleum-based plastics stream, causing quality problems. Therefore they can just be recycled as a mono-fraction. However, the separation of these biodegradable plastics from the conventional plastic is only technically feasible if infra-red spectral sorting is employed. This approach is still not economic because of the small amounts of biopolymer present in the market.

Table 2. Technical standards and testing methods concerning material recycling of paper and board

Technical standards	
Material recycling	**EN 13430:2004** Packaging - Requirements for packaging recoverable by material recycling
	CR 13688. Report on requirements for substances and materials to prevent a sustained impediment to recycling.
TEST METHOD Paper recyclability	**PTS METHOD 021/97**. Testing of raw materials, pulps and additives of paper manufacture.
	ATICELCA METHOD MC 501-13. Analysis of recyclability level of cellulose based packaging.
	ECOPAPERLOOP METHOD 1-14 (technical leaflet available and score card under development for ERPC, adoption foreseen in 2015)

Organic recycling: how can it be certified?

Composting is a treatment for waste streams which contain only biodegradable organic material. As most plastics resist degradation and cause contamination they are traditionally banned from composting. The European norm EN 13432[6] stipulates definitions, methodology and pass levels for testing the **compostability** of packaging products. Also, a neutral, competent third party has to validate the conformity with EN 13432 and guarantee the monitoring of the product on the market.

The effective organic recycling of biodegradable packaging would require the separate collection of biodegradable waste and legal access for certified compostable products to enter respective systems[7].

Table 3. Technical standards and testing methods concerned with organic recycling

Technical standards	
Organic recycling	**EN 13432:2000** Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging
	ISO 17088-2012: Specifications for compostable plastics
	ASTM D64-12. Standard specification for labeling of plastic designed to be aerobically composted in Municipal or industrial facilities.
	AS 4736-2006. Biodegradable plastics- Biodegradable plastics suitable for composting and other microbial treatment.
TEST METHODS: Aerobic biodegradability (composting plants)	**EN14046; ASTM D5338; ISO14855**
TEST METHODS: Anaerobic biodegradability (Anaerobic digestion plants)	**ISO 14853-15985 ASTM D5511**
Disintegration test methods	**EN14045, ISO16929**

Table 4. Suitable end of life options for bio-based packaging solutions with respect to the waste hierarchy priority order

Suitable end of life options for bio-based packaging solutions					
End of life option	Conventional paper & board	Paper & board multilayers Type 1	Paper & board multilayers Type 2	Biodegradable plastics	Non-biodegradable plastics
Material recycling					
Paper	+	+	+/-	-	-
Plastic	-	-	-	-	+
Organic recycling	+	-	+	+	-
Energy recovery	+	+	+	+	+

Communication and Social Aspects

To ensure that bio-based packaging materials are being correctly disposed of, the end-consumer has to be properly informed about suitable end-of-life solutions for a specific material. However, inconsistency in **product labelling** and **variations in terminology**, caused by the lack of accepted definitions, are creating confusion among consumers upon purchasing and when discarding the products. Multilayer paper based products are collected differently in different countries and also within some countries in order to ensure their best end of life option in a specific situation. Producers should be specific when producing labels (e.g. recyclable, please check your local community rules for proper disposal) or alternatively local authorities and waste management companies should always clearly instruct citizens. Moreover, the confusion among consumers will become even more prominent with the introduction of new materials, such as bioplastics and compostable plastics, into the packaging market.

European Bioplastics defines **bioplastics** as **bio-based, biodegradable, or both**[7] implying that not all bio-based products will biodegrade. Many bio-based plastics are designed to behave like traditional petroleum-based plastics, and remain structurally intact over a longer period of time[8]. Thus, it is of the highest importance to distinguish biodegradable bio-based products from non-biodegradable ones. However, a material that is designed to biodegrade will not necessarily compost.

Compostability is a characteristic of a product that allows it to biodegrade under specific conditions (e.g. a certain temperature, timeframe, etc.). These specific conditions are described in standards, such as EN 13432. Materials and products complying with this standard can be certified and labelled accordingly. Also, a clear distinction between products that are **home-compostable** and those which are designed for **industrial composting** may be required, along with consumer education about proper disposal channels. Moreover, biodegradable materials should not be confused with **oxo-degradable** materials which are in fact traditional polymers which contain additives that initiate degradation by ultraviolet light and oxygen. These innovative materials are not at all biodegradable in the composting plants nor do they meet the legislative requirements for organic recovery.

Proper labelling of bio-based packaging can be regarded as an efficient tool in targeting consumer behaviour, thus achieving effective recovery of bio-based products. Hence, a **unified**, **common** and **universal disposal labelling scheme** must be created. Moreover, the labels should provide clear, simple and concise information regarding the recommended disposal (recovery) options for a certain material.

Conclusion

The positive market value of used paper and board based products shows that the current EOL option of material recycling is established and successful. However, considering future demands and technological trends, challenges associated with an increasing complexity of packaging have to be mastered in order to maintain the high level of recycling. A strong focus on packaging design is required as well as stricter criteria to assess the recyclability behaviour of specific new products entering the paper recycling stream. For composting and recycling of bio-based plastics adequate structures still need to be introduced. The amount and value of the bio-based plastic waste fraction needs to rise in order to make separation systems economically feasible.
To ensure that bio-based packaging is being properly disposed of by consumers, the packaging producers must e nsure proper labelling of their products, thus providing clear and concise information about the recommended disposal options for used materials. This would, in the end, satisfy consumers' demand for more environmentally responsible packaging and would help to achieve higher efficiency in bio-based packaging recovery.

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Forest based packaging counts for around 35-40% of the global packaging market and 40% of the paper and board production is used in the packaging market. Hence, the packaging market is of enormous importance for the forest based sector.

To give the forest industry a competitive edge this Action has focused on packaging solutions based entirely on renewable resources in order to remove the serious disadvantages associated with future paper and board packaging solutions that continue to rely on non-renewable materials. The Action has explored possibilities that the forest itself could offer as a raw material base for different components within a given package, thus exploring the full potential of the fibres.

The main objective of the Action has been to enhance the knowledge concerning packaging from the forest sector and thus identify potential new renewable packaging solutions. Since a sustainability approach is the scope of this COST Action, aspects related to technical, environmental, economic and societal outcomes has been addressed taking the whole packaging value chain into account.

The Action has included partners from 19 European COST countries, New Zealand and CEPI.