



## INTERNATIONAL WORKSHOP ADVANCES IN CLEANER PRODUCTION

"KEY ELEMENTS FOR A SUSTAINABLE WORLD: ENERGY, WATER AND CLIMATE CHANGE"

# Contribution of Packaging to Cleaner Production Goals

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### Abstract

Packaging industry is faced with challenges of using different strategies to prevent emissions at the source and to initiate continuous preventive improvements of its production processes. However, numerous other industries and services use packaging products which gives packaging products a specific feature. Thus, firms should be aware of modern trends of packaging products. Dematerialization of packaging is a continuous trend which has important role in source reduction but at the same time has detrimental effects on recyclability. However, the latter is still often believed to be one of the most important environmental criteria for packaging in different cleaner production programmes. Considering such dilemmas, two major questions arise with regards to packaging role within the concept of environmental protection and cleaner production. First, how to quantitatively evaluate its environmental impacts and, secondly, to what extent packaging contributes to the reduction of overall (life-cycle) pollution prevention. Namely, protective role of packaging is too often neglected in discussions on packaging and environmental pollution problems. In a paper different aspects of packaging in line with the environment are discussed which confirm that packaging must be viewed in a wider context as usual because not only technological but also demographic and social changes significantly influence its environmental image. This effects not only the production optimization but also the environmental profile of the whole product supply chain.

*Keywords: packaging, environmental impacts, dematerialization, supply chains.*

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### 1 Introduction

A wide range of technologies and related research disciplines can contribute to cleaner production. One of them is packaging industry whose materials, products and technologies play enormous role in modern economy and society. Question which is permanently facing the packaging industry in last decades is how to evaluate the environmental impacts of the packaging products as objective and accurate as possible and which are the relevant criteria. Defining such environmental criteria is also important for their proper use in cleaner production initiatives and projects. This question is further emphasized with the development of environmental legislative, waste management practices, introduction of environmental taxes and overall environmental protection awareness in a global society.

Cleaner production is the conceptual and procedural approach to production that demands all phases of the life-cycle of a product or of a process should be addressed

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with the objective of prevention or minimization of short and long-term risks to humans and to the environment. That means, cleaner production starts with a holistic optimization of the companies production and service processes in mind. Because prevention must be the first approach within such approach the question arises what are the prevention possibilities which can be linked to the packaging in the context of cleaner production.

Regarding the importance of packaging in economy and society, the question is which are the relevant criteria of sustainable packaging to be included to the cleaner production initiatives. Due to the fact that packaging is bought, used and disposed also by the individual consumers, not just technological but social and demographic aspects and trends play very important role in determination of such criteria, too. For example, recycling of packaging wastes is topic which is regularly put very high in public and professional discussions. It means, packaging, in connection with environmental problems, is usually associated with waste problems only and, consequently, with national recycling schemes. Although it is an important topic, the other aspects which are too often forgotten when judging packaging with respect to the environment, are rather presented in this paper.

## **2 Packaging in connection with cleaner production**

Cleaner production is an ongoing process that can be applied to production processes, products or services. According to Jaworski and Minns (2001), approaches to cleaner production can be grouped into three categories:

### *Level 1: Waste reduction at source*

- good housekeeping;
- process modification;
- product modification;
- change of materials.

### *Level 2: Recycling of wastes*

- internal recycling;
- external recycling.

### *Level 3: Use of renewable resources:*

- for the production of energy;
- for the production of materials and chemicals.

All these levels - which show interdisciplinary character of cleaner production philosophy - can also be linked to the production and use of packaging products. However, packaging can be, on one hand, studied as an independent cleaner production project dealing entirely with packaging industry alone, and, on the other hand, as a part of a wider environmental optimization in different industries and services which have to use packaging for packing their products or delivering their services. Some industries like beverage, food, chemical, pharmaceutical etc. use enormous quantities of packaging per year. Therefore, proper consideration of

packaging within cleaner production initiatives could contribute additional value to the firm's environmental profile and costs reduction.

In addition, packaging connects three major interrelated driving forces for cleaner products and processes: market demand, advances in science and technology, and government policy as defined by Organization of Economic Cooperation and Development (OECD 1995). In this context modern packaging has also a significant preventive role which is in accordance with cleaner production concept taking into account the promotion of efficient use of resources and energy.

Considering this, two major questions arise with regards to packaging role within the concept of environmental protection and cleaner production. First, how to quantitatively evaluate its environmental impacts and, secondly, to what extent packaging contributes to the reduction of overall (life-cycle) pollution prevention (Fig. 1).

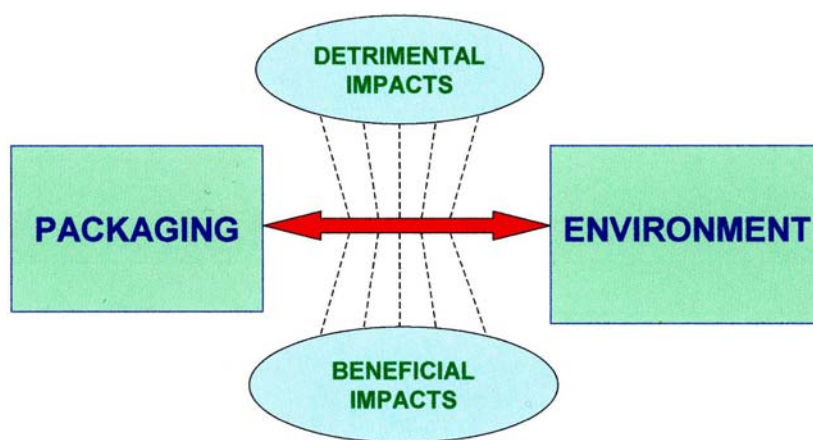


Fig. 1. Packaging in relation to the environment.

### 3 Packaging's environmental impacts and environmental criteria

It is the most common opinion that the environmental burdens of the packaging arise from the manufacturing processes, the transport process and the generation of the solid wastes after its use. The latter, in combination with recyclability, is especially popular in discussions on packaging's environmental impacts. Of course, the role of production processes cannot be neglected. Worell et al. (1995) estimated, for instance, that the technical potential in the Netherlands plastics packaging industry has a potential of about 34 % in improving materials efficiency. The realization of such potential could improve the energy efficiency within the life-cycle of plastics packaging by 30 %. But do these criteria really show the complete picture?

Nowadays, the additional criteria which spread through packaging's life-cycle are often put forward when evaluating packaging's environmental and economical profile (Anon. 2005):

- Is packaging beneficial, safe and healthy for individuals and communities throughout its life-cycle;
- Does it meet market criteria for performance and cost;

- Is it sourced, manufactured, transported, and recycled using renewable energy;
- Does it maximize the use of renewable or recycled materials;
- Is it manufactured using clean production technologies and best practices;
- Is it designed to optimize materials and energy use;
- Is it designed for effective recovery after its use?

One method to support product environmental information needs – developed and internationally accepted in recent years – is life cycle assessment (LCA). LCA considers the entire life cycle of product: extracting and processing raw materials, manufacturing, transportation, use, re-use, recycling and final disposal. It identifies and quantifies energy and materials used and wastes released to the environment and assess the impacts of related inputs and outputs. Due to its holistic approach LCA became the leading quantitative method for the assessment of environmental impacts of products and so of packaging, too. Many LCA studies of the packaging have been carried out during last decades using different methodologies and considering various conditions (many summarized in Radonjič, 2008). Although the concept of the product's life cycle is very reasonable, the question arises whether are the results obtained by standardized LCA methodology enough for the complete identification of the packaging environmental profile or not. Namely, by definition, LCA considers strictly environmental issues. Nevertheless, in reality there are also other issues, like social, economical and technical that cannot be ignored.

Packaging in line with the environment can and must be viewed in some other contexts, too. Various factors which are too often avoided when the environmental aspects of packaging are discussed should be taken into account. Demographic and social changes, for example, significantly influence the environmental image of packaging. This has a significant further effect on the environmental aspects of the supply chains. Therefore, packaging should be considered also in the context of the goods it contains and how they are going to be used. Namely, packaging is made exclusively for the product's sake, not for packaging itself.

### *3.1 Dematerialization of packaging*

Dematerialization means reducing the weight of the packaging without losing its protective and other characteristics. The main question regarding the dematerialization is: could it be possible to deliver the same amount of packed product with less packaging material. Significant weight reductions of packages have been achieved in the last decades through technological development of new materials, improved processing techniques and more efficient design (Bürkle 1998; Radonjič 2008).

Indicator which is becoming more and more important regarding packaging dematerialization is product-to-packaging weight ratio. Using less material has additional advantages because it usually requires less energy in production and transport and reduces associated pollution. For food products such ratio is on average 10:1 (but it ranges between 1 and 200 times depending on the packed food) (Anon. 1998). For technical product this ratio is even much higher. In addition, the product which packaging contains almost always has a far greater environmental impact than the packaging itself. Of course, packaging dematerialization should be assessed without losing product's value due to the breakage or spoilage. That leads to opposite environmental effects.

Recent report from Germany on plastics packaging showed the weight per unit area of flexible plastics packaging material decreased by 36 % between 1991 and 2000, the package weights of bottles and large containers dropped by 21 % and the weight reduction by 11 % for cups and tubs was achieved (Vorspohl and Bruder 2004).

It must be emphasized that the use of lighter packaging materials also reduces the transport costs, energy consumption and emissions at every step of the supply chain. Hekkert et al. (2000) show that evaluation of improvement measures could lead to 9 % reduction of CO<sub>2</sub> emissions related to primary packaging by using lighter primary packages and a reduction of 12 % CO<sub>2</sub> emissions because of the substitution potential of transport packaging.

First problem which is connected with the use of lightweight packagings (which are used mostly in the form of the multilayered structure) is their much worse ability for recycling or even inability of recycling at all. Therefore, the question arises what is environmentally beneficial: a heavier packaging made from a single material or lightweight flexible packaging where much less primary resources and energy were used per packed product. In such case, the environmental balance from cradle to grave will be necessarily.

Second problem which can appear with the use of lightweight packaging is the loss of the packed products due to the insufficient protection. Careful balance of underestimated and overestimated packaging use is one of the crucial aspects of sustainable packaging (Fig. 2). Firms which use high quantities of packaging per year can have significant materials savings even with the weight reduction of few grams per packaging unit. However, lack of protective packaging function can cause, in opposite, high costs and image loss problems because of the damage of the packed products.

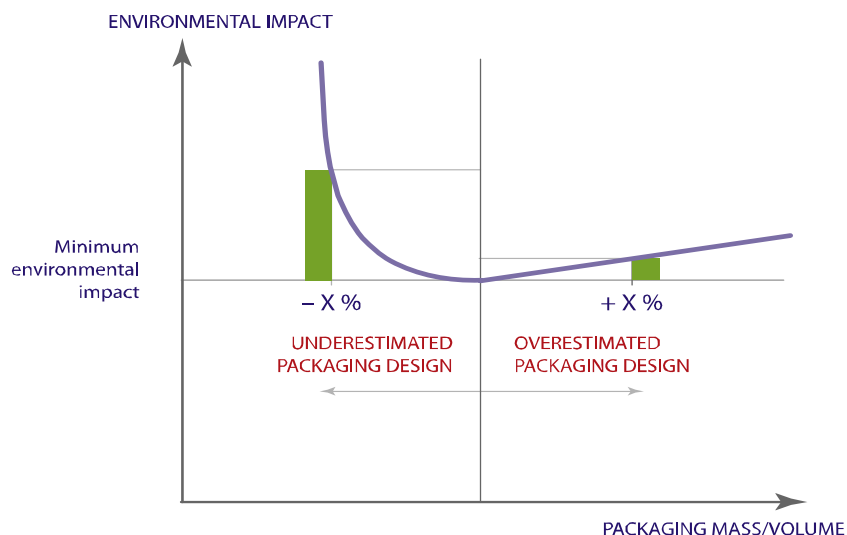


Fig. 2. Packaging environmental impact minimization by proper design (based on Erlov et al. 2000).

### 3.2 Environmental impacts of packaging in supply chains

Packaging is central to the safe, convenient, hygienic and efficient transportation of goods from the place of production to the end consumer. Packaging's role in supply chains is beneficial to the environment because it protects packed goods which would otherwise significantly contribute to the increasing amounts of wastes of all

kinds. Especially, the quantity of spoiled and wasted food would significantly increase compared to packaging wastes. The same is true for technical and other damaged products. It is estimated that the lack of adequate packaging and logistics in less developed countries leads to losses of food up to 60 % compared to 3 % in the more developed countries (Bürkle 1998; Oki and Sasaki 2000).

Compared to the most product groups, packaging is often under an imputation of being harmful to the environment. Not the same is valid for the packed goods. This indicates that the real role of the packaging for distribution, sale and use of commodities is not completely well understood. Some comprehensive studies, like in Great Britain and the Netherlands, confirmed that energy use in the food supply system is dominated by the energy used for producing and preparing the food, whereas energy use for packaging represents on average 10 % of the cumulative food supply chain energy use (Fig.3) (Anon. 1996; Kooijman 1996; Høgaas Eide 2002). Furthermore, it can be seen that consumers have a significant effect on energy use, too. Therefore, effective optimization of the total environmental impact needs careful matching of packaging with total food use and associated waste disposal systems. These studies confirmed that concentrating on subsystems like packaging wastes could be risky without a more extended analysis of consequences for other parts of the food supply chain.

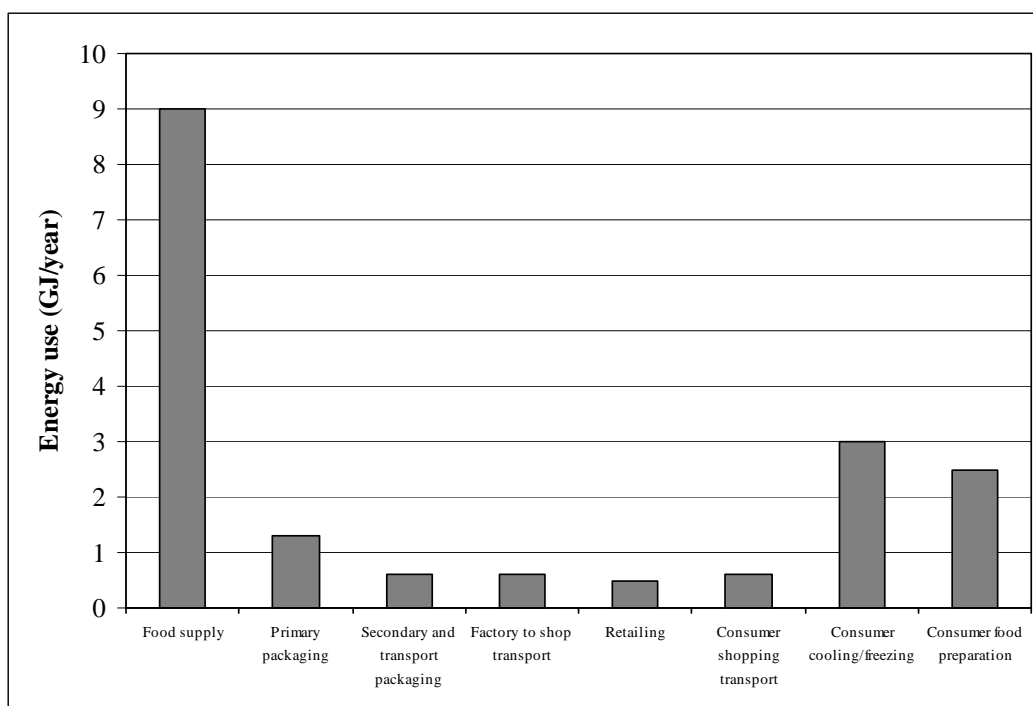


Fig. 3. Energy use in the UK food supply chain (Anon. 1996).

As concluded, much more primary resources and energy is used on average for the production of packed goods than for packaging itself. If products are damaged or spoiled in a supply chain all primary resources used for the production of that product are lost which represent much higher environmental impact than packaging.

### 3.3 Influence of demographic and social trends

World population growth has significant effects on environmental problems in general. In addition, increasing urbanization means more intensive distribution of

goods, especially foods. The role of efficient packaging in such changing society is crucial.

Consumer habits changed in last periods. Changes in society are also having an effect on the food supply system and, consequently, on packaging. First of all, consumers expect to be offered a wide range of food, independently of the season and with a long shelf-life. Marriage and starting a family now occur later than in earlier decades. Single and small households want packaging that is tailored for small portions and this means more packaging. Different members of the family eat at different times of day and, consequently, need more smaller portions. Increased demand for ready-to-cook prepared meals needs more sophisticated packaging and more meals are eaten outside the home and such food needs to be available in individual portions. Therefore, smaller households generate on average more packaging waste per person than larger. But higher level of wasted food per person in smaller households would be probably greater if they could not purchase the small portion sizes to suit their consumption needs (Anon. 1996). All these factors must be considered before designing measures to encourage the reduction of packaging. In general, consumer life styles and expectations influence the packaging development and trends which all have certain environmental impacts (Table 1).

Table 1. Some packaging trends and related environmental impacts (based on James 2004)

Packaging Trend	Driver	Environmental impacts
Sale of products in smaller portions	Increased number of single-person households; Popularity of small portions for children's lunch boxes	More packaging material per unit of product
Increasing range of complete meal replacements	More women working; Longer working hours; Increasing popularity of convenience foods; Changing lifestyle priorities; Reduced interest in food preparation	Many packaging not currently recyclable
Pre-packed meat and vegetables in modified atmosphere packaging (MAP)	Increased popularity of convenience foods; Increased demands for fresh foods	Not currently recyclable; More material per unit product
Products with longer shelf life	Trend to increased consumer convenience; Shopping less frequently for staples	Not currently recyclable; May contaminate recycling streams
Tamper-evident packaging	Contamination cases	Additional packaging; Many materials not currently recyclable

#### 4 Conclusions

Judging the environmental suitability of the packaging on the basis of its recycling ability is not completely in accordance with sustainable development criteria. They emphasize the effective use of the raw materials, effective energy use and reducing the overall emissions in the entire life cycle of packaging. The recyclability of packaging should no longer be automatically the most important aspect for judging environmental profile of the packaging. Awareness of other described aspects which

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are not considered so often show how complex is the problem of packaging in relation to the environment. Such approaches and criteria should also be considered within cleaner production projects and initiatives where packaging represents an integral part of a system.

Numerous cases confirmed that the environmental impact of the packaging must be evaluated together with the packed goods which it protects. Environmental considerations also has to take into account the interrelationships in the product-packaging-trade-consumer system. Namely, the actual use of the packed product determines the quantities of packaging and hence affect waste quantities. Material and energy use throughout the entire supply chain should be taken into account (especially for food packaging).

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