Ecodesign in Food packaging

UNIT 2: International and European standards directives for Ecodesign in food packaging

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2.1 Contributions of eco-design to sustainable development.......2

2.2. The life cycle stages of the package 2

2.3 Packaging and Life Cycle Analysis (LCA) 5

2.4 Implications of the LCA approach for food packaging 7

After learning this unit, the student will be able to:
-Limit the weight and volume of packaging to a minimum;
-Reduce the content of hazardous substances and materials in the packaging material and its components;
-Design reusable or recoverable packaging;
-Ensure a high level of protection for human health and the environment.

Funded by the Erasmus+ Programme of the European Union

Ecoinnovation Skills for European Designers, Project number: 562573-EPP-1-2015-1-SI-EPPKA2-SSA. Disclaimer: The European Commission support for the production of this publication does not constitute endorsement of the contents which reflects the views only of the authors, and the Commission cannot be held responsi-ble for any use which may be made of the information contained therein

Eco-design is an internationally recognized approach to reduce the environmental impact of products in their design process. The overall life cycle of a product is the basis on which eco design substantiates its strategies.

Eco-design has been developed to incorporate new concepts such as product vision thought as a system, life cycle analysis concept (LCA and Life Cycle Assessment) and integration of all stakeholders involved in this system. It may start with improving the environmental aspects of products and extends to include more environmental actions such as waste treatment, recycling and cleaner production. It also evaluates the financial part of the system, for example, eco -efficiency and socio-economic aspects of product development.

Thus, starting with "cradle to the grave"[1] and continuing with, "cradle-to-cradle"[2], environmental aspects[3] are considered for each stage through which the product passes.

2.1 Contributions of eco-design to sustainable development

In order to achieve sustainable development[4], most of the design and manufacturing processes are today controlled or regulated by European Commission standards and regulations or directives.

European Parliament and Council Directive 94/62/EC on Packaging and Packaging Waste (the Packaging and Packaging Waste Directive) covers all packaging within the EU and all its waste, regardless of where they are stored on industrial, private sites or residential houses. For the implementation of Directive 94/62, the EU Standards Organization, CEN, issued several standards, Annex 4.

To further improve the environmental performance of products entering the EU market, its actions focus on the relationship between the product and its environmental aspects throughout the product life cycle. This is the so-called "Producer Responsibility" policy, which requires that through eco-design and product achievement, legal responsibility for product life cycle management is guaranteed.

2.2. The life cycle stages of the package

[1] From creation to disposal; throughout the life cycle

[2] It is a global, economic, industrial and social framework that seeks to create systems that are not only efficient but also essentially waste free.

[3] Element of an organization's activities, products or services that can interact with the environment

[4] "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs. This involves addressing economic, social and environmental factors and their interdependence in an organization's decision-making and activities".

ISO 14040 defines the lifecycle as "the consecutive and interconnected phases of a product system, from the raw, the acquisition of materials or from the generation of natural resources to the final disposal"

The UN Environment Program proposed the concept[5] "Life Cycle Thinking (LCT)" - in order to prevent a fragmented approach and avoid moving a problem from one life cycle stage to another, from one geographic area to another, or from one environment to another.

In the process of designing a packaging or packaging system, life-cycle packaging must be assessed, starting from the production of raw materials and the use of as much recycled material as possible in the manufacture, transport and disposal of the product, its use to the consumer and ultimately waste disposal. A measure implemented at a certain stage with positive effect on the environment can increase the negative impact on the environment in another phase. Therefore, in the company's environmental policy, we need to ensure that the environmental impact is minimized throughout the life cycle.

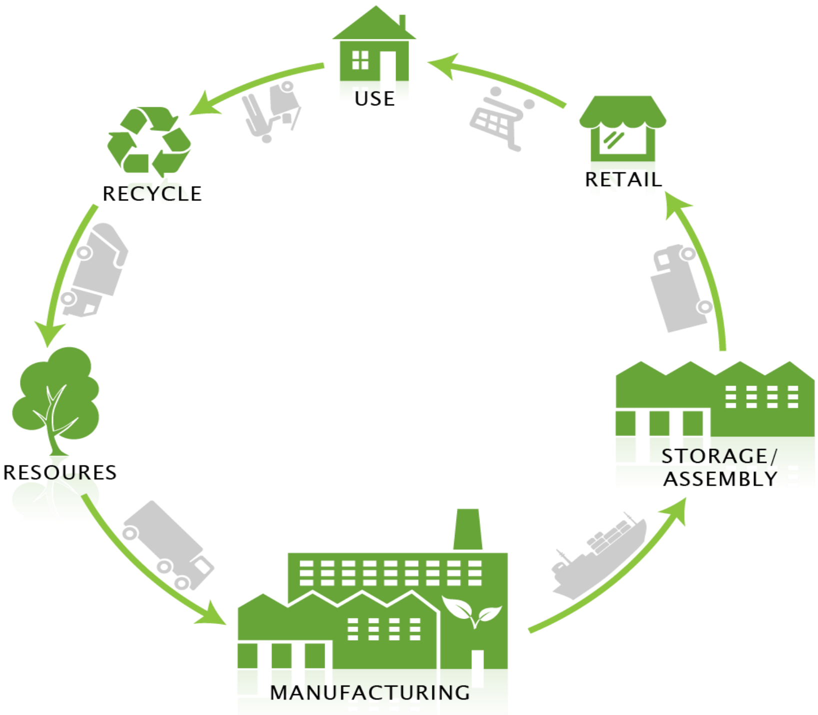

Fig.1 Life cycle phases of the packaging system
(http://pkgpackaging.com/life-cycle-assessment/)

Waste disposal must pursue priority the hierarchy recommended by the EU: packaging re-use, waste collection and recycling, their use to obtain energy through

[5] Packaging in the Sustainability Agenda: A Guide for Corporate Decision Makers - ECR Europe and The European Organization for Packaging and the Environment (EUROPEN) with the assistance of G. Richard Inns, CSR Analyst. © ECR Europe / EUROPEN 2009

incineration or other thermochemical processes, and finally, but not recommended, the landfilling of waste. Solutions adopted to optimize packaging design should minimize its impact[6] on the environment[6] when it is harmful.

In environmental management, the following notions are widely used: Renewable[7], Recovery[8], Recycling[9], Composting and Biodegradation

For the eco design of packaging, from legislation the following requirements can be extracted:

1. **Specific essential requirements for the manufacture and composition of the packaging:**

    a. Packaging shall be manufactured in such a way that its volume and weight are kept to a minimum necessary to ensure the required level of safety, hygiene and acceptability for both the packaged product and the consumer;
    b. Packaging shall be designed, manufactured and marketed in a way that allows its re-use or recovery, including recycling, and minimize the negative environmental impact;
    c. Packaging shall be manufactured with the aim of minimizing the content of toxic substances and materials and other hazardous substances in the packaging material and its components, substances which may be present in the emissions, ashes or leachate resulting from the disposal processes of packaging waste. Thus, the total concentration of lead, cadmium, mercury and hexavalent chromium levels should be less than 100 ppm.

[6] Any change in the environment, harmful or beneficial, resulting in whole or in part from the activities, products or services of an organization

[7] Renewables must be:
a) either composed of biomass (in nature is continuously regenerated after a defined period of time)
b) either naturally regenerated at a rate equal to or greater than that of their exhaustion,
c) come from sources that are managed according to the principles of sustainable development,
d) used when there is a verifiable traceability system.

[8] Recovery refers to a variety of waste management operations (recycling, incineration with energy recovery, composting), which are able to use the waste, eliminating the need to store them in the landfill

[9] Recycling "means any recovery operation whereby the raw materials are reprocessed into products, materials or substances, either for initial use or other purposes. This includes reprocessing of organic materials but does not include energy recovery and reprocessing in materials to be used as fuels or the sterile filling operations "EU Waste Directive (2008/98 / EC).

2. **Specific essential requirements on the reusable nature of a packaging:**

    a. Physical properties and characteristics of the packaging must allow for more rotations under the intended normal use conditions;
    b. Reusable packaging must be prepared, where appropriate, to meet health and safety requirements;
    c. Packaging that can no longer be re-used must become redeemable waste packaging.

3. **Specific essential requirements as to the recoverability of a packaging:**

    a. Packaging must be so manufactured as to allow, when it becomes packaging waste, that a certain percentage of the weight of the materials used is recycled. Fixing this percentage may vary depending on the type of packaging material used;
    b. Packaging must be so manufactured as to enable packaging waste when treated as energy waste recovery to have a minimum calorific value to optimize energy recovery;
    c. Packaging must be so manufactured as to enable packaging waste to be sufficiently biodegradable when packaging waste is used for composting;
    d. Biodegradable packaging must be so manufactured as to enable it to become physically, chemically, thermally or biologically decomposed, when it becomes packaging waste, so that most of the material is converted into carbon dioxide, biomass and water.

2.3 Packaging and Life Cycle Analysis (LCA)

According to Laura Flanigan[10], the Life Cycle Analysis (LCA) is a quantitative determination of how each phase of the packaging life cycle affects the environment intended to assess the environmental performance of the packaging system life cycle. This analysis is a well-developed framework to lead to environmental decisions in industry.

Depending on the purpose of the analysis, Life Cycle Analysis (LCA) of packing can be done for the packaging itself, for example to find the optimal packaging solution when analyzing more different packing technologies or for the whole packaging system, including the very food to be packaged, in order to determine the overall environmental impact of the system.

[10] An Analysis of Life Cycle Assessment in Packaging for Food & Beverage Applications - Laura Flanigan, Rolf Frischknecht, Trisha Montalbo - UNEP/SETAC Life Cycle Initiative, 2013

The LCA general methodology developed in international standards ISO 14040[11] and 14044[12] has already been presented in the first part of the course. It relates to the structure and assessment of the environmental impact of inputs and outputs of the system for all phases of its life cycle.

Thus, ISO defines four stages in LCA realization:

1. Defining the LCA goal
2. Determining the life cycle phases of the packaging system
3. Life cycle environmental impact assessment
4. Interpretation of results and conclusions

According to the ISO 14040 standard, life cycle analysis (LCA) consists of the following components:

- Defining purpose and degree of detail;
- Clear formulation of objectives and selection of system boundaries so that no significant process is omitted;
- Inventory analysis;
- Identification and quantification of all inputs (material and energy consumption) and outputs (emissions and waste) into / out of the system between the specified limits;
- Unconventional impact analysis;
- Quantification of environmental impacts based on inventory data, converted into impact indices using equivalence factors specific to the various impact categories, followed by characterization and impact classification;
- Optimization analysis;
- Identifying and selecting optimal solutions for improving the technological and environmental performance.

To complete life cycle analysis (LCA), you need to complete the following steps:

1. Formulation of the objective and degree of detail of the analysis;
2. Defining the system and boundaries;
3. Drawing up the flow diagram of the analyzed system, with all the subsystems;
4. Collecting the data needed to conduct the analysis;
5. Processing and organization of inventory data (data banks);
6. Quantifying the impact of a product's production on the environment throughout its life cycle, based on specific indicators;
7. Classification of inventory data by categories of environmental effects and impact characterization;
8. Interpreting the classification and characterization results and determining the critical areas to be the subject of optimization analysis;

[11] ISO, Environmental management — Life cycle assessment — Principles and framework, 14040:2006
[12] ISO, Environmental management — Life cycle assessment — Requirements and guidelines, 14044:2006

2.4 Implications of the LCA approach for food packaging

The definition of the degree of detail of the analysis (field of analysis) is closely related to the objective formulated at the beginning of the analysis. In relation to this objective, life cycle analysis can be done on:

- The entire life cycle;
- The partial cycle;
- Activities or independent stages.

Objective

LCA food packaging options may have different objectives such as improvement in the design of future packaging or future packaging systems, or to understand the environmental performance differences of alternative packaging models fulfilling the same function or to compare options for End-of-life treatment for different packages. Another emphasis can be put on the relevance of packaging in the life cycle of the product. Some studies focused only on packaging, others take account of the product to be packaged. The purpose of the study can directly influence the scope of LCA. Thus, a clear definition of the purpose helps to adapt the necessary purpose of the LCA study and to optimize the efforts needed to achieve LCA.

Life Cycle Analysis uses, in detail, the matrix of environmental requirements

Environmental requirements can be defined by words or numbers (figures). It is recommended that those expressed in figures be more severe than the limits provided by the legislation in force, given the dynamic character of the legislation. Wording the requirements is more difficult for existing products as performance limitations may be due to existing facilities and processes, which in turn can condition the use of materials with certain characteristics, whose processing may be involved in a more substantial impact on environment.

In the life cycle analysis (LCA) of a product, its production is usually characterized by the most significant contribution to the consumption of raw materials and energy but also by the most relevant impact on environmental factors.

Packaging manufacturing processes cause air, water and soil pollution, with various consequences: climate change (CO_2 emissions, CO, CH_4, often expressed as CO_2 equivalent n-CO_2e), photochemical pollution (VOC – Volatile Organic Compound and NOx emissions), Ozone depletion (CFC – Chlorofluorocarbon - type VOC), acid rain (SO_2 and NOx), eco-toxicity and human toxicity (VOCs with high potential for toxicity, other organochlorine compounds, heavy metal powders and suspensions, cyanides).

The stage of Product use has less impact on the environment and human health. It is only after the end of the product life that it contributes to the accumulation of waste if the used product can no longer be reused or recycled.

Recycling used products (including collection, separation, and treatment) and wastes storage (as final disposal) are often ignored in life cycle analysis, the main reason being the lack of information. Unarranged or arranged landfills (dumps) do not represent the end point of the life cycle. The impact of hazardous, latent substances in these landfills must also be estimated; so it is important to know the quantities of accumulated waste, pollutant concentrations with a high hazard potential (toxicity, flammability), possible physical and chemical reactions under weather factors (rainwater, solar radiation) that favors the occurrence of chronic or acute risk situations. These situations can be prevented by carrying out stabilization treatments, whereby the pollutants are transformed into inert compounds with respect to the environment.

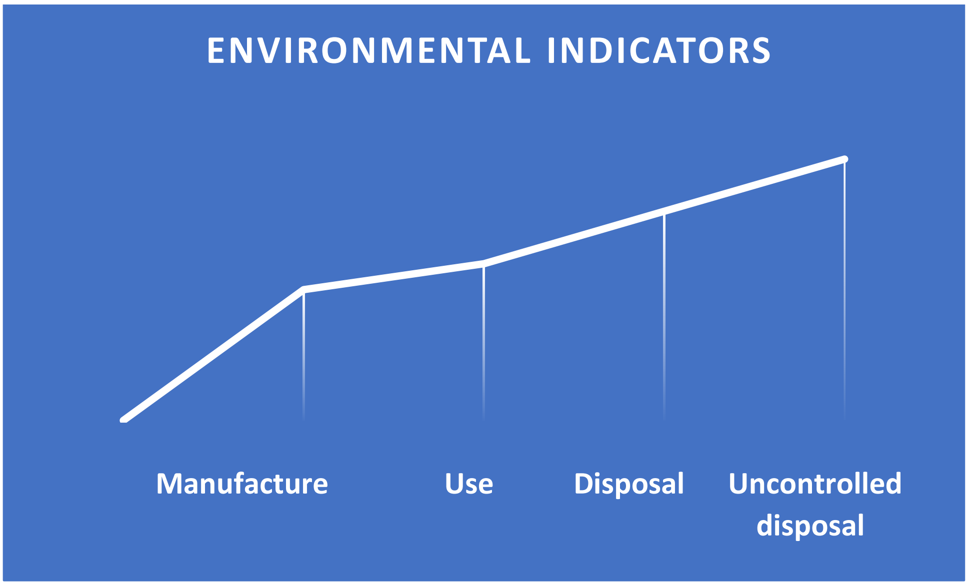

Fig 2. The environmental impact of the life cycle phases

Functional unit

An LCA of a product should clearly specify the functions to be assessed. The measure of a performance that the system offers is called a functional unit. The functional unit offers a reasonable reference value when comparing different products.

Two products, A and B, may perform differently even if they perform the same function. An example is the comparison of different types of milk packaging. Two alternatives are possible: a box (can) of milk and a returnable bottle of milk. A bottle can be used ten or more times, while a can of milk can only be used once. On the other hand, a box of milk does not require extra washing and transport. When comparing a cardboard box and a bottle we can conclude that the best choice from an environmental point of view is the box. However, if the functional units of the two packages are set, the analysis is not distorted by arbitrary assumptions. Consider, for example, that the packaging for 10 liters of milk could be a functional unit. In this case, we must compare 10 packs of milk each in a can with a bottle and 9 washes (assuming we have 9 bottle returns)[13]

Therefore, the functional unit:

- considers and packs a unit of volume or mass of the food product,
- distributes it in a geographical location,
- the two above are done so that the product (the packaging and the food itself should maintain their qualities until use).

The boundaries of the analyzed packaging system

All stages of the life cycle will be analyzed and any exclusion will be justified. An analysis that accounts for all stages of the life cycle of a packaging or packaging system is recommended.

It is essential to determine the boundaries of the packaging system. It helps us to define the activities to be included in the analysis. System boundaries comprise the various component subsystems of the packaging system (see Annex 1). All component sub-systems must be well documented. A description of the packaging system from Annex 1 is given in Annex 2. With regard to Annexes 1 and 2, the following comments[14] can be made:

Materials, energy and resources include water, electricity, steam chemicals and raw materials.

Packaging production includes:

- the production and transport of raw materials required for primary, secondary and tertiary packaging;
- Production and transport of raw materials for additional components (ex. lid, seal, label, etc.);
- The applied process (ex. injection, extrusion, thermoforming, fusion, waving, foil, drawing, etc.).

Assembling and packaging includes:

- filling activities;
- packaging for transporting and conveying the finished product.

Distribution includes:

- Handling if refrigeration is required;
- transport from the packaging manufacturer and distribution center;
- transport from the distribution center and storehouse of the retailer;
- transport from the retailer's store at the point of sale of the final product;
- refrigeration during transport and storage.

Use includes:

- Storage, refrigeration and freezing by the consumer.

End of life and waste management includes:

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[13] Product Design and Life Cycle Assessment, Ireneusz Zbicinski, John Stavenuiter Barbara Kozlowska and Hennie van de Coevering, The Baltic University, Environmental Management, book series No.3
[14] Guidelines for environmental life cycle assessment - Québec Packaging Industry -2011

- end-of-life transport;
- End-of-life packaging management, taking into account municipal and / or regional waste management practices:
- transport (collection);
- sorting;
- Recycling, reuse, incineration, energy recovery (gasification, pyrolysis, energy recovery incineration), waste storage (with and without biogas recovery) and composting;
- Wastewater management.

Food losses caused by the type of packaging used and the product declarations include:

- packaged food product when loss rates (as a result of filling, transport, handling and use) are not considered to be null (for an environmental profile) or equal (in comparative studies). Account is taken of the lost fraction of the packaged product.

Excluded processes include:

- Construction and dismantling of production and distribution facilities, and capital goods (ex. building, machinery, roads). The impact of these processes on packaging production is considered negligible.
- activities related to the marketing of packaging (ex. transport of employees, use of hygiene equipment).

Packaging design will take into account all aspects that differentiate them

If packaging options differing in volume of distribution and product losses are envisaged, in order to avoid shifting of the environmental aspects from packaging to product, these aspects should be taken into account for each package. Product losses can occur when food is packed in packaging, distribution (more durable packaging), seller or consumer (ex. multiple breaks, breakouts).

If the designed packaging allows product changes, then the product itself should be included in the analysis.

In the case of exclusion from analysis of food or beverage losses and for other potentially relevant issues, rigorous justification is required.

Differences in distribution may occur, for example, if a packaging designer is able to reduce the primary volume of packages, so that more packages can fit on a pallet for the same amount of product. In this case, for more packaging options, the space occupied by them is analyzed.

Also, different packaging options, which require different distribution modes (e.g., chilled, frozen, or ambient), require consideration to be given to differences in energy

Allocation

Generally, the life stages of a packaging system lead to the co-production of energy and / or materials for other uses. Thus, from a methodological point of view, it is important to allocate coherently and relevant the portion referring to the life cycle of the packaging, the life cycle of the food product contained in the packaging and the life cycle of the products generated by related multifunctional processes. The allocation of emissions and the environmental impact of each co-product must be based on logical methodological choices. More allocation rules are needed and their approaches can have a significant impact on the interpretation of the scenarios and study findings.

One of these is below

Allocation method 50/50: The 50/50 Allocation Method allocates equal portions of the benefits of recycling at the end of the life cycle and the use of recycled material at the production stage as follows: on the one hand, 50% of the recycling benefits include the total impact of End-of-life recycling management as well as the avoided impact by reducing the production of original raw materials. On the other hand, 50% of the benefits of using the recycled material include the impact of the production of recycled material upstream of its use in the studied system of products, as well as the avoided impact of the use of virgin material at the production stage of the packaging.

Methods for allocation of the Life Cycle Staging:

<u>Production and assembly of raw materials</u>

- For material and energy co-products that are reused in the same process of the product under study (eg steam or recycled materials), system boundaries should be defined to include all processes and elements that will allow closed-loop recirculation (closed loop system)

- For recovered material and energy co-products intended for internal uses not related to the studied project, it is better to use a reduction. Impacts on the environment will be attributed only to the studied processes in which they are involved. The environmental impact of raw material production will be allocated to the original product and the impact of intermediate recovery processes (eg washing, sterilization, shredding, etc.) will be assigned to the forwarding product.

- In cases where the co-products are sold or simply recovered by a third party, it is best to extend the system boundaries. In addition to considering the impact of the acquisition by third parties (eg on-site transport and distribution to the endusers processes), the benefits of the avoided impact by using the recovered co-product must be credited to the supplier as the use of the sub- products by the supplier may replace energy or the production of original materials.

Distribution

-The impact of the transport shipment must be attributed to the packaging according to the mass or volume criterion. The criterion will depend on the type of material transported, and the allocation criterion must reflect the impact of a change in the shape of the package (ie the volume) or the mass to be transported. The choice between the two criteria must be determined by the maximum transport capacity: a mass criterion must be used when reaching the maximum limit even if the available space (truck volume) is not full and a volume criterion should be used when the space is full before reaching the mass limit. The maximum mass limit can be defined based on established national or regional standards.

- In the distribution of goods, the transport by truck is generally limited by a mass constraint. Fuel consumption will increase with the mass of the product contained in the package and the mass of the packaging itself. The transport impact can be allocated proportionally to the distance traveled and the transported cargo (tons * km) (Figure 3).

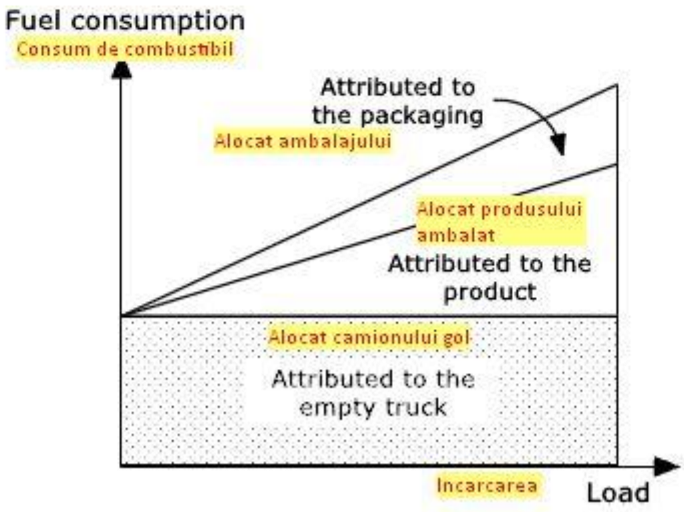


Fig. 3 Transport modeling approach

Several methods and allocation rules specific to the field of food packaging can be studied on paper [16])

- In the case of refrigerated transport, the consumption will depend on the total distance and the transport time during which refrigeration is required. The transport impact must therefore be allocated according to the volume criteria and the total refrigeration time (m^3 * h).

- In the storage phase, the impact of the refrigeration consumption is allocated to the package according to a volume criterion (ex the occupied space in the cooler). However, the thermal transfer properties differ from one packaging material to another. When these properties become a limiting factor, the choice of the allocation criterion can be based on the physical characteristics of the packaging (ex the thermal conductivity of the material).

Data collection, data sources and LCA computation methods

Firstly, primary data on all the manufacturing steps included in the packaging production system must be collected. Also information, called specific data, should be collected directly from packaging manufacturers, their suppliers and from any other related activities. Data can also be obtained from industry practice guides and product specifications. Without complete or easily accessible data, secondary data is required. They are generally taken from commercial databases, expert assessments, literature reviews and published study reports. Data should be used with caution and adapted to ensure representativeness. Based on the collected data, the LCIL (Live Cycle Inventory List) is compiled. An example of such a list for 1 kg of PVC is given in appendix no. 3.

The inventory list (LCI) includes environmental impact data, relevant inputs and outputs of a technical system model. The ecoinvent database **(www.ecoinvent.ch/)**, commonly used in LCA and recognized by the international scientific community, is particularly comprehensive as it covers a wide range of production processes. This database as well as others can be accessed from OPEN LCA Software: **http://www.openlca.org,** the official reseller for ecoinvent and GaBi databases and which also provides free databases for their use in software OPENLCA. Like any software, using OPEN LCA requires acquisition of the free resources available on the site or appropriate training. OpenLCA Nexus **(https://nexus.openlca.org)** is an online LCA data store. It combines the data provided by leading LCA data providers such as ecoinvent center (ecoinvent database), PE International (GaBi databases) and the Joint Research Center of the European Commission (ELCD database). The sets of data provided in Nexus can be easily imported into the OPENLCA software. The OpenLCA and Nexus databases have a common set of basical streams and other reference data that have been harmonized in coordination with their respective data providers to overcome methodological differences, for example on waste management. Nexus contains both free and paid data sets. To order and download Nexus databases, you must sign up using a valid email address.

The Life Cycle Impact Assessment (LCIA) method is available at **www.openlca.org/downloads.** This comprehensive package of methods for environmental impact assessment is formatted for use with all databases available in OpenLCA Nexus, including, for example, ecoinvent 3, GaBi and ELCD. This package includes normalization and weighting to the extent that these are provided by the method. A package, which contains an LCIA social method for use with the Social Hotspots database, is available at **www.openlca.org/downloads.** LCIN methods from Ecoinvent for OpenLCA are also available. You can download them from OpenLCA Nexus **(https://nexus.openlca.org/database/ecoinvent).**

Simplified methods of LCA

- The MET matrix

A MET analysis consists of five steps. The first is a discussion on the social relevance of product features. Then the Life Cycle of the product under study is determined and all relevant data is collected. Then the data is used to fill the matrix, divided into three categories (Table 1): material consumption, energy consumption and toxic emissions. Completing the MET matrix can be done with the help of environmental experts. Finally, when identifying significant environmental impacts, possible measures should also follow as to be taken to improve the product or service

	M- Material	E- Energy use	T Waste/toxic emissions
Production and supply of all materials and components			
Manufacturing: in-house production			
Distribution			
Use			
End-of-life system: recovery and disposal etc.			

- Spider charts

Diagrams allow the user to evaluate the product using a set of environmental criteria and to visualize them. Criteria usually include the use of materials, transport, product use, energy consumption, waste produced, toxicity and longevity. The product has a value of 0 to 5 (sometimes 1-6 or 1-10) for each criterion, where 0 (or 1) is weak and 5 is excellent. The value is marked on the corresponding axis in the chart. When the marked values are united by means of lines, we have an image that characterizes the product. The task for eco designer is to propose the change of the product in order to improve one or more criteria. Only relative values are used in the chart, but it still offers a very vivid, qualitative image of the improvements that are required, and old and new products can also be compared. A spider diagram is used for both analysis and prioritization for ecological design. Fig. 4 shows two examples of spider diagrams.

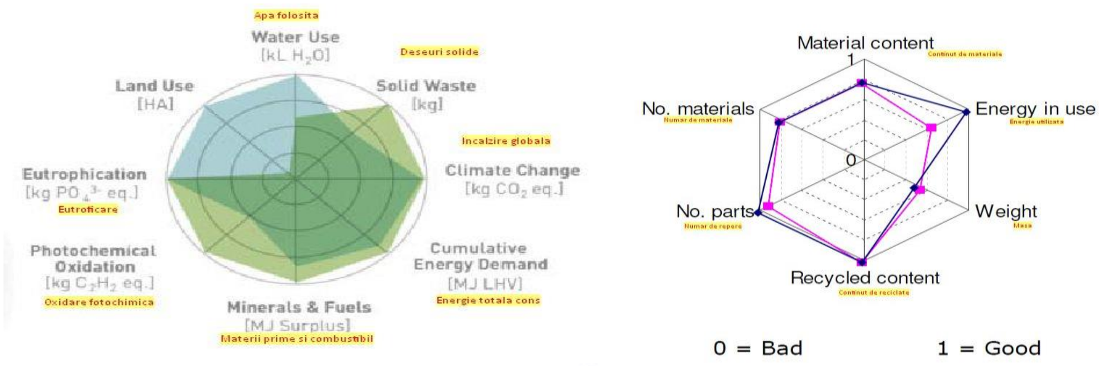


Fig. 4 Examples for Spider Diagrams (Charts)

Online calculator for assessing the impact of technological processes

Link: http://cpmdatabase.cpm.chalmers.se/IACalc/IACalcSelect.ASP?IAM=ECO-indicator+default&IAMVer=1999

It is a simplified calculation of the LCA result for some technological processes, including for each classification, characterization and weight. It clearly shows how much each impact stream contributes, and also what inputs and outputs are excluded from calculations. On the home page of the computer, select the impact assessment method that appears by clicking on the appropriate link.

On the next page, all the available technological processes and all categories of the impact assessment method indicators are displayed in two lists. Here you can select:

- A technological process for which results will be calculated
- Any number of the category of indicators used in the calculation

Start the calculation by clicking on the "Calculate environmental impact" button. The documentation on the selected impact assessment method can also be viewed by accessing the "View documentation of the impact assessment method" button.

Examples of technological processes useful in LCA projects of packaging systems that can be addressed by this computer: fuels and raw materials, plastics, wood, cleaning and washing, combustion, incineration, electrical, paint coatings, transportation, waste management etc .

For the other technological processes you can use the complete method or OpenLCA.

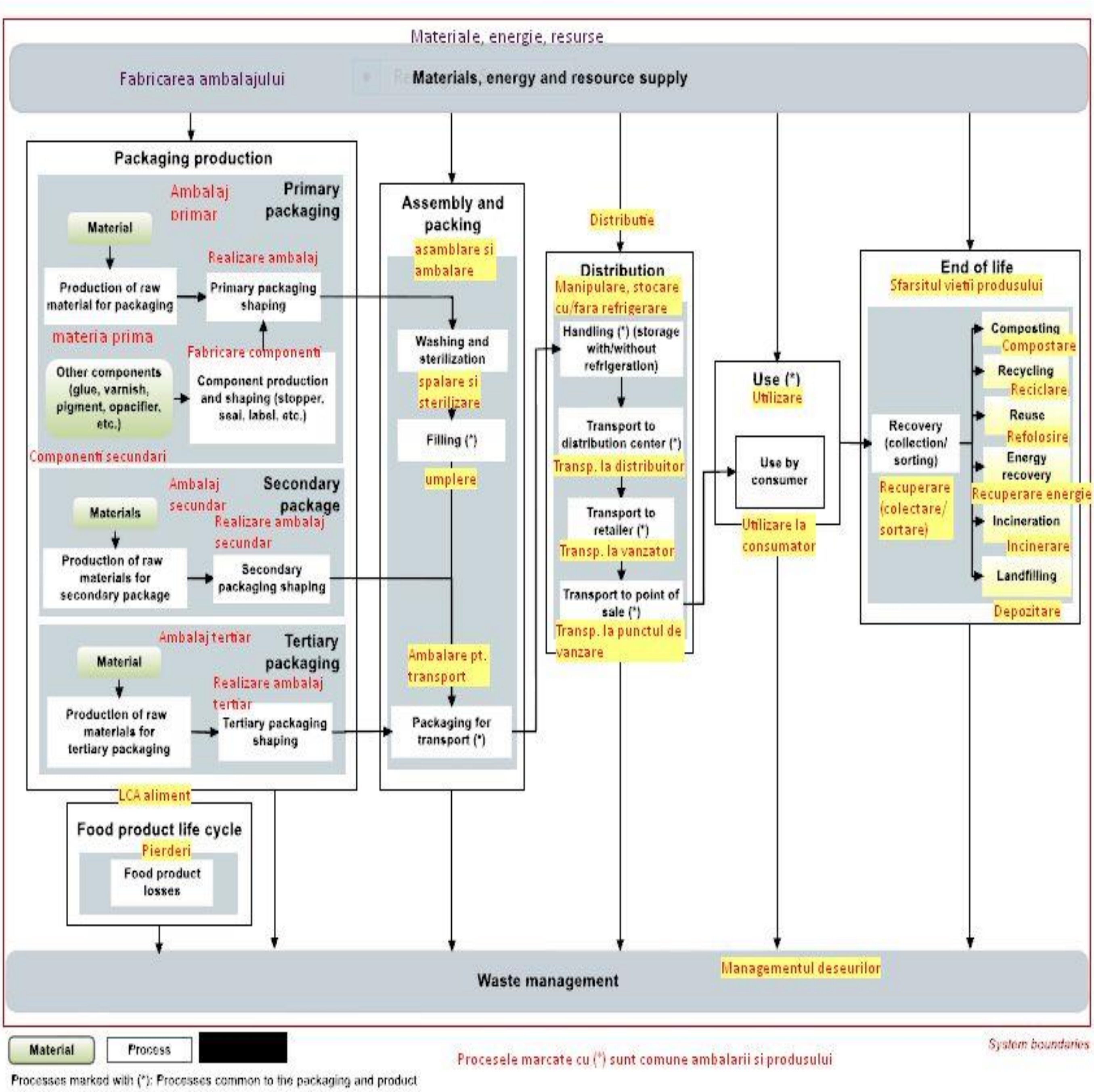
The complete "Life Cycle Impact Assessment Method" is documented on the same link in the CPM LCA database, which is based on the ISO 14042 concept and methodology. Here you can find all the impact indicators that serve to **the impact assessment methodology project analysis. Some of these methods are presented in the Basic Concepts module of the course (view and [15] and [16] to** https://hero.epa.gov/hero/index.cfm/reference/download/reference_id/749231)

[15] ILCD Handbook: Analyzing of existing Environmental Impact Assessment methodologies for use in Life Cycle Assessment First edition – JRC, EUROPEAN COMISSION

[16] LIFE CYCLE ASSESSMENT: PRINCIPLES AND PRACTICE - Scientific Applications International Corporation (SAIC) 11251 Roger Bacon Drive Reston, VA 20190 - 2006

Annex 1: LCA for food packaging system

[Guidelines for environmental life cycle assessment - Québec Packaging Industry -2011]



Annex 2: System description

No	Process / sub-process, packaging production	Description
1	Production of the raw materials required to produce the primary, secondary and tertiary packages	Raw materials extraction, energy and resources to produce materials , For all packaging type sub-categories
1.1	Cardboard packaging	Cardboard production Electricity and fuel consumption and water use
1.2	Plastic packaging	Resin production Collection and transformation of biomass (for plastics made from biomass, such as PLA) Electricity and fuel consumption and water use
1.3	Steel packaging	Steel sheet production Electricity and fuel consumption and water use
1.4	Aluminum packaging	Aluminum ingot production Electricity and fuel consumption and water use
1.5	Glass packaging	Glass melting Electricity and fuel consumption and water use
2	Production of additional components (cap, label, seal, etc.)	Raw materials extraction Component production and shaping Electricity and fuel consumption and water use
3	Supply transport	Transport of all raw materials required to produce and shape the packaging and additional components Transport of recycled materials (fibers, resins, metals, etc.)to the production plant
4	Packaging processing and shaping	Processes to shape each packaging type sub-category Energy consumption of machinery and equipment (ovens, shears, crimpers, tying machines, printers, etc.)
5	Washing and sterilization	Washing and sterilization between transformation processes Electricity and fuel consumption and water use
	Assembly and packing	
1	Storage and warehousing	Energy consumption
2	Filling the packaging	Primary package filling Sterilization and cleaning
3	Sealing and assembly of the additional components	Assembly
4	Packaging for transport (tertiary package)	Packaging for shipping
5	Inter-plant transport	Transport when the shaping, assembly and filling activities are carried out on different sites
	Distribution	
1	Transport to the distribution center	Energy consumption in the transport and ware housing stages at distribution center
2	Transport from the distribution center to the retailer/point of sale	Energy consumption in the transport and ware housing stages at the point of sale

3	Refrigeration	Energy consumption
	Use	
1	Refrigeration/freezing by the consumer	Included if the product loss rates are not considered null or equal (in comparative studies) Energy consumption for refrigeration
	End-of-life and waste management	
1	End-of-life transport and recovery	Waste (packaging) transport and sorting (if applicable) to the waste management facility
2	End-of-life management of the packaging	Processes such as recycling, reuse, incineration, energy recovery, landfilling and composting
3	Waste management	Management of contaminated or rejected packaging Industrial production, product losses and additional material waste management of the effluents and wastewater (cleaning and disinfection) generated at all life cycle stages

Annex 3: Sample Inventory List

LCA for producing 1 kg of PVC				
No	**Substance**	**Compartment**	**Unit**	**Total**
1	Air	Raw material	g	220
2	Water	Raw material	kg	99
3	Barite ($BaSO_4$)	Raw material	mg	82
4	Bauxite	Raw material	mg	440
5	Bentonite	Raw material	mg	32
6	Clay	Raw material	mg	9
7	Charcoal	Raw material	g	135
8	Oil IDEMAT (crude oil IDEMAT contents 42.7 MJ / kg)	Raw material	g	400
9	Dolomite	Raw material	mg	2
10	Energy (undefined)	Raw material	MJ	113
22	Cl_2	Air	mg	2
23	CO	Air	g	2,3
24	CO_2	Air	kg	2
25	C_xH_y	Air	g	19
26	Dust	Air	g	29
36	Acid as H^+	Waste water	mg	48
37	BOD	Waste water	mg	850
38	Calcium ions	Waste water	mg	47
39	Cl	Waste water	g	37
40	COD	Waste water	mg	76
41	C_xH_y	Waste water	mg	26
42	Detergent/oil	Waste water	mg	49
60	Mineral waste	Solid waste	g	42
61	Plastic production waste	Solid waste	mg	440
62	Slag	Solid waste	g	9,4
63	Unspecified	Solid waste	mg	9
64	Occupied area as industrial area	Storage space	m^2	400

Annex 4: EN and ISO packaging standards

For the implementation of Directive 94/62, the EU Standards Organization, CEN, issued several standards,

- 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 specification of minimum inferior calorific value
- EN 13432:2000 - Packaging - Requirements for packaging recoverable through composting and biodegradation - Test scheme and evaluation criteria for the final acceptance of packaging

Other standards in the field of life cycle analysis are:

- ISO 14040 - methodology and principles of life cycle analysis;
- ISO 14041 - definition of scope and degree of detail and inventory analysis;
- ISO 14042 - impact analysis (unconventional impact analysis);
- ISO 14043 - optimization analysis (interpretation).

At present, work is done on how to present inventory data (ISO 14048) and to illustrate examples of life cycle analysis (ISO 14049).