Step 2 Sustainability

Online Course

UNIT 9
Sustainable packaging for footwear

How to Implement Sustainable Manufacturing in Footwear
- New Occupational Profile and Training Opportunities -

How to Implement Sustainable Manufacturing in Footwear - New Occupational Profile and Training Opportunities

Credits

Title
UNIT 9 - Sustainable packaging for footwear

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1. Introduction

Packaging must meet several functions. In first place, to protect the packaged contents. It is an extremely important element in the supply chain, distribution system, and finally the method of use or handling of the product. It also contributes significantly to a more secure and long-term use of the products. Despite this, packaging has a negative connotation in the general public's perspective due to the huge accumulation of packaging waste on landfills.

With regard to packaging, there is also the other side of the coin. Actually, packaging prevents the formation of additional massive amounts of waste, which may arise due to the rapid deterioration of food and the damage to goods during transportation or storage. Packaging also enables easier and cheaper delivery of goods to the consumer.

Packaging manufacturing companies and companies who use packaging for their products will be less competitive in the future if they ignore the obviously increasing trend of the environmental requirements in product development. Therefore, the question arises how to tackle the planning, design, development, and deployment of environmentally friendly packaging. What are the criteria they should comply with?

This publication is designed in such a way that the problem of packaging in relation to environmental protection in the footwear industry is presented in a comprehensive manner, from the basic to the wider aspect of its development. The purpose of this publication is also to provide guidance for the design and development of modern packaging, because the process of development without using environmental criteria is not sufficiently thorough.

2. Definition and purpose of packaging

There are a lot of definitions for packaging, but a broad and well-established one can be: packaging is "a coordinated system of preparing goods for transport, distribution, storage, retailing, and their end-use; the means of ensuring the safe delivery to the final consumer in a sound condition at minimum cost; a techno-economic function aimed at minimising the costs of delivery while maximising sales (and hence profit)".

According to Hanlon, the functions of packaging system are basically to protect, contain, carry, and dispense a product. The Consumer Goods Forum has also made a broader definition of packaging system functions, which are:

- Protect the product.
- Promote the product.
- Provide information on the product, usage, health and safety, disposal, etc.
- Enable the convenient transportation and usage of the product.
- Allow the unitisation of the product through the supply chain.
- Support the efficient handling of the product throughout the supply chain.

Finally and obviously, it is possible to conclude that one of the main purposes of packaging is to ensure that a product can be transferred from the point of production to the point of use in perfect condition, so that the product itself is in the condition expected by the user.

3. Packaging classification

The packaging classification can be made with regard to many different categories. Most important classifications are: composition material, purpose of use and packaging layer, durability of use, field of use, contact of packaging with the material, etc.

3.1. Packaging material

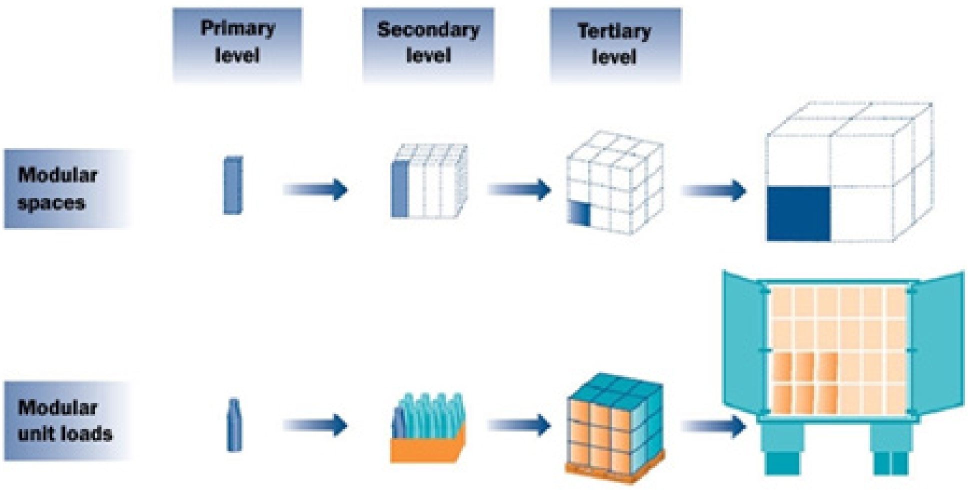
Packaging can be made from different kinds of material. Most important are: paper and cardboard, plastic, textile, wood, metal, glass, and composite materials. In shoemaking production, paper and cardboard are the most often used packaging materials. Less important are plastics and/or metal cans, glass bottles for liquids, and chemicals and wood for wooden pallets for the transportation of goods.

3.2. Purpose of packaging use and packaging layer

Depending on the purpose and/or the function in the logistic chain, packaging is divided into more basic types of packaging:

- Sales packaging (also called consumer, retail, or primary packaging), is the sales packaging at the point of purchase. This is the term used to designate the layer of packaging in immediate contact with the product; in other words, it is the first packaging layer in which the product is contained. As such, sales packaging is constructed both with the product itself and any existing secondary layers of packaging in mind. The properties of the product (form, dimensions, and consistency) obviously dictate the main priorities of this packaging. Primary packaging can have diverse applications and functions, depending on the product, transit, and storage variables. The most obvious, and important function is to protect and preserve the product from damage, external interference or contamination, spoiling and chemical imbalances. This packaging also serves to keep a product in storage, often for long periods of time. In this case, it is imperative that sales packaging keeps the product absolutely sealed off from its environment. Ease of handling and shelving is a further aspect to be considered, so as to ensure the product can be easily handled by consumers (Figure 1).
- Display packaging (also called merchandising or secondary packaging) is the packaging used at the point of purchase to contain or present a number of sales units. It can be removed from the product without affecting its characteristics. This packaging designates the packaging used to group various pre-packaged products together. As secondary packaging is not in direct contact with the actual product, its use and application usually differ distinctly from those of primary packaging, although the purpose of both types may at times converge. Display packaging serves to group several products together for ease of handling, transport, and storage. This means that the packaging must be able to: contain relatively large volumes of primary packaged products, transport the product safely to its retail or consumer destination, and to keep the primary packaging in its original condition during storage. Secondary packaging is intended to protect not only the product, but also the primary packaging, which is often the packaging most visible to the consumer in retail displays (Figure 1).
- Transport packaging (also called distribution, traded, or tertiary packaging) is the packaging used to facilitate handling and transport of a number of sales units or grouped packages in order to prevent physical handling and transport damage. This packaging focuses on the packaging requirements of the goods in transit, in particular for items travelling overland by road or rail. Given the nature of the road and rail infrastructure, transport packaging should be manufactured so as to absorb unintended shocks, impacts, or accidents of any kind, as well as protect against the elements such as humidity, excessive temperatures, or heavy weather. Transport packaging must take into account the possibility of multiple stages in transit before the product reaches its final destination. This packaging should be as individual as the product itself and perfectly match the product’s consistency (dimensions). The focus here is also on packaging that is lightweight, robust, easy to handle, and that takes up as little space as possible (Figure 1).

- Some sources also mention a fourth level of packaging: so-called industrial or business-to-business packaging used for the transport and distribution of products for industrial use. This kind of packaging is usually big containers for transporting tertiary packaging by train, air, or ships. Industrial packaging must also give priority to conserving the product for long stretches of time during storage, keeping the product hermetically sealed and free from external contamination. Tailor-made industrial packaging is only as good as the materials it uses. As industrial goods are often either heavy, bulky, sensitive to external contact or hazardous substances, industrial packaging materials include: stainless steel, corrugated containerboard, paperboard and fibreboard, wood, etc. It should be able to meet international packaging standards, as well as the quality control requirements of the countries of manufacture and final destination (Figure 1).



F1. Example of packaging layers

- In the field of shoemaking, we should also mention a special group of packaging, called packaging for dangerous goods. This refers to the materials and procedures employed to pack hazardous materials for safe transit and storage. Due to the sensitive nature of the products being handled, dangerous goods packaging is undertaken by specialist packers with suitable experience in this field. Most items that require dangerous goods packaging consist of chemical substances containing one or more unstable components, which may react when mishandled or when coming into contact with their external environment. The main priorities of dangerous goods packaging are to ensure that the packaged product is stable and sealed, so as to protect both the product itself and the persons handling it. Dangerous goods packaging often comes in a secondary form (to reinforce the primary packaging, or facilitate its handling/ bulk packing). Labelling is of the utmost importance in dangerous goods packaging, as this indicates the correct manner in which the hazardous material ought to be handled, carried and stored. Incorrect labelling can greatly reduce the effectiveness of dangerous goods' packaging and can pose great risk for the persons handling the product. Dangerous goods packaging must comply with international standards and regulations, which may differ from country to country (Figures 3 and 4).

3.3. Durability of packaging:

With regard to durability, two different types of packaging exist:

- Reusable (returnable) packaging: after use of the product, it is returned to the shop, from where it is returned to the manufacturer and re-used (e.g. a beer bottle of).
- Non-refundable (disposable or non-reusable) packaging: it is for single use only. After use, it is recycled or otherwise harmlessly removed.

3.4. Field of use

Regarding the field of use, the following types of packaging exist:

- Fast-moving consumer goods (FMCG) or consumer packaged goods (CPG) are products that are sold quickly and at relatively low cost. Examples include non-durable goods such as soft drinks, toiletries, over-the-counter drugs, toys, processed foods, and many other consumables. A customer usually spends minimum effort to procure them.
- In contrast, durable goods or major appliances, such as kitchen appliances, are generally replaced over a period of several years.

3.5. Contact with the product

Regarding the contact between the product and the packaging, the following types of packaging exist:

- Packaging separable from the product: packaging that is not part of the product (e.g. protective wrapping paper, a cardboard or corrugated paper box for shoes, etc.).
- Packaging that is inseparable from the product: packaging that is part of the product (e.g. tube, can, plastic bottle for oil, etc.).

3.6. Other packaging categorisations

There are also many more categorisations of packaging types:

- Standard packaging: this is a type of packaging made according to a certain standard, and the exact shape, size, and from a particular material. Standard packaging means cheaper production and is used by most manufacturers, while allowing the use of single filling machines and packaging.
- Protected packaging: is a type that a company develops exclusively for its own needs, protecting it with licence or patent, and thus cannot be used by anyone else without their permission. The most famous example of such packaging is the Coca Cola bottle.

4. Packaging materials

The following materials are used most often in the different fields of packaging production:

4.1. Wood

Wood packaging material or WPM is also called Non-Manufactured Wood Packing (NMWP) or Solid Wood Packing Material (SWPM). It is defined as hardwood and softwood packaging other than that comprised wholly of wood-based products such as plywood, particle board, oriented strand board, veneer, wood wool, etc. which has been created using glue, heat, and/or pressure, or a combination thereof, used in supporting, protecting, or carrying a commodity (includes dunnage). Examples of WPM include pallets, skids, pallet collars, containers, cratings/crates, boxes, cases, bins, reels, drums, load boards, or dunnage (Figure 2).

F2. Example of a wooden packaging

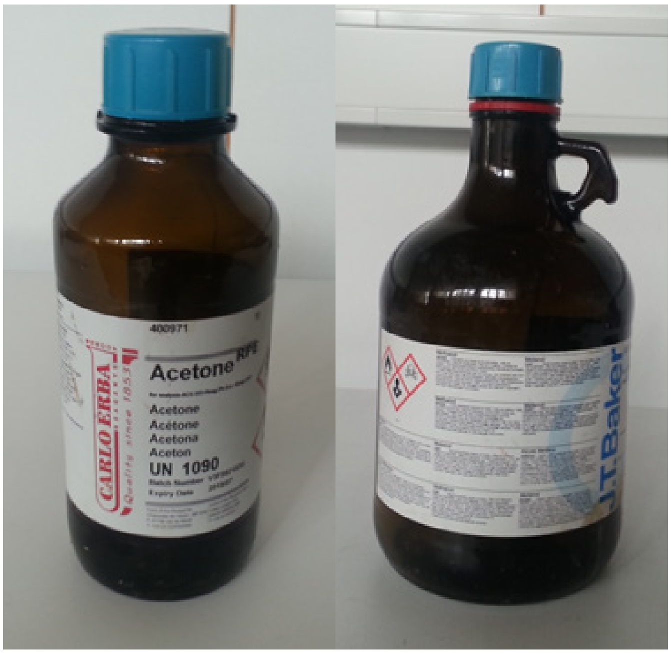
4.2. Metal

Steel coated with tin to protect it against rust which is used to package canned foods. It can be separated by magnets and should be recycled in all cases. Aluminium is attractive, light, and strong at the same time, but requires a lot of raw materials and energy to make. The majority of cans of soft drinks, lids, aluminium foil, etc. are made from aluminium. In footwear production, metal packaging is mostly used for transporting glue or for different kinds of protective finishing for the finished footwear (Figure 3).

F3. Examples of metal packaging for glue used in shoemaking

4.3. Glass

Is the material used most often for different kinds of liquids. It is inalterable, strong, and easy to recycle. It is the traditional vessel in the home (jars, glasses, jugs, etc.). Its weight and shape may involve some difficulties for transport storage. Glass packaging in the footwear industry is mostly used for glue hardeners and for different kinds of chemicals (Figures 4).



F4. Examples of glass packaging for chemicals

4.4. Plastic

This is the most common packaging material and, at the same time, one of the most difficult to dispose of. The factors common to all plastics are that they are light, strong, and cheap to manufacture. These are the reasons that they are used so much, as an alternative to cardboard and glass packaging materials. Almost 10% of our waste consists of different types of plastic. They are a problem in landfills as they are bulky, they contaminate, and degrade slowly. In the footwear industry, plastic packaging is mainly used for glue, chemicals, packaging components or finished products (e.g. ski boots, rollers), and plastic shopping bags or carrier bags made from various kinds of plastic. In use by consumers, these bags are sometimes called single-use bags, referring to carrying items from the shop to home. However, reuse for storage or rubbish is common, and modern plastic shopping bags are increasingly recyclable or biodegradable. In recent decades, many countries have introduced legislation restricting the sale of plastic bags, in a bid to reduce littering and pollution (Figure 5).

F5. Examples of plastic packaging for glue used in shoemaking (above) and for water and chemicals (below)

4.5. Paper and cardboard

Paper and cardboard are one of the oldest materials which still cover the largest proportion of packaging. They are the most widely used materials in the footwear industry as well. Mostly, they are used as:

- shoe stuffing paper or filler paper to preserve the shape of the shoe
- wrapping paper to protect the footwear in a pair box
- pair box to protect the finished pair of shoes before delivery to the customer (Figure 6 above)
- transport packaging for transporting the finished products (shoes) from the place of production to the place of sale (Figure 6 below)

F6. Example of a pair box (above) and transport box (below) made from corrugated paper

4.5.1. Materials used in the production of paper and the production process of paper

Probably half of the fibres used for paper today come from wood that has been purposely harvested. The remaining material comes from wood fibres from sawmills, recycled newspaper, some vegetable matter, and recycled cloth. Coniferous trees, such as spruce and fir, used to be preferred for papermaking because the cellulose fibres in the pulp of these species are longer, therefore making for stronger paper. These trees are called "softwood" in the paper industry. Deciduous trees (leafy trees such as poplar and elm) are called "hardwood". Because of the increasing demand for paper and the improvements in pulp processing technology, almost any species of tree can now be harvested for paper. Other materials used in paper manufacture include bleaches and dyes, fillers such as chalk, clay, or titanium oxide, and sizings such as rosin, gum, and starch.

The method of making paper is essentially a simple one. Mix up vegetable fibres and cook them in hot water until the fibres become soft but not dissolved. The hot water also contains a base chemical such as lye, which softens the fibres as they are cooking. Then, pass a screen-like material through the mixture, let the water drip off and/or evaporate, and then squeeze or blot out any additional water. A layer of paper is left behind. Essential to the process are the fibres, which are never totally destroyed, and when mixed and softened form an interlaced pattern within the paper itself.

The number of trees and other vegetation cut down in order to make paper is enormous. Paper companies insist that they plant as many new trees as they cut down. Environmentalists contend that the new growth trees, so much younger and smaller than what was removed, cannot replace the value of older trees. Efforts to recycle used paper (especially newspapers) have been effective in at least partially mitigating the need for the destruction of woodlands, and recycled paper is now an important ingredient in many types of paper production. The chemicals used in paper manufacture, including dyes, inks, bleach, and sizing, can also be harmful to the environment when they are released into the water supplies and nearby land after use. Paper production requirements are now based on pollution-free paper production.

4.5.2. Paper types

Paper can be produced with a wide variety of properties, depending on its intended use:

- for representing value: paper money, bank notes, cheques, as security paper, vouchers and tickets
- for storing information: books, notebooks, magazines, newspapers, art, booklets, letters
- for personal use: diaries, notes to remind oneself, etc.
- for communication: between individuals and/or groups of people
- for packaging: corrugated boxes, paper bags, envelopes, packing and wrapping papers, paper string, charta emporetica, and wallpaper
- for cleaning: toilet paper, handkerchiefs, paper towels, facial tissue, and cat litter
- for construction: papier-mâché, origami, quilling, paper honeycomb, used as a core material in composite materials, paper engineering, construction paper, and paper clothing
- for other uses: emery paper, sandpaper, blotting paper, litmus paper, universal indicator paper, paper chromatography, electrical insulation paper, filter paper, etc.

Paper is often characterised by weight. In Europe and a lot other regions using the ISO 216 paper sizing system, the weight is expressed in grams per square metre (or usually just in grams or gsm) of the paper. Printing paper is generally between 60 gram and 120 gram. Anything heavier than 160 gram is considered as card. The weight of a ream (500 sheets) therefore depends on the dimensions of the paper and its thickness.

The ISO 216 system used in most countries is based on the surface area of a sheet of paper, not on a sheet's width and length. It was first adopted in Germany in 1922 and generally spread as nations adopted the metric system. The largest standard size paper is A0 (A zero), measuring one square metre (approx. 1189 × 841 mm). Two sheets of A1, placed upright side by side, fit exactly into one sheet of A0 laid on its side. Similarly, two sheets of A2 fit into one sheet of A1 and so forth. Common sizes used in the office and at home are A4 and A3.
The density of paper ranges from 250 kg/m3 for tissue paper to 1,500 kg/m3 for some speciality paper. Printing paper is about 800 kg/m3.

Paper may be classified into seven categories:

- printing papers of a wide variety
- wrapping papers for the protection of goods and merchandise – this includes wax and kraft papers
- writing paper suitable for stationery requirements – this includes ledger, bank, and bond paper
- blotting papers containing little or no size
- drawing papers usually with rough surfaces used by artists and designers, including cartridge paper
- handmade papers, including most decorative papers, Ingres papers, Japanese paper, and tissues, all characterised by lack of grain direction
- specialty papers including cigarette paper, toilet tissue, and other industrial papers

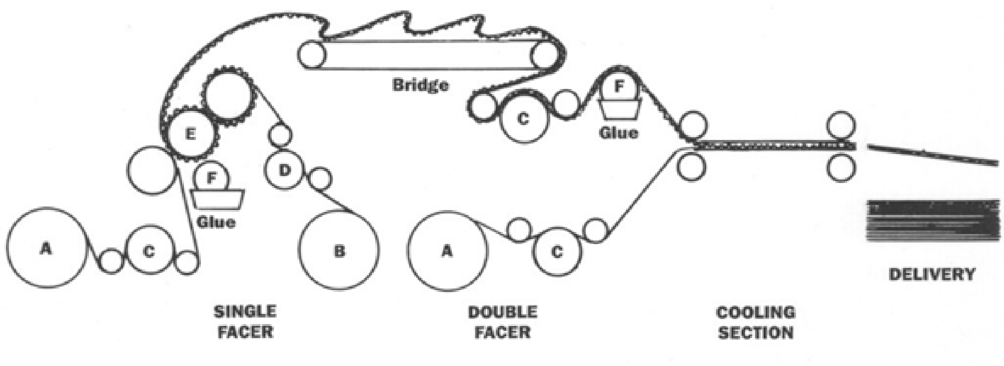
5. Packaging made from corrugated paper

A corrugated box is a shipping container made of corrugated fibreboard. These are most commonly used to transport and warehouse products during distribution, and are rated according to the strength of the material or the capacity of the finished box. This kind of packaging is probably the most used type of packaging in the footwear industry.

5.1. Structure of corrugated board

The basic structure of corrugated board is simple. It consists of a fluted sheet glued to one or more liners. The most common construction is a sheet of "corrugated medium", sandwiched between two liners. A wide variety of combinations are possible, depending on the packaging requirements. Where great strength is required, three sheets of medium can be combined with appropriate liners.

The structural characteristics of corrugated board are governed by four variables: the strength of the liners, the strength of the corrugated medium, the strength and the number of flutes per metre, and the number of walls (single, double or triple).

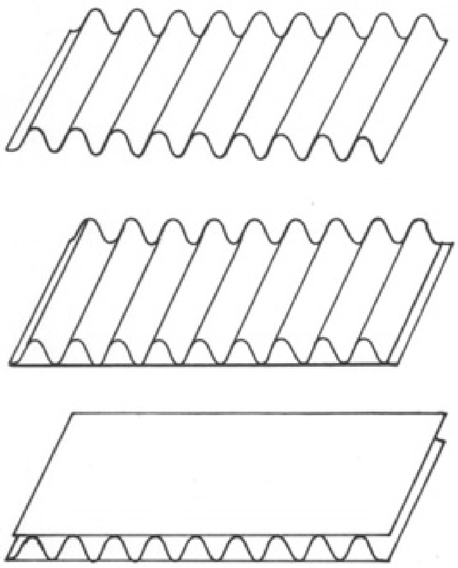


F7. Simplified scheme of corrugated board production

A simplified schematic of a corrugator is presented in Figure 7. The corrugating medium is preconditioned and shaped by the corrugating rolls. The preheated line-board is then glued to the face of the corrugated paper and conveyed to the double facer for attaching the liner on the opposite side. The assembly is then dried over hot plates and run through pressure rollers for stability. Once the medium has passed through the cooling section, it's cut to the required size at the delivery section.

5.2. Flute structures

A number of flute structures are available depending on the packaging specifications. A-flute has a great capacity to absorb shocks owing to the wider spacing of the flutes. B-flute, because of the larger number of flutes per metre, provides maximum crush resistance. C-flute combines the properties of the first two types, and E-flute is used where very thin corrugated board is recommended (Figure 8).



F8. Unlined corrugated A-flute (up), single-face corrugated A-flute (middle) and single-wall (double face) corrugated A-flute (below)

The flute types vary in the dimensions of the flute pitch t and flute height h (Table 1).

FLUTE TYPE	FLUTE HEIGHT h [mm]	FLUTE PITCH t [mm]
G	≤0.55	≤1.8
F	0.6–0.9	1.9–2.6
E	1.0–1.8	3.0–3.5
D	1.9–2.1	3.8–4.8
B	2.2–3.0	5.5–6.5
C	3.1–3.9	6.8–7.9
A	4.0–4.9	8.0–9.5
K	≥5.0	≥10.0

T1. Flute types and dimensions

5.3. Designing and printing corrugated boxes

The design of a corrugated box is a major undertaking. The process of selecting the correct packaging design for a particular product has grown more complex as new technologies and materials present ever-increasing manufacturing options.

The ways in which corrugated board may be used are practically limitless. Certain basic container styles and designs are suitable for packaging a wide range of products. There are some corrugated interior devices (platforms, paddings, or inserts) and plastics (moulded polystyrene foam) used to provide reinforcement, bracing, and shock absorption.

Specialty containers are tailored to the requirement of a particular product. These requirements may involve everything from the "shipability" of the product itself to how the container is filled, stored, loaded, stacked, braced, dropped, and unpacked.

Directly printing on brown corrugated board, which has a highly absorbent surface, is usually limited to the use of line art. This is the least expensive printing method usable on corrugated board. Letterpress and, more recently, flexography are the typical printing methods.

It is difficult to print full colour on most corrugated board, with the exception of E-flute. Therefore, labels are often prepared to cover the boxes on one or more of their sides. There are several variations of label application, including lamination onto the box, depending on size, shape, and cost considerations.

6. Key problems of packaging in connection with sustainability

Packaging undoubtedly represents a serious environmental problem, but it is necessary to look on this issue from different perspectives and draw attention to the complexity of this problem.

Environmental problems in the field of packaging can be summarised in four basic and interdependent areas:

- resource depletion
- environmental impacts in the production of packaging materials
- content and migration of toxic substances
- waste packaging and handling of waste packaging

Because of the steadily increasing packaging waste, companies that either produce or use packaging therefore often face comments and complaints, such as:

- that a lot of products have too much packaging material
- the increasing use of disposable packing products for the needs of producers, but not due to the needs of customers
- the usual disposal methods can't meet the latest packaging technology

6.1. Waste packaging

Packaging makes an important contribution to the quantities of total solid waste (municipal and industrial) in the industrialised world. In 2008, Slovenia produced 106 kg of packaging waste per capita (in 2004, this amount was 81 kg per capita). For comparison: in Germany, the amount of packaging waste in 2010 was 196 kg per capita and in the EU-27, 157 kg per capita. Among the EU countries, there are significant differences not only in terms of the quantities of packaging waste per capita but also in the dynamics of its growth. While some countries recorded a constant growth in packaging waste, others (e.g. France, Austria) have managed to contain and stabilise its creation.

In order to coordinate measures to prevent and reduce the impact of packaging and packaging waste on the environment in EU member states and thus prevent the emergence of obstacles to the functioning of the internal market, the European Commission in 1994 issued a Directive on packaging and packaging waste no. 94/62/EC.

The objectives of the Directive are as follows:

- reduce the amount or prevent packaging waste
- a system of packaging waste management (collection, return, processing) and transfer requirements in national legislation
- to achieve the lowest shares of recycled packaging
- removal of hazardous substances (e.g. heavy metals) from packaging and packaging waste
- increase the re-use of packaging waste through recycling, composting, and incineration

The Directive covers all types of packaging and packaging waste arising in the European Union market.

Key elements of sustainable development for packaging are in fact:

- the efficient use of raw materials and materials
- efficient use of energy in production, packaging, and distribution
- to reduce emissions into the atmosphere and water at all stages of the life cycle of the packaging
- product development from recycled packaging materials

Packaging waste is a significant source of high-quality secondary raw materials. For this purpose, there are different ways of recovering packaging waste which are used depending on the type of packaging material, or in relation to the heterogeneity of the waste. Between the packaging materials, there are a lot of differences in the composition and hence different physical properties, which also result in different properties in their processing. For the recovery of packaging waste, there exist the following basic methods of recycling:

- mechanical recycling
- chemical recycling
- organic recycling (composting, biomethanisation)
- energy recovery
- deposit

6.2. Rational use of primary source material for packaging

For the production of any product (also its packaging), sources of raw materials are unconditionally needed. The term raw material in this case is understood as the material goods which are obtained from nature and are defined as the primary sources of raw material. For a variety of packaging materials, different sources of raw materials are used, which differ not only in the sense of the different technological processes in production, but also in terms of their availability and accessibility in the natural environment.

Because the scope of the field of packaging material is very extensive, the use of primary sources should be even more deliberate and in clear harmony with the concept of sustainable development. Table 2 shows the consumption of the most important raw materials for the production of one tonne of different packaging materials. The data included in Table 2 represent the average value of the consumption of raw material sources for packaging materials published by BUWAL. These types of data can change regarding the current technological development processes and increases in their efficiency.

PACKAGING MATERIAL	TYPE AND QUANTITY OF RAW MATERIALS
Aluminium	3710 kg of bauxite 174 kg of CaCO3 54.5 kg of rock salt
Glass (white)	80.5 kg of dolomite 35.5 kg of feldspar 110 kg of CaCO3 253 kg of flint sand 108 kg of rock salt
Kraft paper	0.7 kg of oil 838 kg of wood 20 kg of CaCO3 64.6 kg of clay materials
Corrugated paper	660 kg of wood 26.7 kg of CaCO3 21.5 kg of rock salt
PE-LD	600 m3 of natural gas 530 kg oil
PE-LLD	860 m3 of natural gas 310 kg of oil
PP	250 m3 of natural gas 830 kg of oil
PS	347 m3 of natural gas 728 kg of oil
PVC	330 m3 of natural gas 370 kg oil 690 kg of rock salt 16 kg of CaCO3
PVDC	300 m3 of natural gas 310 kg of oil 1,350 kg of rock salt 645 kg of CaCO3
PET	320 m3 of natural gas 730 kg of oil

T2. The average consumption of raw materials for the production of 1,000 kg of different packaging material

7. The corporate and business decisions for the development and use of sustainable packaging

Words such as green, sustainable, eco, environmentally friendly have also become everyday words in the packaging industry or in the supply chains of goods. Because the role of packaging in society is quite large and layered, the reasons for the correct design, development, and use of environmentally preferable packaging are equally important. Some of them are impacting companies directly, some indirectly. Companies that have already established an active environmental policy can integrate packaging quickly and efficiently into their practice. However, the issue of eco-design of packaging companies should not be underestimated. Examples that confirm this are listed below, but there are still many others:

- regulatory requirements and easier tracking of upcoming legislation (more strict and more comprehensive requirements, higher taxes and charges)
- reduction of packaging waste (packaging is part of a wider social problem of waste management)
- rational use of raw materials (the costs for them are increasing and are expected to increase even further in the future)
- improved image of companies (eco-design of packaging can be an important part of an environmental company's policy for the wider public)
- market development (environmentally preferable products are becoming more present and visible; without proper packaging, their environmental profile is not complete)
- customer or user requirements (everyday, there are more companies that pursue an active environmental policy and develop environmentally preferable products, so companies will not be able to afford to use packaging that does not meet modern environmental standards)
- recycling (the recycling quota future will be probably higher, packaging waste is an important source of valuable secondary raw materials, it is also necessary to establish an effective means of eco-design circular flows of packaging waste)
- innovation potential (eco-innovation as one of the key strategic development orientations of the EU)
- sustainable use of resources (less waste due to appropriate packaging, less energy consumption during transportation because of lighter packaging, less use of energy in storage, thus contributing to a smaller carbon footprint)
- international standards (standardisation with new requirements supports the regulatory requirements by international standards)

The European Parliament and Council Directive 94/62/EC on packaging and packaging waste covers all the packaging placed on the market in the Community and all packaging waste, whether it is used or released at an industrial, commercial, office, shop, service, household, or any other level, regardless of the material used. The Directive is focused on the following:

- Packaging must have volume and weight as small as possible, while still providing the level of security and integrity of health.
- It should be designed and manufactured in such a way that permits its reuse or recovery, having as little impact as possible on the environment.
- It must be designed and produced so that basic and auxiliary packaging materials contain as few harmful and hazardous substances as possible.
- It must meet the requirements for recycling when disposed of.
- The recycling process must allow the use of a specific part of the weight of the used material in new material.
- The packaging waste processed for the purpose of energy recovery must have such a low calorific value to allow the generation of heat by maximising energy efficiency.
- Packaging waste, which is ready for composting, must have such characteristics that allow the separate collection and decommissioning when it is exposed to the anaerobic and aerobic processes of decomposition.
- Biodegradable packaging waste must chemically, thermally, or biologically decompose in such a way that most of the finished compost ultimately decomposes into carbon dioxide, biomass, and water.

The packaging requirements, as set out in the EU Directive on packaging and packaging waste, represent the basic guidelines in the design of packaging and the minimum criteria for placing packaging on the market in order to avoid market restrictions in the member states.

To help meet the requirements of the EU Directive 94/62/EC of the European Committee for Standardization (CEN), more European standards (EN) and Committee Reports (CR) have been prepared. They assist in assessing compliance with the essential requirements of the directives of the European Union, in order to reduce the impact of packaging on the environment and prevent barriers to international trade in goods. A few examples of such standards are listed below:

- EN 13427:2004 Packaging – Requirements for the use of European Standards in the field of packaging and packaging waste
- EN 13428:2004 Packaging – Requirements specific to manufacturing and composition – Prevention by source reduction
- EN 13429:2004 Packaging – Reuse
- EN 13430:2004 Packaging – Requirements for packaging recoverable by material recycling
- EN 13431:2004 Packaging – Requirements for packaging recoverable in the form of energy recovery, including the specification of the minimum inferior calorific value
- EN 13432:2001 Packaging – Requirements for packaging recoverable through composting and biodegradation – Test scheme and evaluation criteria for the final acceptance of the packaging
- EN 13193:2001 Packaging – Packaging and the environment – Terminology
- EN 13437:2003 Packaging and material recycling – Criteria for recycling methods – Description of recycling processes and a flow chart
- EN 13440:2003 Packaging – Rate of recycling – Definition and method of calculation
- CR 1460:1998 Packaging – Energy recovery from used packaging
- TP CEN/TR 13910:2011 Packaging – Report on the criteria and methodologies for a life cycle analysis of packaging
- CR 13686:2002 Packaging – Optimisation of energy recovery from packaging waste
- CR 13504:2001 Packaging – Material recovery – Criteria for the minimum content of recycled material
- TP CEN/TR 13688:2008 Packaging – Material recycling – Report on the requirements for substances and materials to prevent a sustained impediment to recycling
- CR 13695-1:2001 Packaging – Requirements for measuring and verifying the four heavy metals and other dangerous substances present in packaging and their release into the environment – Part 1: Requirements for measuring and verifying the four heavy metals present in packaging
- TP CEN/TR 13695-2:2005 Packaging – Requirements for measuring and verifying the four heavy metals and other dangerous substances present in packaging and their release into the environment – Part 2: Requirements for measuring and verifying dangerous substances present in the packaging, and their release into the environment
- CR 14311:2002 Packaging – Marking and material identification system
- ISO/TR 16218:2013 Packaging and the environment – Processes for chemical recovery
- ISO/TR 17098:2013 Packaging material recycling – Report on substances and materials which may impede recycling
- ISO 18601:2013 Packaging and the environment – General requirements for the use of ISO standards in the field of packaging and the environment
- ISO 18602:2013 Packaging and the environment – Optimisation of the packaging system
- ISO 18603:2013 Packaging and the environment – Reuse
- ISO 18604:2013 Packaging and the environment – Material recycling
- ISO 18605:2013 Packaging and the environment – Energy recovery
- ISO 18606:2013 Packaging and the environment – Organic recycling

8. Analysis of the environmental life cycle of packaging

Effects of packaging on the environment are different. Each product directly and indirectly affects the environment, some also the health of users. In the past, attention was reserved exclusively for waste generated after the use of products. Today, they have finally become aware that it is necessary to consider products comprehensively, in the sense that they have environmental impacts at all stages (phases). That means during the packaging production, during use, and also after use. This concept is crucial to improve the environmental profile of materials and products, enabling environmental interventions and improvements along the entire value-added system.

The environmental life cycle of a product generally involves the following stages: extraction and preparation of raw materials, product manufacturing, distribution and transportation, consumption or use, and disposal.

For the calculation of the relevant environmental life cycle, there are several different methods. Nevertheless, it is important to note that each method has its positive and negative features, and it is sometimes difficult to properly compare the obtained results within the same method. Therefore, the user should be very careful during the interpretation of the result. However, the most commonly used methods at this moment are the "life cycle assessment" (LCA) method and the "carbon footprint".

8.1. Environmental life cycle assessment (E-LCA)

Environmental Life Cycle Assessment (E-LCA), normally referred to as Life Cycle Assessment (LCA), is a technique that aims to address the environmental aspects of a product and the potential environmental impacts throughout that product's life cycle. The term "product" refers to both goods and services. A product's life cycle includes all stages of a product system, from raw material acquisition or natural resource production to the disposal of the product at the end of its life, including extracting and processing of raw materials, manufacturing, distribution, use, re-use, maintenance, recycling, and final disposal (i.e. cradle-to-grave).

The ISO standards identify four phases for conducting a LCA:

- **Goal and Scope** – where the reasons for carrying out the study and its intended use are described, and where details are given on the approach taken to conduct the study. Notably, it is in this phase of the study that the functional unit is defined and the modelling approaches are specified.
- **Life Cycle Inventory (LCI)** – where the product system (or systems) and its constituent unit processes are described, and exchanges between the product system and the environment are compiled and evaluated. These exchanges, called elementary flows, include inputs from nature (e.g. extracted raw materials, land used) and outputs to nature (e.g. emissions to the air, water and soil). The amounts of elementary flows exchanged by the product system and the environment are in reference to one functional unit, as defined in the Goal and Scope phase.
- **Life Cycle Impact Assessment (LCIA)** – where the magnitude and significance of the environmental impacts associated with the elementary flows compiled during the previous phase are evaluated. This is done by associating the life cycle inventory results with the environmental impact categories and category indicators. LCI results, other than elementary flows (e.g. land use), are identified and their relationship to the corresponding category indicators is determined. LCIA has a number of mandatory elements: the selection of impact categories, category indicators, and characterisation models, as well as the assignment of the LCI results to the various impact categories (classification) and calculation of category indicator results (characterisation). This can then be followed by optional elements such as normalisation, grouping, and weighting.
- **Life Cycle Interpretation** – where the findings of the previous two phases are combined with the defined goal and scope in order to reach conclusions or recommendations.

It is important to note that E-LCA provides an assessment of potential impacts on the basis of a chosen functional unit.

The LCA analysis can help in determining how different technological procedures vary on their environmental impact, which are the most influential stages in the life cycle of packaging, and which environmental impacts are the most problematic and where in the life-cycle they can occur. Furthermore, the results of the LCA analysis figure out how to change the impact on the environment if a company decides to replace the old packaging with the newone, how to change the impacts on the environment if a company changes the transport routes of the packaged goods or packaging materials by the new supplier. The LCA analysis can also express the relative contribution of the packaging in the integrated system of packaging and the use of the packaged product.

On the other hand, it has been confirmed by many studies that the LCA analysis is insufficient and largely inappropriate for the comparison of different competitive packaging options and other products because of several methodological shortcomings of the LCA methods.

8.2. Carbon footprint

A carbon footprint is defined as the total amount of greenhouse gas produced to directly and indirectly support human activities. Greenhouse gases are those that can absorb and emit infrared radiation, but not radiation in or near the visible spectrum. The most abundant greenhouse gases in the Earth's atmosphere are, in descending order: water vapour (H_2O), carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and ozone (O_3). These gases have the most important contribution to the greenhouse effect in the atmosphere.

In other words: while driving a car, the engine burns fuel, which creates a certain amount of CO_2, depending on its fuel consumption and the driving distance. When somebody heats the house with oil, gas, or coal, they also generate CO_2. Even if somebody heats the house with electricity, the generation of the electrical power may also have emitted a certain amount of CO_2, and so forth.

Each of the greenhouse gases has a different global warming potential (GWP), a so-called "equivalent factor". The GWP of each greenhouse gas shows its relative harmfulness and therefore actually represents the weight to determine the harmfulness of each greenhouse gas in the total greenhouse effect. In order to take into account these differences or compare the materials between each other, the reference substance was determined (CO_2), which has a value of one (1) of the global warming potential (Table 3). The values are based on the global warming potential of the gas over a hundred years since its release (GWP_{100}).

The emissions of different greenhouse gases are converted into a so called carbon dioxide equivalent (CDE) and/or equivalent carbon dioxide (CO_2e), by multiplying the quantity (mass) of an individual greenhouse gas with its global warming potential (Table 3). With such an adjustment, it is possible to calculate and express the influence of various greenhouse gases in the same units, which represent the carbon footprint. It is expressed with a unit of the equivalent carbon dioxide (CO_2e).

GREENHOUSE GAS	GLOBAL WARMING POTENTIAL GWP_{100}
CO_2	1
CH_4	25
N_2O	298
CCl_3F (CFC-11)	4,750
CCl_2F_2 (CFC-12)	10,900
$C_2F_3Cl_3$ (CFC-113)	6,130
$C_2F_4Cl_2$ (CFC-114)	10,000
C_2F_5Cl (CFC-115)	7,370
CHF_2CF_3 (HFC-125)	3,500

T3. Global warming potential (GWP_{100}) for different greenhouse gases

9. The environmental design of packaging – Packaging Eco-Design

The traditional design is targeted at the production phase and the use of products, but neglects those phases that are made prior to the production and management of products when they become waste. The environmental problems in traditional design are pushed into the background or are even completely ignored in extreme circumstances. Today, the approaches are completely changed. It raises the question of how to integrate those environmental aspects in product development, and what criteria and tools to use for this purpose. It is important to recognise that environmental considerations must be balanced with other features of the product and quality aspects as well as costs. The integration of environmental considerations will be more successful if it becomes part of a broader environmental policy or the environmental management of the companies.

Eco-design (environmental planning and product design) is defined as the integration of environmental aspects into product design and development with a view to reducing the negative environmental impact throughout their entire environmental life cycle. In short, the design of environmentally friendly products can be generally defined as the systematic consideration of environmental and health and safety factors during the designing/planning of products from raw material to waste management.

The aim is to use an appropriate material, appropriate design, and the appropriate technology to reduce material and energy consumption per unit of product, to eliminate the use of toxic and harmful substances, and/or facilitate the recycling process. The identification of environmental problems in the early stages enables organisations to firstly adopt appropriate decisions and, on the other hand, to better understand how such decisions impact the environmental aspects which are controlled by other players, such as manufacturers of basic and auxiliary materials, waste processors, etc. Approaches and concepts to the environmental design of products are different and many times interrelated. They include the different stages of product life cycles, which allow the use of different eco-design strategies.

The eco-design of packaging includes various criteria and aspects which are interrelated. Modern concepts of eco-design, based on the entire life cycle of the product, are in many ways changing the design of packaging. Regardless of whether the company develops its packaging by itself or in cooperation with an external partner, it is vital that all included partners (including company management) are aware of the criteria to be considered. It is necessary to proceed from the basic elements of the design and be able to connect them to the consequences that such decisions can have on the environment (Table 4). Sometimes, compromises are necessary; and such decisions are easier and more accurate when they are supported by relevant information, for example – the results of the LCA analysis.

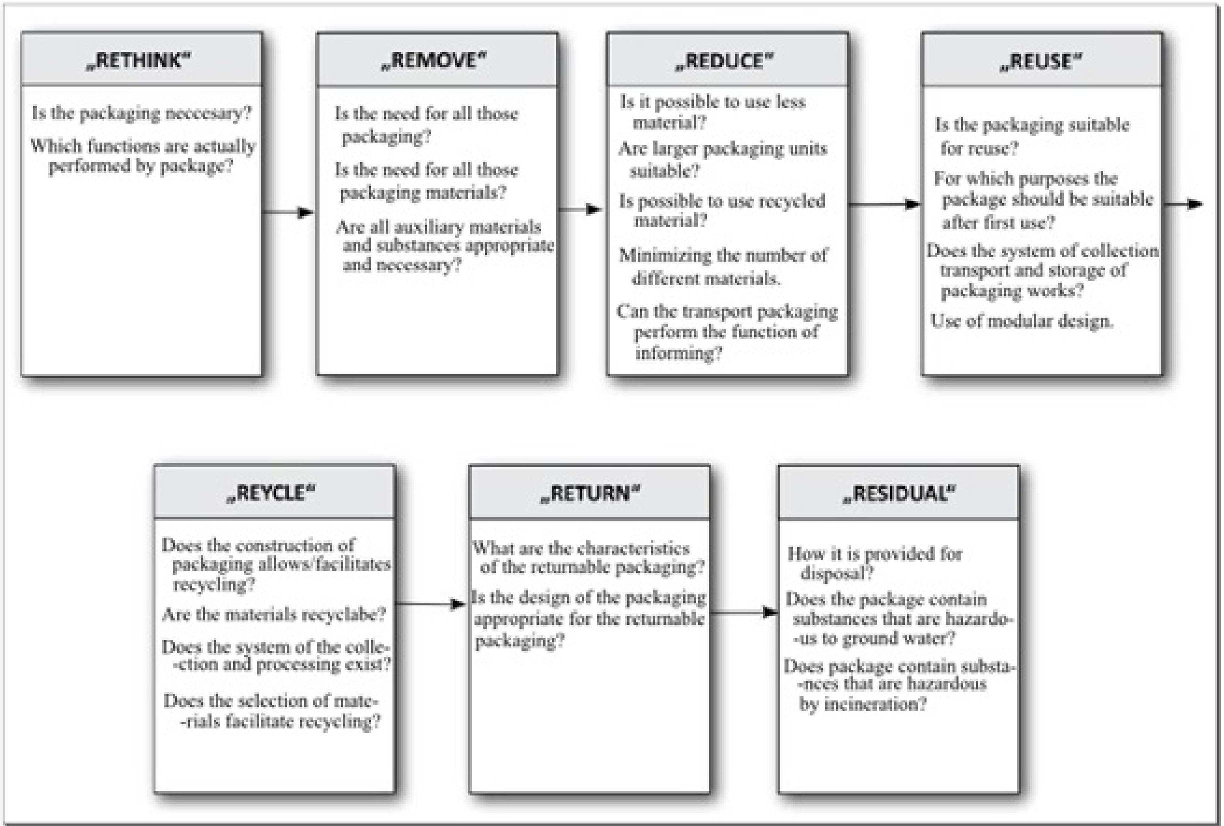
ASPECT OF PACKAGING DESIGN	SUITABLE ENVIRONMENTAL CRITERIA
Raw materials	Efficient use of resources, emissions in the production, the ability of recycling, the migration of harmful substances
Colour	The ability of recycling, toxicity
Size and design	Efficient use of resources, emissions during transportation
Thickness	Efficient use of resources, emissions during transportation, reuse
Structure (components)	Efficient use of resources, reuse, the ability of recycling
Plugs, labels, etc.	The ability of recycling, reuse, the migration of harmful substances
Glue, printing colours, paints	The ability of recycling, emissions during production, toxicity
Graphical design	Reuse

T4. Basic elements and aspects of packaging design and associated environmental impacts

The approaches and concepts of the environmental packaging planning are diverse, but often mutually complementary and interdependent. Figure 9 shows the general guidelines and guidelines for environmentally preferable packaging planning, the so-called concept "7xR". These aspects represent, together with the standards, a framework for the self-assessment of environmental appropriateness of the packaging and facilitate the integration of environmental considerations into the development process. But it raises the question: How to integrate the environmental aspects in the development of packaging and what criteria and tools for this should be used?

The eco-design of the packaging thus covers more areas which constitute the basis for the redesign of the existing packaging or the introduction of new packaging concepts. These areas are presented in more detail the following chapters and they include:

- designing the minimal amount of packaging (dematerialisation)
- designing for recycling
- designing for reuse
- designing for composting
- avoiding harmful substances
- designing for better consumer awareness



F9. General guidelines for planning environmentally preferable packaging (concept 7xR)

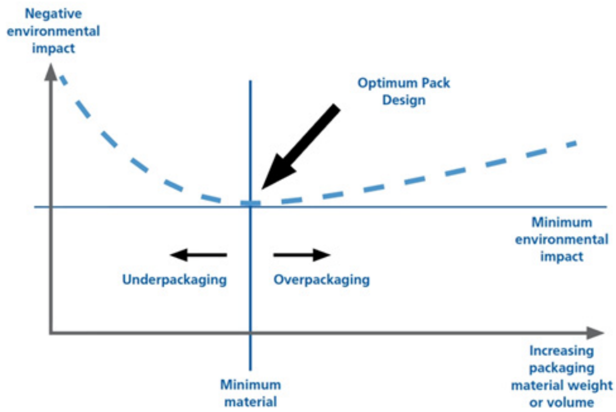
10. Design for a minimal amount of packaging (dematerialisation)

Minimising or reducing the weight of packaging, or dematerialisation, represents one of the most important development trends in the field of packaging. Dematerialisation of all types and categories of packaging is also one of the main criteria for eco-design. The reasons for reducing the weight of packaging per unit of packaged product does not lie only in increasing environmental awareness, but also play an important role in the economic interests of producers and users too. Not only in the field of making additional costs but also because of the continuing increases of raw material prices. The fact is that producers are often using too much packaging. It is also obvious that the trend of dematerialisation could not be carried out without certain technological developments in the field of packaging materials.

An important indicator of the efficiency of the packaging is the ratio between the weight of the packaged goods and the weight of the packaging. The higher the ratio, the better it is in terms of resource efficiency and reducing packaging waste. The weight ratio of the packaged product and the necessary packaging thus spans a wide range, from 1:1 to 200:1, and is on average about 10:1. In the footwear industry, however, this ratio is somewhere between 2:1 for summer light shoes and 12:1 or 15:1 for trekking or mountaineering shoes, for example.

One of the key issues of packaging design is how to optimally determine the amount of packaging material. Two different demands face each other here: the demand for adequate protection (which is a key feature of the packaging) and the minimum possible amount of packaging material used. Both are linked to the economic function of the packaging, which aims to optimally achieve other functions of the packaging at minimal cost.

Oversized packaging increases the impact on the environment due to too much unnecessary packaging material used; however, excessively reducing the packaging weight can lead to the opposite effect on the environment (Figure 10). For example: oversized packaging by 10% means that after use, 10% of the resources needed to produce and transport it will be lost. On the other hand, insufficient packaging (one that does not sufficiently protect the packaged goods) will result in a 100% loss of all the resources necessary for the production, manufacturing, transportation, and storage of the product, including the packaging (Figure 11).



F10. Optimum packaging

The amount of packaging material used is dependent on the:

- type of packaging
- size of the packaging
- construction of the packaging
- coordination in the use of the packaging material with a packaging production system
- selection of basic and auxiliary packaging materials

A few additional measures on how to improve material efficiency in relation to the packaging are mentioned below:

- reducing the thickness of the packaging within the limits that ensure the protection of the goods
- eliminating unnecessary empty space, layers, and components (Figures 11 and 12)
- selection of the quantity or volume of the packaged goods that actually meets the needs of the consumer
- minimal use of printing resources (especially in cases where these resources are not the key factor for customer decisions)
- ensuring the good fit of the sales packaging into the packaging group
- optimisation of the collective packaging for maximising the volume of the pallets
- determining which are the most effective competitive packaging products in terms of minimum material consumption for the same purpose of use

F11. The shoe box size must be of a suitable size for the footwear (left figure), ensuring there is no excessive movement of the footwear (right figure) within the box; alternatively, the shoe box is too small (figure in the middle), which could damage the product.

F12. The same rule as for a pair box must also be considered for packaging the pair boxes in the transport packaging.

11. Design for recycling

According to the Directive 94/62/EC, recycling means reprocessing in the production process of the waste materials for the original purpose or for other purposes, including organic recycling but excluding energy recovery.

In recent years, the recycling of packaging waste has grown in importance. Quantities of recycled packaging waste in the EU increase from year to year. There are several reasons for this:

- The growing concern for the environment in society and the use of recycled materials are recognised as some of the important measures to reduce negative impacts on the environment. The collection system and waste separation are also much easier today than in the past because there is a broad social consensus in the population on the advisability of recycling.
- EU environmental legislation intensively implements the recycling waste policy in its broadest context.
- The economic reason is becoming more important every day. The prices of raw materials are much higher than a few years ago, so waste material is gaining importance as a valuable source of secondary raw materials.
- The use of recycled materials in many places means improving a company's reputation in the eyes of consumers. It can be a part of a more effective environmental policy of the company, because customers appreciate companies that use recycled materials for their products.

The advantages and positive effects of recycling (such as economic or environmental) will be achieved only when the quality of recycled materials will achieve the quality of "fresh" materials. Unfortunately, this is not always the case and recycling processes are often accompanied by serious technical and economic limitations that reduce efficiency and, consequently, can significantly increase costs.

It is possible to recycle the majority of packaging materials (plastic, metal, glass, paper) but a more detailed description of recycling paper and cardboard packaging as the most important packaging in the footwear industry will be presented in chapter 11.1.

11.1. Environmental legislation for packaging

Paper and paper products can't be recycled indefinitely, because the cellulose fibres become shorter with each additional cycle. This causes a deterioration of the quality of the paper products made from recycled fibres. Such packaging therefore requires more material to achieve the desired strength than those made from fresh material. Depending on the type of paper, it is therefore often necessary to add some fresh fibres to the recycled ones. The number of recycled cycles is limited and depends on the type of paper. Overall, it is estimated that these products can be recycled 4 to 6 times. When designing the packaging from cardboard, it is therefore essential that paper from recycled material is used for the mechanically less burdened layers or inner layers of the packaging. Due to the shorter fibres, recycled paper is generally less porous, which should be considered when selecting additives and inks. Nevertheless, it is possible to find a lot of products made from 100%-recycled paper.

A major problem in the processing of waste paper is the content of impurities and of foreign materials, because it is very difficult to remove them. Therefore, the success of recycling depends largely on the quality of the collected material, which can be of varying quality. Therefore, it is very important to collect waste paper and cardboard separately at the place of the source.

Additives, such as inks and dyes, usually cause problems in reprocessing. Problems could also arise with the presence of self-adhesive tapes, labels, and with plastic laminated or wax coated cards. The treatment of such waste can be much more difficult and more expensive than those in paper production from new cellulose fibres. Modern technologies allow the recovery of waste paper and cardboard with a high degree of impurities, but the selection of production technologies is usually dependent on the subsequent use of the recycled paper.

11.2. Labels for recycled materials

One of the key success factors for recycling is also an effective separation of waste at the source of their formation, depending on the type of material. Therefore, the information about waste must be given in advance – for example, when the packaging is designed. There exist several international recycling symbols for the identification of the source materials of the packaging.

The primary purpose of marking is to give correct and unambiguous information about the material from which the packaging is produced. The identification of the materials is a precondition for the successful establishment of a recycling process. This is particularly important for plastic polymer materials, which must be suitable for achieving a quality recyclate, which can be provided only with a high level of homogeneity. The homogeneity can only be achieved with the manual process of waste selection, where the identification codes for the materials are very important.

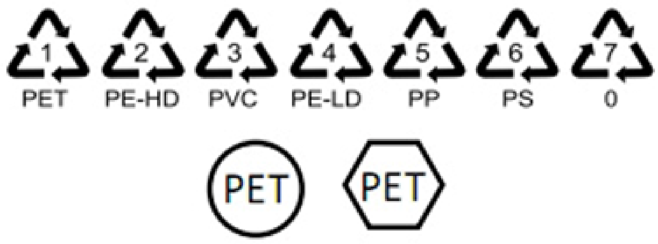
There are more graphic symbols illustrating that the packaging material is suitable for recycling or re-use. Packaging eco-labelling in the European Union is governed by the Commission Decision 97/129/EC from 2nd January 1997. Its aim was to establish the numbering and abbreviations on which the identification system for packaging materials could be used. At this moment, the use of signs and abbreviations is still voluntary (ID's for different polymer packaging materials are presented in Figure 14).

The most common sign on the packaging is the so called "Mobius loop" symbol (Figure 13). The symbol has three legs. Each represents one of the stages of the product: reduce, reuse, and recycle. This triangle is a very well-known international symbol, and the rule is also that in the middle of the triangle is an abbreviation for the type of material.

F13. Different types of Mobius loops

For certain kinds of polymer materials, which can't be distinguished visually or by touch, the identification is of particular importance. Signs for plastic packaging are decorated with symbols for the type of material and with numbers 1-7 or 01-07 (Figure 14, above).

In some countries, the use for PET bottles labelling the marks in the form of a hexagon or a circle within which is written PET (Figure 14, below).



F14. ID signs for different polymer packaging materials. Above: standard signs; below: optional signs.

The label "Green Dot" is also well-known which indicates that the packaging of the product is included in the system of packaging waste management. It can therefore be collected, reused, recycled, or otherwise properly processed. The Green Dot is probably the most widely used ecological mark in Europe (Figure 15).

F15. Green Dot

The European daisy flower is a label awarded by the European Union to those products that reduce negative impacts on the environment, contributing to the efficient use of energy resources and a high level of environmental protection, and, for environmental reasons, provide added value to the final consumer (Figure 16). The criteria for the European daisy flower award were determined by the European Commission in cooperation with various stakeholders.

F16. European daisy flower label

12. Designing reusable (returnable) packaging

With the growth of the quantity of packaging waste, its criticism is growing ever louder, because of the dominance of non-reusable packaging. Customers thus begin to appeal to the producers for an increased use of returnable packaging. The packaging may therefore be designed in a way to allow another consumer use (re-use), or in a manner that is included in a broader economic returnable packaging system.

In its broadest sense, the definition of reusable packaging includes reusable pallets, racks, bulk containers, hand-held containers, and dunnage, which transport a product efficiently and safely throughout the supply chain. Reusable packaging is typically used by manufacturers/processors and their suppliers/customers in a well-organised supply chain, with very tightly managed shipping loops. The packaging is constructed of durable materials such as metal, plastic, or wood, and is designed to withstand the rough handling of a typical logistics system.

Reusable packaging can be: owned and managed by the user, owned by the user and managed by a third party, rented by the user from a third party pooling company, transferred between multiple end users and recycling companies, or exchanged between members of a co-op or association.

The Slovenian regulation on the management of packaging and packaging waste in returnable packaging systems also defines a so-called controlled and closed circulation of returnable packaging.

The controlled circulation of returnable packaging means the circulation of returnable packaging in a controlled system in such a way to achieve the highest possible rate of the packaging return in the circulation system. The packaging should be eliminated from the system only by a special controlled procedure. The aim of this circulation is to achieve the highest potential rate of return of the packaging in the circulation system.

Closed circulation means the circulation of returnable packaging in a controlled cycle, in which the recycled material for the packaging manufacture is used as far as possible from the packaging waste material generated in the controlled circulation system. Adding fresh material in the production of new packaging is limited to the minimum necessary amount.

In some cases both circulation systems can achieve about a hundred cycles, and the rate of return and circulation also determines the final eco-returnable profile of some packaging.

The use of returnable packaging is most common in the industry producing different kinds of liquids (e.g. drinks). In the footwear industry, it is rare but possible (pallets, cans, transport boxes, etc.).

13. Design for composting

Composting means the directed aerobic microbial changing of waste into compost, which is useful for improving and fertilising the soil. In other words, composting is the biological decomposition of the substances with the presence of air to form a humus-like or similar substance. The EU Directive 94/62/EC mentions composting very briefly. However, the Slovenian Regulation on the management of packaging and packaging waste ranks composting in a so-called organic recycling group together with biomethanisation.

In accordance with the definition of the Slovenian Regulation, biodegradable packaging is such that it can be physically, chemically, thermally, or biologically decomposed in such a way that most of the finished compost decomposes into carbon dioxide, biomass, and water.

The effectiveness of the composting procedure is determined by a number of conditions, such as temperature, humidity, the ratio of carbon and nitrogen in the waste, the amount and the ratio of nutrients for the microorganisms, etc.

One of the main composting problems is the potential contamination of the waste for composting with substances that are not only non-biodegradable, but can also be dangerous (e.g. heavy metals and toxic organic compounds). In such cases, the quality of the compost is unacceptable for use in agriculture.

Packaging waste is nowadays mostly made from paper, cardboard, or wood. Recently, the first biodegradable polymeric materials have also been introduced (so-called biopolymers).

14. Avoiding harmful substances in packaging

Packaging may contain hazardous substances for health and the environment in primary packaging material or due to the additional graphic processing, printing, and/or gluing. Due to the migration of different substances, which are ingredients or contaminants of the packaging, these can migrate from the packaging into the finished products.

The effects of pollutants on health are specific and in some cases different from the impact on the wider environment. However, a modern design and development of packaging must include this dimension in the development of new products. In leading industrialised countries, this issue is usually included inside the eco-design of packaging. In general, packaging must not adversely affect the health of consumers due to the migration of different dangerous substances.

Below, some substances are mentioned that can be found in the packaging that can migrate into the finished products:

- Plastics: a residue of unreacted monomers, additives to achieve the desired properties of polymeric materials, the residue of catalytic polymerisation, etc.
- Metal packaging: heavy metals (lead, cadmium, chromium, mercury, nickel), components of protective sprays (phenol, formaldehyde, aromatic amines, BADGE, BFDGE, etc.).
- Paper packaging: heavy metals, formaldehyde, polychlorinated biphenyls, pentachlorophenol, phthalates, primary aromatic amines, benzophenone, fluorescent dyes, etc.
- Glass packaging: heavy metals (lead and cadmium).
- Wooden packaging: impregnation products against rot and drying.

In terms of environmental protection, the use of different kind of inks and adhesives has also become very important.

There are probably as many different definitions of ink as there are types. Perhaps the simplest description is that ink is a liquid or semi-liquid material used for writing, printing, or drawing. Chemists view it as a colloidal system of fine pigment particles dispersed in a solvent. The pigment may or may not be coloured, and the solvent may be aqueous or organic. Due to the increasing printing speeds, the requirements for printing inks and machines also grow. With environmental legislation becoming increasingly stricter every day, it is important to select the correct solvent. Recently, water-based inks are becoming prevalent.

Printing inks based on water contain water as the solvent. They can be marked as water inks, if they contain at least 85% water. They have been developed to protect the environment and health, as well as for decreasing the cost of the printing process, since, with the use of such inks; water replaces more costly and often harmful organic solvents. However, working with them is a bit more problematic, as they are more corrosive and need more energy for drying, and they also cause major problems in the recycling of printed paper in the process of deinking.

Adhesives are mostly used for the assembly of paper packaging or for sticking labels on the packaging. As with inks, adhesives with organic-based solvents were also used here, but they have been almost completely replaced by glue made from latex or starch. Another very good solution is the use of hot melted adhesives.

Another substance not directly connected with packaging material but also very important is the use of silica gel in packaging finished shoes. Silica gel is a desiccant, a substance that absorbs moisture, which makes these packets perfect for keeping things extremely dry and moisture-free. Silica gel itself is not dangerous (it is non-toxic), but can have additives of some dangerous chemicals (e.g. dimethyl fumarate (CAS n° 624-49-7) and cobalt dichloride (CAS n° 7646-79-9)). Usually, it is used in packaging ready for transporting overseas, where the products are exposed to high temperatures and high levels of relative humidity (Figure 17).

F17. Different silica gel sachets

Because of the excessive risk of the presence of dangerous substances inside the silica gel, in the last few years, the new anti-mould stickers (e.g. Micro-Pak), glued to the top of the shoe-box, became very user-friendly (Figure 18).

F18. Anti-mould stickers

15. Conclusions

As has been shown in the previous chapters, the concept of sustainable packaging has outgrown the concept that only a few of the most progressive companies consider. The concept of sustainable packaging development has become a worldwide trend. But, unfortunately, sustainability is very often neglected, and the economic aspects of packaging are given priority. During the planning and developing of new packaging, the companies should always make compromises between the following different aspects of packaging:

- environmental (rational use of primary resources)
- social (meet consumers' expectations in terms of product protection, safety, handling, and information)
- economic aspects (lower cost of distribution, storage, and sales and also the higher added value of the products)

Here, the customers play a crucial role. If they do not accept the packaging as it is, a company must change its packaging development policy, if it wants to sell its products.

16. Test of knowledge

Choose the correct option:

Q1. What is the most important function of the packaging?

○ To hide the product.

○ To protect the packaged contents.

○ For the producers' advertising.

Q2. Why does the packaging have a negative connotation in the general public's view?

○ Because of too many printed advertisements.

○ Because not all packaging can be recycled.

○ Because of a huge accumulation of packaging waste on landfills.

Q3. Which material is most commonly used for packaging finished shoes?

○ Paper.

○ Wood.

○ Plastic.

Q4. Which material is most commonly used for glued packaging?

○ Glass.

○ Plastic and metal.

○ Wood.

Q5. What type of packaging is a paper shoe box?

○ Tertiary packaging.

○ Primary packaging.

○ Secondary packaging

Q6. Do we use secondary packaging in footwear transport?

○ Yes.

○ No.

○ Only for transport between production departments.

Q7. What is important for the safe transport of dangerous goods?

○ Easy handling with the packaging.

○ Clear and correct dangerous goods labels for correct handling of dangerous the goods.

○ Producers' company data on the packaging.

Q8. For what purpose do we not use paper in the shoemaking industry?

○ As wrapping paper to protect the footwear in a pair box.

○ As shoe stuffing paper or filler paper to maintain the shape of the shoe.

○ As decorative paper for shoe packaging.

Q9. What is the main source for paper production?

○ Textile fibres.

○ Wood fibres.

○ Cotton fibres.

Q10. What is the most common packaging material in the footwear industry?

○ Waxed paper.

○ Origami paper.

○ Corrugated paper.

Q11. What is the most important part of the corrugated paper?

○ Flute in the middle of the paper structure.

○ Outside flat liners.

○ Colour and the final finish of the outside paper layer.

Q12. What is the biggest problem in the production of corrugated paper?

○ Production of the flute.

○ Printing on the outside of the flat liner.

○ Cutting and assembling the final box.

Q13. Is it possible to make the multi-wall corrugated paper (corrugated paper with different flute type layers inside the same paper wall)?

○ Yes.

○ No.

○ Only on special demand of the customer.

Q14. What are the physical and mechanical properties of corrugated paper vs. one layer paper?

○ Corrugated paper has better mechanical properties, is more rigid, and has better protection features.

○ Corrugated paper has worse mechanical properties, is less rigid, and has worse protection features.

○ They are the same quality; they are only different viewed from the outside.

Q15. What is not a key element of sustainable packaging development?

○ Efficient use of raw materials.

○ Efficient use of energy.

○ Efficient use of dangerous goods.

Q16. Which European directive covers the packaging and packaging waste on the market in the Community?

○ 94/62/EC.

○ 914/620/EC.

○ 914/62/EC.

Q17. What is the definition of the LCA (life cycle assessment) analysis?

○ This is a technique to assess the environmental impacts associated with all the stages of a product's life from cradle to grave.

○ This is the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO2).

○ This is the amount of weight of all the raw materials used for 1 tonne of the final product.

Q18. What is the definition of the Carbon footprint method?

○ This is a technique to assess environmental impacts associated with all the stages of a product's life from cradle to grave.

○ This is the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO2).

○ This is the amount of weight of all the raw materials used for 1 tonne of the final product.

Q19. What is included in the modern concept of eco-design?

○ Development of visually customer-friendly packaging.

○ To use only raw materials for production.

○ To use an appropriate material, design, and technology to reduce material and energy consumption per unit of the product, to eliminate the use of toxic and harmful substances, and/or facilitate the recycling process.

Q20. What are the general guidelines for planning environmentally preferable packaging called?

○ 5S concept.

○ Concept 7xR.

○ Concept 3R.

Q21. What is the average ratio between the weight of the packaged boots and the weight of the packaging?

○ 1:10.

○ 1:50.

○ 1:100.

Q22. What is recyclable packaging?

○ Packaging that can be cleaned and re-used.

○ Packaging that will easily break down in the soil or the atmosphere.

○ Packaging that is made of materials that can be used again after processing.

Q23. What is the meaning of the Mobius loop?

○ Reduce, reuse, recycle.

○ Produce, use, throw away.

○ Biodegradable or recyclable packaging.

Q24. For which territory is the daisy flower label relevant?

○ Territory of the European Union.

○ Territory of the United States.

○ Territory of the former Soviet Union countries.

Q25. What is important for the correct recycling of polymer materials?

○ The correct identification of the polymer material with the Mobius loop or the hexagon symbol integrated into the product and the correct number inside the symbol.

○ The correct identification of the packaging using a paper label.

○ A correctly filled in form packed together with the secondary packaging.

Q26. What does the Mobius loop or the hexagon symbol on the polymer bottle with the number 3 inside mean?

○ PET.

○ PVC.

○ PP.

Q27. What does the Mobius loop or the hexagon symbol on the polymer bottle with the number 6 inside mean?

○ PVC.

○ PET.

○ PS.

Q28. What is biodegradable packaging?

○ Packaging that can be cleaned and re-used.

○ Packaging that will easily break down in the soil or the atmosphere.

○ Packaging that is made of materials that can be used again after processing.

Q29. What is the main problem of composting materials?

○ Contamination of the material with non-compostable or dangerous substances.

○ Material coming from third world countries.

○ Material without a material source symbol.

Q30. In which material is it possible to find harmful substances?

○ Only in plastic, glass, and paper.

○ Only in plastic and metal.

○ In all materials.

Q31. Which harmful component can be found in PET bottles?

○ Lead.

○ Phthalates.

○ Styrene monomers.

Q32. Which of the following packaging materials is chemically inert?

○ Glass.

○ Metal.

○ Plastics.

Q33. What kind of glue for paper packaging assembling is most environmentally unfriendly?

○ Glue based on organic solvents.

○ Latex and glue from starch.

○ Hot melted adhesives.

Q34. Is the pure silica gel in paper sachets a dangerous substance?

○ Yes.

○ No.

○ Only when it's wet.

Q35. Which are the best known unwanted chemicals added to silica gel sachets?

○ Dimethyl fumarate and cobalt dichloride.

○ Heavy metals (hexavalent chromium, aluminium, lead, etc.).

○ Phthalates (dimethyl phthalate, butyl benzyl phthalate, diisobutyl phthalate, etc.).

Q36. Packaging is the largest section of household waste.

○ True.

○ False.

Q37. What are the most important functions of labelling?

○ The attraction of customers and providing legal documents.

○ Advertising.

○ Fashion trend forecasting.

Answer Key:

Q1.	To protect the packaged contents.
Q2.	Because of a huge accumulation of packaging waste on landfills.
Q3.	Paper.
Q4.	Plastic and metal.
Q5.	Primary packaging.
Q6.	Yes.
Q7.	Clear and correct dangerous goods labels for correct handling of dangerous the goods.
Q8.	As decorative paper for shoe packaging.
Q9.	Wood fibres.
Q10.	Corrugated paper.
Q11.	Flute in the middle of the paper structure.
Q12.	Printing on the outside of the flat liner.
Q13.	Yes.
Q14.	Corrugated paper has better mechanical properties, is more rigid, and has better protection features
Q15.	Efficient use of dangerous goods.
Q16.	94/62/EC.
Q17.	This is a technique to assess the environmental impacts associated with all the stages of a product's life from cradle to grave.
Q18.	This is the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO2).
Q19.	To use an appropriate material, design, and technology to reduce material and energy consumption per unit of the product, to eliminate the use of toxic and harmful substances, and/or facilitate the recycling process.
Q20.	P-Concept 7xR
Q21.	1:10.
Q22.	Packaging that is made of materials that can be used again after processing.
Q23.	Reduce, reuse, recycle.
Q24.	Territory of the European Union.
Q25.	The correct identification of the polymer material with the Mobius loop or the hexagon symbol integrated into the product and the correct number inside the symbol.
Q26.	PVC.
Q27.	PS.
Q28.	Packaging that will easily break down in the soil or the atmosphere.
Q29.	Contamination of the material with non-compostable or dangerous substances.
Q30.	In all materials.
Q31.	Phthalates.
Q32.	Glass.
Q33.	Glue based on organic solvents.
Q34.	No.
Q35.	Dimethyl fumarate and cobalt dichloride.
Q36.	False.
Q37.	The attraction of customers and providing legal documents.

17. Glossary

- The carbon footprint is the total amount of greenhouse gases produced to directly and indirectly support human activities, usually expressed in equivalent tonnes of carbon dioxide (CO2).
- Cardboard: A material made from cellulose fibres (wood pulp) like paper but usually thicker.
- Composting is a form of waste disposal, where organic waste decomposes naturally under oxygen-rich conditions.
- Corrugated board: A major packaging material consisting of a medium which has been fluted or pleated on a machine called a corrugator. Flat layers of paperboard are glued to one or both sides of the fluted medium to form a single-faced or double-faced (single-wall) corrugated board. Additional walls and faces can be added to meet the desired performance specifications.
- Eco-design assumes that the effect a product has on the environment should be considered and reduced at all stages along the product's life cycle. These stages include the extraction of the raw materials, the manufacturing of the product, its marketing and distribution, the use, and, finally, the disposal of a product.
- Flute: A rib or corrugation on a surface – one of the undulations or pleats of a piece of corrugated sheet.
- Hazardous material (goods) packaging or packaging for dangerous goods: Certain products which have been designated as potentially hazardous to people and the environment require special packaging, labelling, storage, and handling as prescribed by the national and international regulations.
- Hazardous substances cause damage or are able to be harmful to the human body or in a wider sense (animals, nature, etc.).
- Hot melt: An adhesive or coating based on thermoplastic polymer, generally modified with resins or waxes, which is solid at room temperature. It is heated to fluidity at the time of application, and is normally quick setting as it cools.
- Label: A slip of paper, film, or foil to be affixed to a packaging. The label usually carries a graphic design and printed information about the product.
- Life-cycle assessment (LCA, also known as life-cycle analysis, eco-balance, and cradle-to-grave analysis) is a technique to assess the environmental impacts associated with all the stages of a product's life from cradle to grave (i.e. from raw material extraction through materials' processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling).
- Non-refundable packaging is the packaging for single use only. After use, it is recycled or otherwise harmlessly removed.
- Packaging: The general term for the functions, materials, and overall concept of a coordinated system of the preparation of goods for handling, shipment, storage, marketing, distribution, and use at the optimum cost, and compatible with the requirements of the product.
- Packaging costs: All the costs associated with the chain of packaging operations – from developing the packaging concept to the packaged products to the consumer and the disposal of the packaging.
- Paper: The general name for a wide variety of fibre based materials primarily made from vegetable or wood fibre base, formed from a water suspension by withdrawing the moisture through a fine wire screen.
- Paperboard: A form of paper, the distinction being that paperboard is heavier in its basic weight, thicker and more rigid than paper.
- Primary (sales, consumer, or retail) packaging: The unit container which is actually in contact with its contents.
- Product life cycle (PLC) is the cycle through which every product goes through from introduction to withdrawal or eventual demise.
- A radio frequency identification device (RFID): A microchip encased in plastic that is attached to the packaging and other articles for identification and tracking purposes.
- Recycling is a process to convert waste materials into new products to prevent the waste of potentially useful materials, reduce the consumption of fresh raw materials, reduce energy usage, reduce air and water pollution by reducing the need for "conventional" waste disposal, and lower greenhouse gas emissions as compared to plastic production.

- Reusable (returnable) packaging is packaging that is intended to be reused several times for the same purpose. Reusable packaging includes reusable pallets, racks, bulk containers, hand-held containers, and dunnage, which move product efficiently and safely throughout the supply chain.
- Secondary (display or merchandising) packaging: Packaging that collates, groups, or wraps one or more primary packs.
- Silica gel: A form of colloidal silica resembling sand. Used as a desiccant to absorb moisture inside the packaging.
- Tertiary (transport or distribution) packaging: All forms of distribution packaging, containing primary and secondary packaging.

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