Commissione europea

imageen

LCA AND WASTE MANAGEMENT

A Short Smart Guide

LIFE CYCLE ASSESSMENT E WASTE MANAGEMENT

One of the keys to making a successful, ecologically sustainable product is to base its actions on efficient tools and policies which are universally shared and recognized.

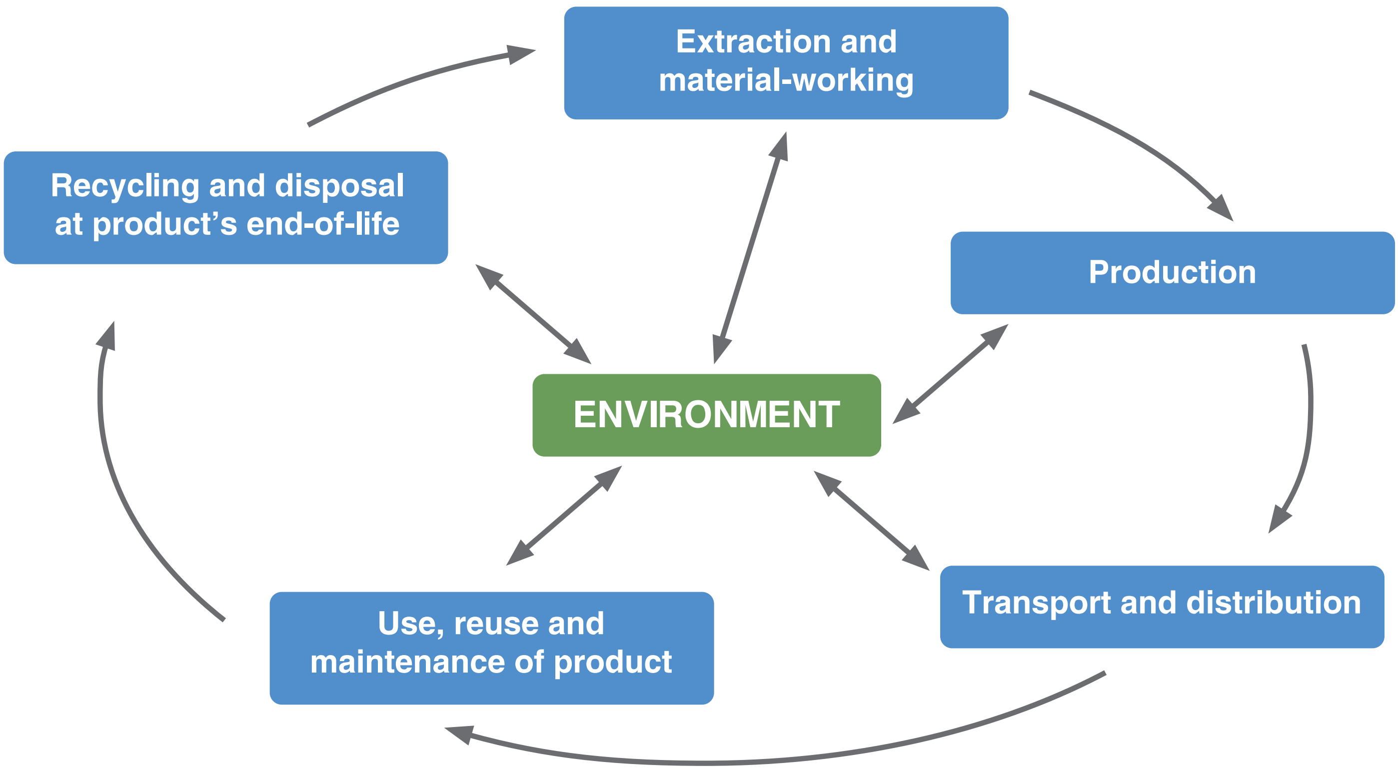
Therefore, in this publication we have decided to condense the essential information pertaining to Life Cycle Assessment (LCA) and Waste Management (WM), which respectively are the primary tools and methodologies which an ecological designer must refer to in order to reduce the impact of packaging on the environment.

LCA and Waste Management are intimately connected to one another, although they operate on two different levels: LCA, which regards the entire life cycle of a product, also considers its end-of-life, and so Waste Management, in the defining and revisiting of its procedures and methodologies, makes use of LCA in order to carry out an in-depth evaluation of the environmental impact of specific choices and procedures.

LIFE CYCLE ASSESSMENT

INTRODUCTION

The term LCA is an acronym for Life Cycle Assessment and it consists in a methodology for an accurate and thorough evaluation of the environmental impact associated with all of the stages of the life cycle of a product "from the cradle to the grave"; that is, starting from extraction of raw materials, material-working processes, assembly of the semi-finished product to the manufacturing of the final product, distribution, use, its eventual repair and maintenance, and ending at its final disposal and recycling.

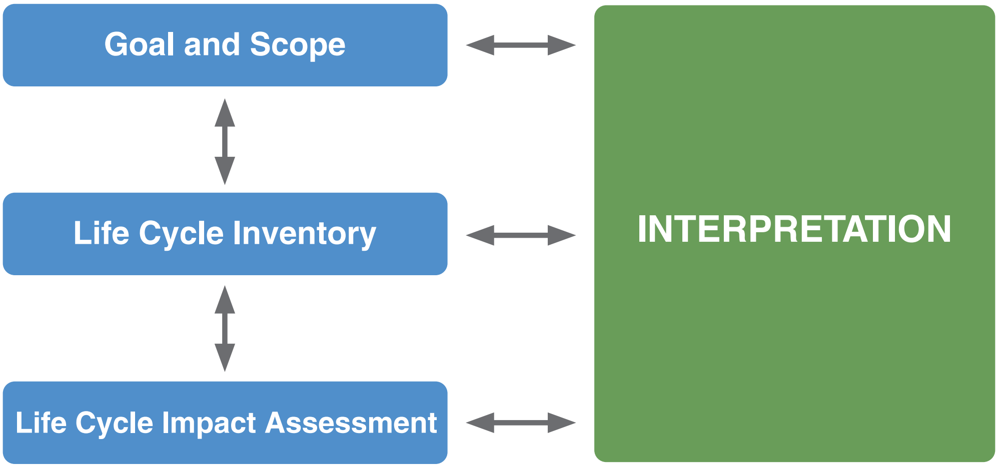


By carrying out an LCA study we can understand what the impacts and environmental effects of a product or an existence service are. The goal may be to compare that product or service with other products on the market or to evaluate the potential environmental and economic implications linked to specific strategic choices and decisions.

The procedure for correctly conducting an LCA study is found in the norm ISO 14000, the international standard for environmental management; all definitions or details can be found in this norm.

THE FOUR PHASES

The norm divides the LCA procedure into 4 phases: Goal and Scope, Life Cycle Inventory, Life Cycle Impact Assessment and interpretation.



GOAL AND SCOPE

It is fundamental to begin the study be clearly stating the aim and explaining how and to whom the results must be communicated. The stated goal must always be consistent with the pursuit of the study.

Information and technical details must be provided concerning:

- Functional unit: processes which modify the raw material or the semifinished product into another product. In the packaging sector a functional unit could be the extruding of master polymers. Every functional unit is linked to the environment and with other functional units through product, material and energy flow;

- System boundaries: the entirety of all considered unit processes. It defines what can be considered the system to be analysed and what, instead, can be defined as environment;

- Eventual assumptions and limitations regarding the unit processes and system limits;

- Allocation methods: in cases where a process interests Product A and B it is necessary to specify how each flow (material and energy) can effectively be partitioned to those two products.

- Chosen impact categories: the most common are climate change, ozone depletion, acidification, eutrophication, ecotoxicity, etc.

LIFE CYCLE INVENTORY

In this phase a list of flows to and from the environment must be compiled (normally represented by earth, air and water) of the elements needed to manufacture a product (water, energy, raw materials, etc.). Generally, the final product of this phase is a flow chart which contains all activities with their respective input and output flows.

One of the critical points of the inventory is the determination of flows coming from the use of secondary, artificial products; understood both as a product used in the functional unit that does not come from nature but is man-made (for example, from a functional unit outside of the system boundaries), as well as the manual work that a person can provide within the process.

In this case databases are regularly used which are created expressly to carry out inventory assessments. This involves the addition of an objective nature to the study if one does not take data that is consistent with the regional or national context into consideration.

LIFE CYCLE IMPACT ASSESSMENT

Life Cycle Impact assessment is defined as the entirety of effects caused by LCI flows on the environment. This is equivalent to the estimation of the significance of potential environmental impact, based on prior results. In this phase, impact categories, category indicators and characterisation models are selected.

The most important phase is that of classification, where data from the inventory phase for each specific category come together. For example, if the impact category is eutrophication, the category indicator is nitrification expressed as the quantity of NO_2 that enters or exits the system.

Therefore, the flows of Nitrogen compounds capable of causing the impact will be classified and the chemical-physical models to be considered will be specified.

In this phase it is also possible to compare the results obtained from the total impacts in the territory being analysed in order to understand if the product's impact is significant in comparison with other impacts found in the territory (from single regions to entire nations), to gather and classify impact categories, to obtain related normative indexes in order to be able to indicate the sum of all registered impacts in analysis with a single numerical value.

INTERPRETATION

Interpretation means an analysis of the outputs of the inventory phase and the impact evaluation in order to obtain a series of conclusions and recommendations to apply in the future. Moreover, in this phase it is possible to verify the completeness, sensitivity and consistency of the study.

A key point in the interpretation phase is determining the level of confidence in the final results and communicating them in an accurate and effective manner. Interpretation is not normally just a simple comparison of data.

If product A impacts 1 and product B impacts 2, the interpretation does not end with the foregone conclusion that "product A is preferable to product B", but the features that significantly contribute to each impact category must be identified, along with the sensitivity of the study; every recommendation or conclusion must be a consequence of a thorough comprehension of how the study was conducted.

USE OF THE LCA

The main uses of the LCA regard:

- Business strategy support;
- Decision support connected to product research and development;
- Defining product and process design principles;
- Environmental education;
- Environmental product declaration and labelling;
- Integrated policies for waste management;
- Studies on the quantifying and reduction of environmental pollution.

A recent LCA study conducted by the IFEU (Institute for Energy and Environmental Research) has recently confirmed that UHT milk containers made with multi-layered carton have lower CO_2 emissions than PET or HDPE bottles.

OVERVIEW LCA RESULTS BEVERAGE CARTON VS PET BOTTLE AND HDPE BOTTLE

	carton vs. PET	carton vs. HDPE	
Fossil resource consumption (in kg crude oil equivalent)*	- 57 %	- 56 %	Resource - related impact categories
Non-renewable primary energy (in giga joule)*	- 50 %	- 46 %	Resource - related impact categories
Total primary energy consumption (in giga joule)*	- 36 %	- 30 %	Resource - related impact categories
Use of nature (in m²)*	+ 95 %	+ 95 %	Resource - related impact categories
Climate change (in kg CO_2 equivalent)*	- 45 %	- 34 %	Emission - related impact categories
Acidification (in g SO_2 equivalent)*	- 43 %	- 14 %	Emission - related impact categories
Eutrophication (in g PO_4 equivalent)*	- 16 %	+ 22 %	Emission - related impact categories
Human toxicity PM_{10} (in g PM_{10} equivalent)*	- 39 %	- 97 %	Emission - related impact categories

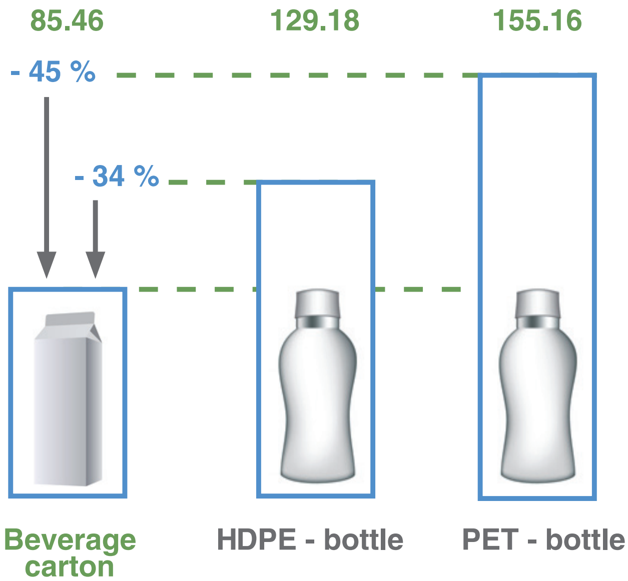
- Carton significantly better
- No significant difference
- Carton significantly worse[1]

* per packaging required for 1,000 L UHT milk

1 at a 10 % significance level

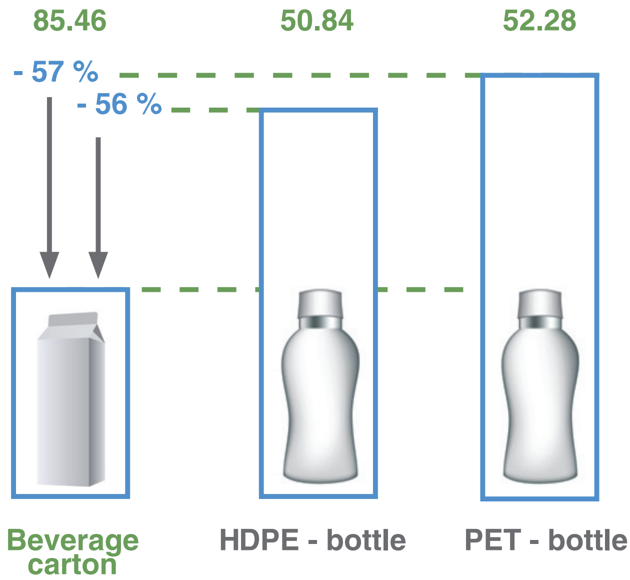
CLIMATE CHANGE

(in kg CO_2 equivalent: per packaging required for 1,000 L UHT milk)



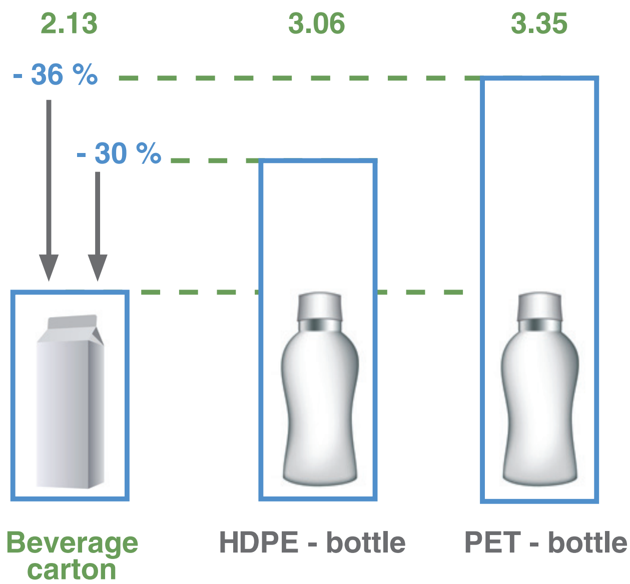
FOSSIL RESOURCE CONSUMPTION

(in kg kg crude oil equivalent: per packaging required for 1,000 L UHT milk)



TOTAL PRIMARY ENERGY CONSUMPTION

(in in giga joule: per packaging required for 1,000 L UHT milk)



The validity of an LCA study strongly depends on the quantity, accuracy and how current the data is at its disposal.
In terms of quantity, when one compares LCA results of different products, it is of the utmost importance that the same data is available for all of the studies. If, for example, one product has a higher amount of data, it is not possible to simply compare those results with another that has a smaller amount.

Having current data is exceedingly important. Data regarding processes comes from investigations carried out within companies that produce the product of interest, according to the system boundaries that were settled on at the beginning of the study. Due to globalisation and the increased pace of research and development, new materials and new methods of production and working are available on the market.

For this reason, in order to best interpret an LCA study it is fundamental to have detailed knowledge of innovative materials and processes. At the same time, an LCA study does not represent an absolute truth, but must continuously be updated by introducing innovations that involve all unit processes.

Updating must be done according to the technological developments of the product and the sector. LCA studies on electronic products, smartphones for example, should be updated every 9-12 months.

As mentioned, a complete LCA study considers the product from its origins (raw materials) to the end of its life. In some cases — decided before or after a complete LCA — it can be more interesting to submit the product to an LCA focused on one part of its life cycle which may be more significant. Some of the most common and important examples of this are:

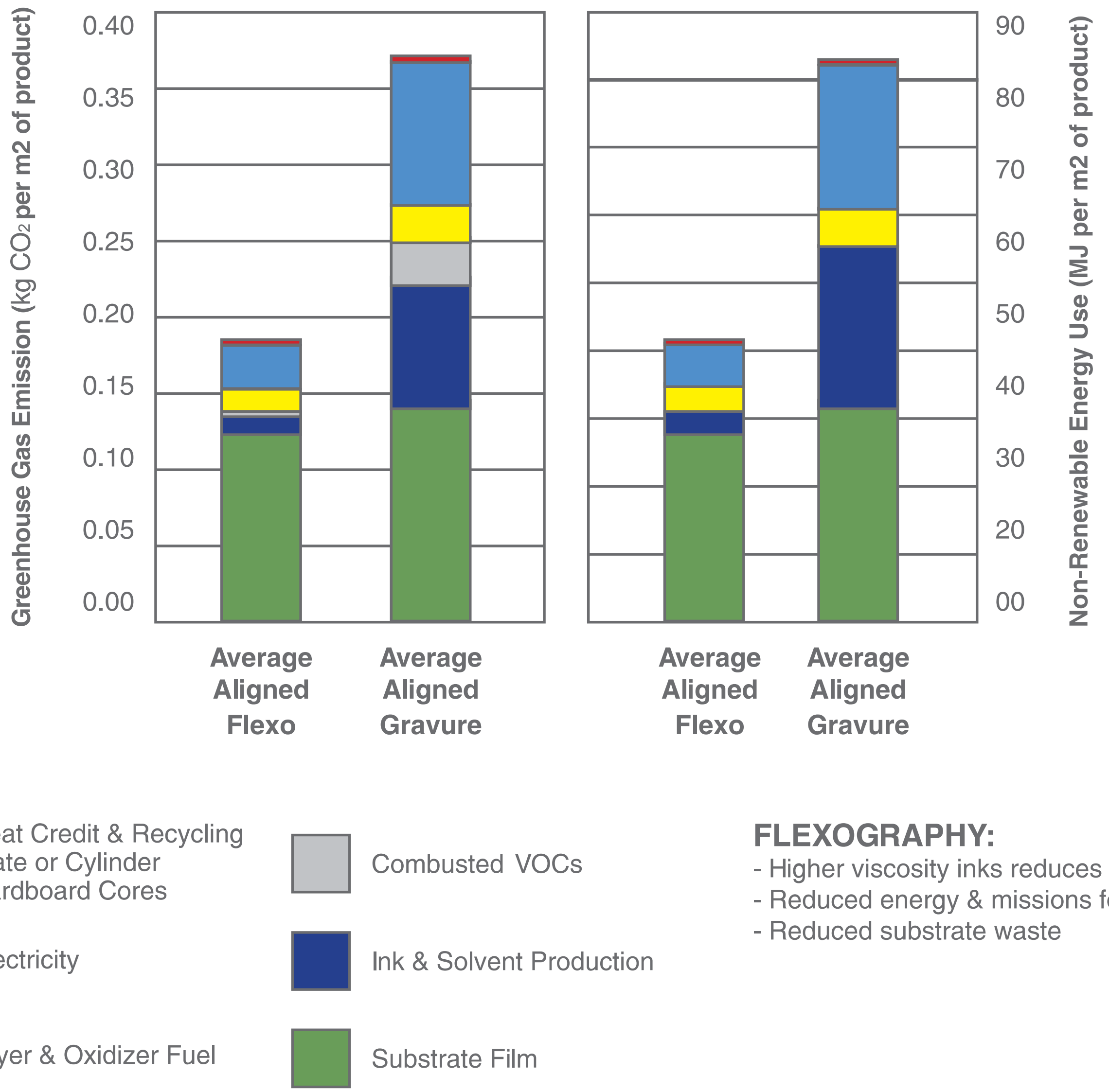
- LCA concerning phases that range from the extraction of raw materials until prior to the distribution of the product. The study, which does not involve the use or end-of-life phases, can also be applied to single materials. The results can constitute an EPD (Environmental Declaration Product) or, if it is a by-product, results can be used as data in the LCA inventory phase of the finished product;

- LCA concerning only the production phase of the product. The decisions that will ensue from this type of LCA will surely quickly put into action, given that the results evaluate the efficiency of production processes within the company. An example is the LCA study of a packaged tomato sauce conducted by CIPACK, which demonstrated how its primary and secondary packaging had 50% more environmental impact than any other category.

For example, in the packaging sector a recent LCA study by DuPont demonstrated how the technique of flexographic printing produced fewer CO_2 emissions compared with rotogravure printing.

ORIGINAL LCA FLEXOGRAPHY VS. ROTOGRAVURE

Average 50% Savings with Flexographic Printing



FLEXOGRAPHY:

- Higher viscosity inks reduces solvent use
- Reduced energy & missions for drying
- Reduced substrate waste

- LCA concerning only the phase of transport and distribution. The advantage is in comparing different systems for transport and evaluating the opening of new production sites;

- LCA concerning only the phase of use and maintenance.

If we consider, for example, the LCA of an automobile and of an aeroplane, the life phase of use is the one with the most impact, due to its elevated fuel consumption. Therefore, one should study innovations for reducing the environmental impact in this step, considering for example lighter materials for the structure, such as carbon fibre in place of aluminium.

At this point, however, one will have to re-evaluate the entire study as changing raw materials changes the evaluations made concerning the first part of the life of the product.

WASTE MANAGEMENT

INTRODUCTION

Waste management is the set of policies, procedures and methodologies for the management of waste, from its production until its final destination; its management occurs as early as the first phase of waste production, as those involved attempt to encourage waste prevention and reduction, then passing to the collection phase, transport, and treatment (recycling or disposal) for its reuse as discard material.

The main objective of MW is to ensure that waste, regardless of its final destination, has a minimal impact on the environment and on human health.

WM deals with all types of waste: deriving from industrial manufacturing or commercial, residential, institutional and agricultural activities. It also includes special waste, such as the waste coming from pharmaceutical industries, the medical field, and radioactive material. It is applied both in industrialised countries as well as developing ones.

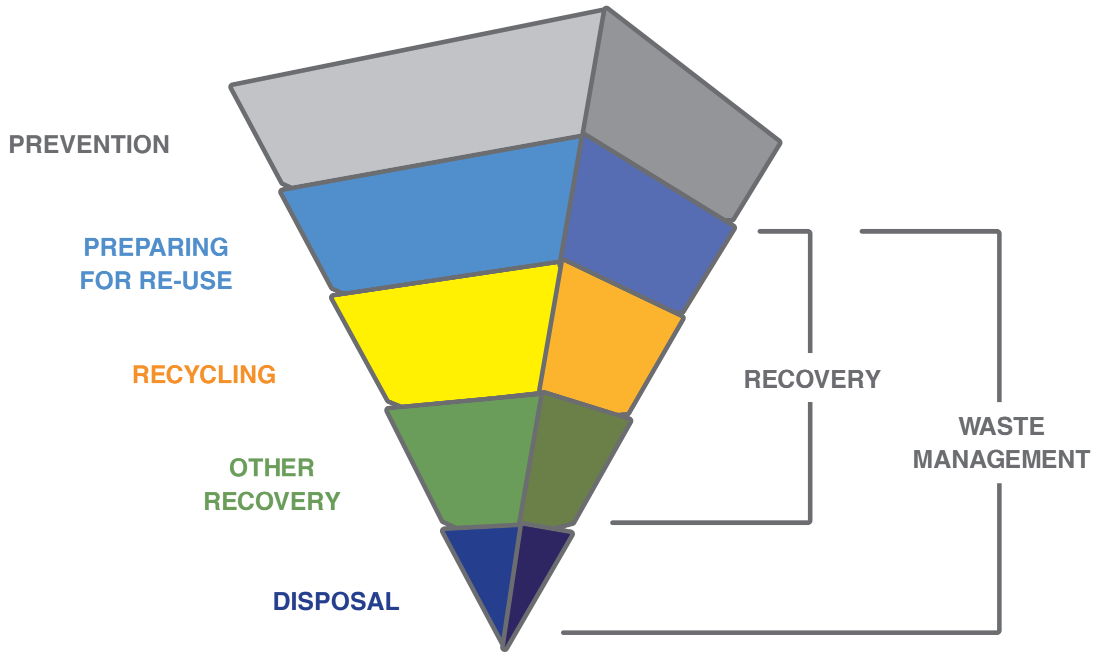
WM can follow different procedures depending on the country involved, as each country is regulated by specific legislature or socio-economic factors. WM is a key component in obtaining and maintaining environmental certification ISO14001.

DESCRIPTION OF EXPECTED WM ACTIVITY

In 2008 the European Parliament adopted the Directive 2008/98/EC which “establishes the legislative framework for the handling of waste in the Community [..] It also establishes major principles such as an obligation to handle waste in a way that does not have a negative impact on the environment or human health”.

This directive establishes a “waste hierarchy” which lays out a “priority order of what constitutes the best overall environmental option in waste legislation and policy”.

EUROPEAN WASTE HIERARCHY



In applying this hierarchy to waste, the directive states, “Member States shall take measures to encourage the options that deliver the best overall environmental outcome”.

They also must consider the general principles of precaution and sustainability in terms of environmental protection, technical feasibility and economic practicality, and the protection of resources as well as overall social, economic, health and environmental impacts.

Prevention lies at the top of the hierarchy, meaning measures - taking before a substance, material or product becomes waste - which reduce the quantity of waste, the negative impacts of the waste product on the environment and human health or the content of dangerous substances in the materials and products.

Therefore, the ‘reuse’ of products or components that have not yet become waste materials and are repeatedly used for the same purpose as the original are found in this phase

Some examples of “Prevention”:

• Yogurt pack without cardboard packaging. The company, thanks to the redesign of the product and changes in its production process, was able to eliminate the secondary packaging which performed the dual function of containing (keeping the two packs together) and communication.

Before

After

• Bottles of water manufactured with a lesser quantity of plastic material. In this case, too, in focusing on eco-design obtained a product that guaranteed the same mechanical performance of the traditional bottle, but used a lower amount of polymers which added up to a lesser quantity of waste at its end-of-life.

• Reusable shopping bags; some companies, thanks to the redesign of the traditional shopping bag, have produced more robust materials, inviting their customers not to throw away the product once it has been used, but rather to reuse it over and over.

As reported in the latest technical updates concerning the European Directive, once Prevention has been carried out, the procedures commence for correct Waste Management; the two macro-areas are ‘Recovery’ and ‘Disposal’.

Recovery involves three activities: “ Preparing for Re-Use”, “Recycling”, and “Other Recovery”. ‘ Preparing for Re-Use’ involves checks, cleaning and repair with which the waste product or waste product components are prepared in order to allow them to be reused without further pre-treatment.

The difference between ‘Reuse’, which is included in ‘Prevention’, and ‘Preparing for Re-Use’ lies in the fact that, in the latter case, the material or object is already waste material, while in the former it has yet to become so.

An example of ‘Preparing for Re-Use’:

• Body cream in glass jars with hermetic seal; a few changes in shape and the aesthetic-emotional appearance of the product can suggest other possible uses for that product.

The second activity of ‘Recovery’ is Recycling, considered any form of recovery through which waste materials are treated in order to obtain products, materials or substances that are used in their original functions or for others. This includes the re-treatment of organic material but not the recovery of energy or treatments to obtain materials for uses as fuel.

Some examples of ‘Recycling’:

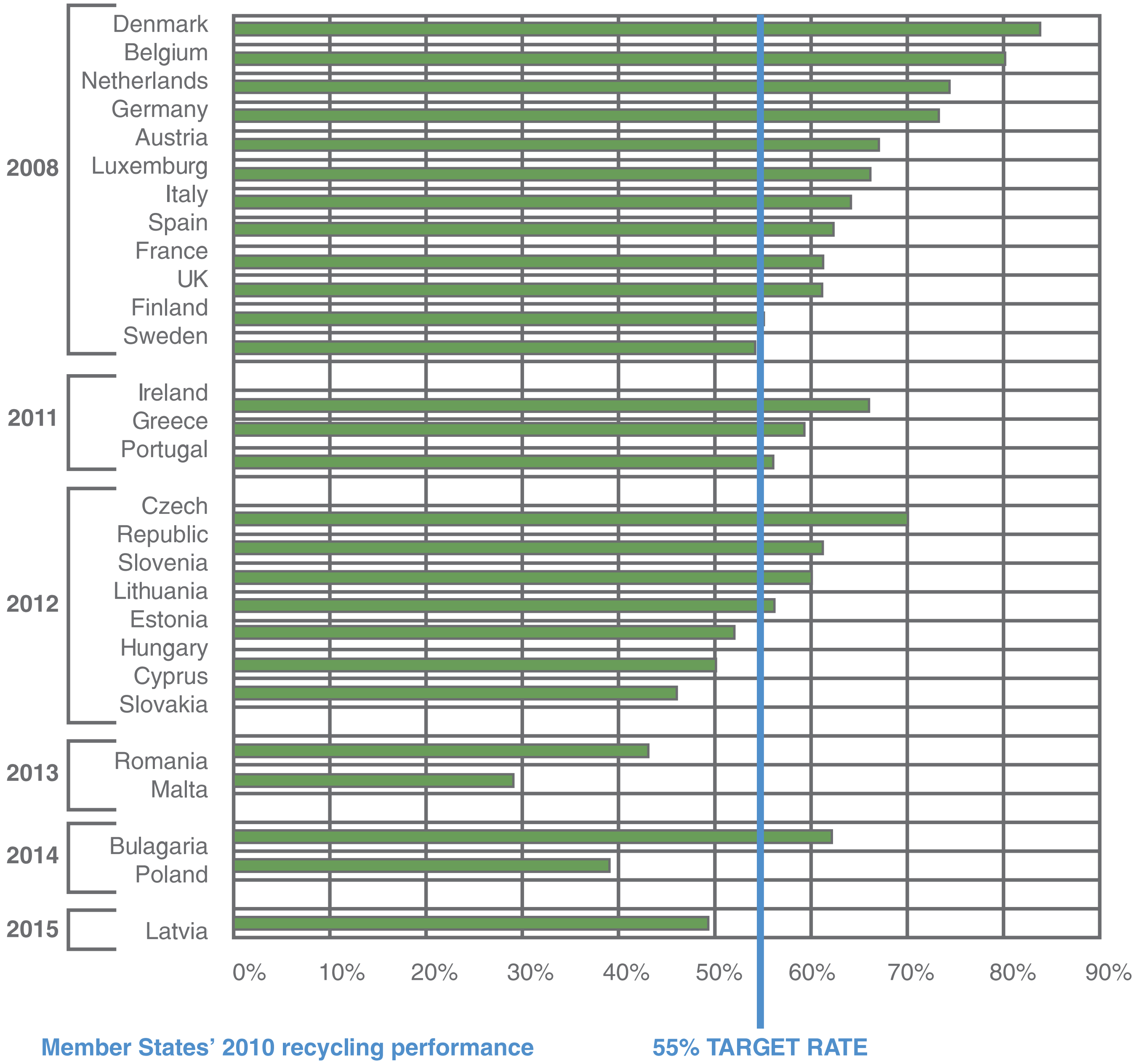
• Plastic fruit crates obtained by recycling other crates

• Felt pads for the automotive sector or filtration obtained from recycling plastic bottles (PET); these are cut, broken down and reduced through various processes to obtain forms similar to the plastic granules of the initial polymer.

It is then possible to insert these flakes in a new production process, which can bring about the manufacture of other bottles or of completely different products, such as the previously-mentioned felt pads.

Many countries have already achieved an excellent level of waste management, which takes place primarily through the “separated collection of waste”. In the figure below the percentages of recycled waste carried out in the European Union in 2010 is reported in regards to the required target of 55%.

TARGET DEADLINE



Member States’ 2010 recycling performance against the 55% recycling target

The next stop in the scale of hierarchy is the so-called ‘other recovery’, which includes all operations that differ from ‘preparing for re-use’ and ‘recycling’. It refers specifically to energy recovery and other operations in which the main result is in “serving a useful purpose by replacing other material.”

Waste, therefore, undergoes thermal treatments, thanks to which electric energy and heat are recovered. There are a number of different types of these treatments, such as incineration (which occurs in incinerators), pyrolisis and gasification. In incinerators the waste is burned in ovens and reduced to ashes of extremely reduced volume (20-30% less than initial volume); the thermal energy of the fumes that are produced is used to produce water vapour that, passing through a turbine, generates electric energy.

The quantity of recovered electric energy in comparison with the energy utilised is rather low (19-25%), while thermal energy is much higher. In this regard, the directive specifies that incinerator systems for solid urban waste can only be considered recovery systems if they satisfy specific requisites for “energy efficiency” established by the directive itself. In fact, incineration is a process that is the subject of significant controversy connected to the emission of pollutants (dioxin, furans, etc.), which derive from imperfect combustion within the incinerator.

Instead, systems that take advantage of pyrolisis and gasification technology are not based on combustion but rather molecular dissociation, thus obtaining gaseous molecules that are smaller and less polluting than the originals (syngas) and solid or liquid slag.

Waste is not burned but rather is heated at variable temperatures (from 400 to 1200°C depending on the process) in the absence of oxygen (with pyrolisis) or in the presence of a limited quantity (with gasification). As with incinerators, these systems also produce electric energy but their performance is better and the impact of gaseous emissions is substantially reduced.

The last phase, called “Disposal”, includes everything that does not fall under the “Recovery” macro-category.

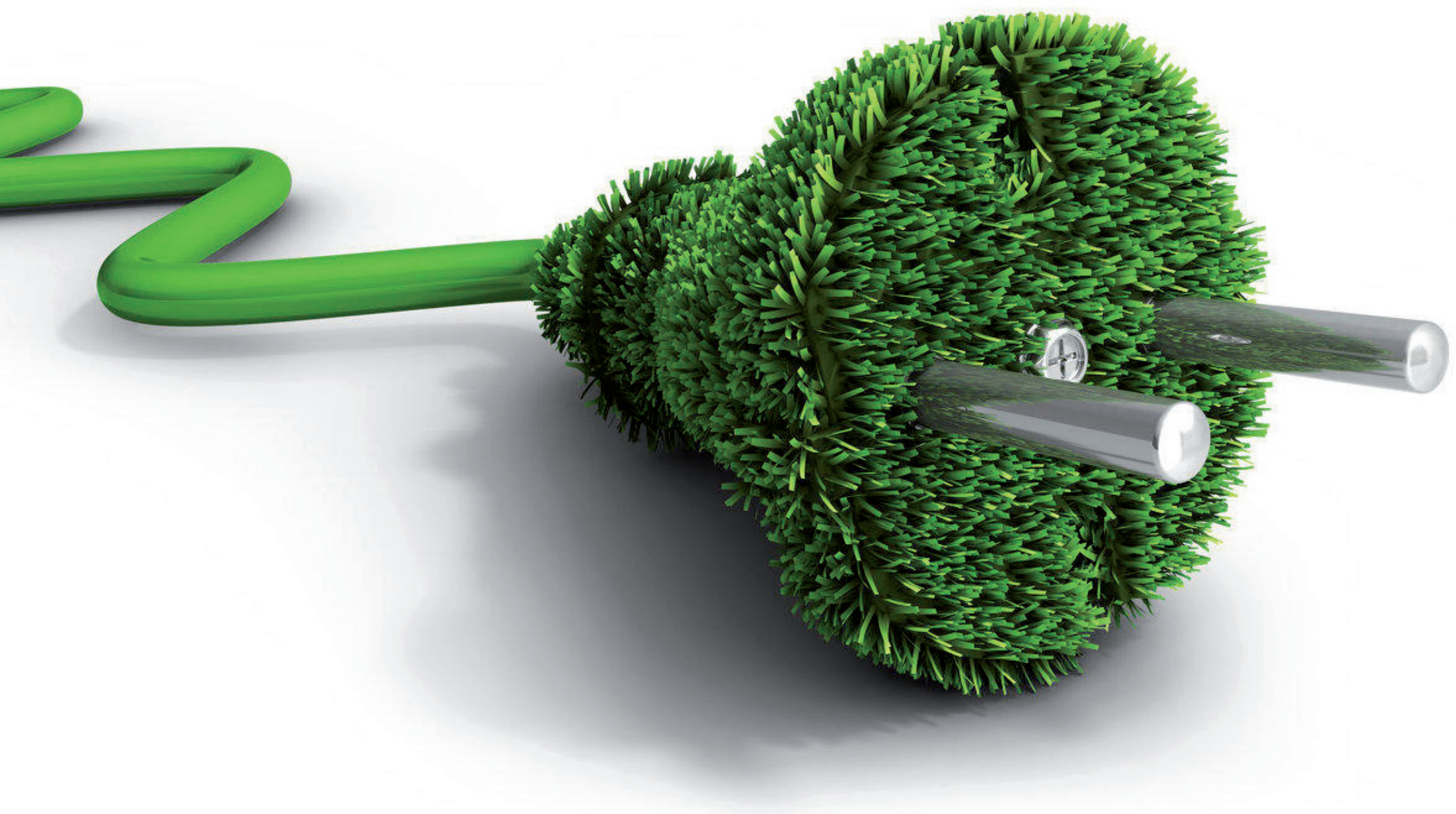
Landfilling is the most common and widespread among the different types of disposal, followed by biodegradation of liquid or sludgy discards in soils, the injection of pumpable waste in wells, salt domes or naturally occurring repositories, and incineration or permanent deposit (e.g. emplacement in containers in a mine).

This activity can entail substance and/or energy recovery which, however, in contrast to recovery activities constitutes a marginal or secondary effect.

Landfills are the most common method for waste disposal in many countries, and this process is one of the most harmful for the environment.

Poorly managed or poorly designed landfills can create numerous problems for the surrounding environment: waste dispersion, parasite proliferation, sewage generation and gas production from decomposition (normally methane and carbon dioxide), which, besides emitting unpleasant odours, destroys nearby vegetation and increases the greenhouse effect.

Modern landfills, which are designed according to technical and normative criteria, utilise systems and technological solutions that partially reduce and minimise the problems mentioned above: the use of plastic or clay membranes allows for sewage containment; thanks to this, waste is then compacted in order to increase its density and stability, and then covered to prevent parasite proliferation; many landfills are also equipped with systems capable of extracting and transporting the gases produced which are then burned and used, for example, for the production of electric energy.



Commissione
europea

imageen