Guidelines for environmental life cycle assessment

Québec Packaging Industry

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Quantis is a leading life cycle assessment (LCA) consulting firm specialized in supporting companies to measure, understand and manage the environmental impacts of their products, services and operations. Quantis is a global company with offices in the United States, Canada, Switzerland and France and employs close to 70 people, amongst which several are internationally renowned experts in the LCA field.

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The Conseil de la transformation agroalimentaire et des produits de consommation, Éco Entreprises Québec and Quantis would like to extend gratitude to the following collaborators :

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List of acronyms

AAC	Aluminium Association of Canada
ABS	Acrylonitrile-butadiene-styrene
CCME	Canadian Council of Ministers of the Environment
COMPASS	Comparative Packaging Assessment
CTAC	Conseil de la transformation agroalimentaire et des produits de consommation
ÉEQ	Éco Entreprises Québec
EPI	Environmental Packaging International
EPPS	Efficient Program Planning Sessions
EPR	Extended producer responsibility
GHG	Greenhouse gas
GPP	Global Packaging Project
HDPE	High-density polyethylene
ISO	International Organization for Standardization
LCA	Life cycle assessment
LDPE	Low-density polyethylene
PCR	Product category rules
PET	Polyethylene terephthalate
PIQET	Packaging Impact Quick Evaluation Tool
PLA	Polylactic acid
PP	Polypropylene
PS	Polystyrene
PVC	Polyvinyl chloride
PU	Polyurethanes
rHDPE	Recycled high-density polyethylene
rPET	Recycled polyethylene terephthalate
WRAP	Waste & Resources Action Programme

GUIDELINES FOR LIFE CYCLE ASSESSMENT

FOR BUSINESSES

QUÉBEC PACKAGING INDUSTRY

RESPONDING TO A MARKET SEEKING INFORMATION ON THE SOCIAL AND ENVIRONMENTAL PERFORMANCES OF PRODUCTS

According to a study by the Grocery Manufacturers Association (GMA)[1], 95% of North American consumers are open to considering green products and over 60% actively seek out green products in stores. This trend is of direct relevance to the food industry, which now faces new challenges:

- New **environmental performance** and greening requirements set out in specifications for buyers and distributors;
- **Regulatory constraints** making eco-labelling mandatory—a practice that is already in force in certain European countries and should soon take root in North America;
- **Extended producer responsibility requirements** (passing of Bill 88 in Québec) that transfer the net costs of packaging, containers and printed matter of municipal curbside recycling services to the companies and organizations that contribute to Éco Entreprises Québec (ÉEQ);
- Increasing energy, transport, raw material and waste management **costs**.

Retailers, which are intermediate buyers, are also formulating these demands. Retail stores of all sizes are progressively implementing sustainable procurement policies and increasingly requiring guarantees for their suppliers' environmental and social practices. For example, Loblaws (Provigo) launched its Sustainable Seafood Commitment in March 2010, and Metro and Sobeys quickly followed suit in May 2010 and October 2010, respectively. On a broader scale, Walmart has become a leader in responsible procurement, since it is currently developing a sustainability index with which all supplier products must comply.

[1] *Finding the green in today's shoppers: Sustainability trends and new shopper insights*

LIFE CYCLE ASSESSMENT, INSTRUMENT OF CHANGE

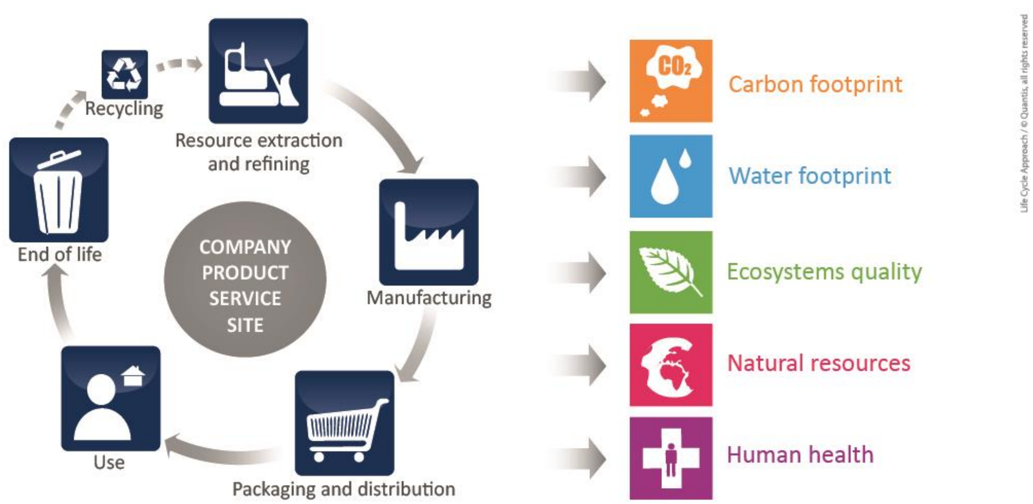
In response to the need for information on the environmental performances of products and organizations, a range of labels and certifications of all types have appeared. Some target specific issues (e.g. forest protection, greenhouse gas (GHG) emissions), while others have a broader focus, seeking to assess overall sustainability based on a multicriteria approach. Environmental life cycle assessment (LCA) falls into the latter category.

Environmental LCA is an internationally recognized method regulated by the ISO 14040 standard set out by the International Organization for Standardization (ISO). LCA assesses the environmental performance (or ecobalance or environmental footprint) of a product or processes throughout its life cycle, from raw materials extraction to its end-of-life. A life cycle assessment involves four main phases: **1) goal and scope** definition; **2)** life cycle **inventory** analysis; **3)** life cycle **impact** assessment; and **4) interpretation**.

LIFE CYCLE ASSESSMENT: BEYOND THE CARBON BALANCE

The advantage of the **life cycle approach** is that it provides information on all of the stages in the life cycle of a product, enabling manufacturing businesses to adequately respond to the increasingly stringent standards set out by their clients and other stakeholders.

Environmental life cycle assessment accounts for some 15 potential impact indicators, including greenhouse gases (GHG). It makes it simpler to determine the issues and priority sustainable development actions, guide the optimization of operations, reduce costs (energy, packaging, etc.) and foster the development of greener products without transferring the potential impacts from one life cycle stage to another.



Environmental life cycle approach

A BEST PRACTICE TOOL TO OPTIMIZE QUÉBEC'S PACKAGING INDUSTRY

Seeking to provide Québec businesses with the optimal conditions to gain a competitive edge, the Conseil de la transformation agroalimentaire et des produits de consommation (CTAC) and Éco Entreprises Québec (ÉEQ), with the financial support of the Fonds de développement de la transformation alimentaire (FDTA), initiated the development of LCA guidelines for Québec's packaging industry in an effort to foster and facilitate the undertaking of environmental life cycle analyses by food processors.

When based on the life cycle approach, the design and production of a packaging system will lead to fewer environmental impacts as well as energy and raw materials savings. The packaging industry is crosscutting, since it is presumed that all life cycle assessment projects undertaken by stakeholders in the food processing sector will include packaging issues.

These guidelines are chiefly intended for consultants carrying out life cycle analyses and aim to provide a framework without substituting the expertise required to carry out an LCA, whose scientific and technical quality is imperative to ensure its credibility. In addition to meeting the ISO 14040-14044 (2006) standards, an environmental life cycle assessment must be technically rigorous and transparent in its methodological choices.

The guidelines will lead to several benefits that will:

1. **Reduce the unit costs of LCA projects and increase their access**, since the guidelines make it possible to share the time and costs involved in carrying out the early phases in the LCAs of various types of packaging, which are often similar from one study to the next within a specific industry. By the same token, seeing as the scope of the study is already set out, internal investments in time and resources are reduced.
2. **Lead to more applied outcomes** for participating businesses. Since fewer efforts are required to get the analyses underway and establish the scope of the study, consultants will focus on assessing the results, setting out tangible recommendations and supporting businesses in the process.
3. **Standardize processes to ensure the quality and coherence of the studies** carried out within an industry and in various sub-sectors.
4. **Facilitate the comparison and communication of results as well as comparisons within a specific sector**, since all industry studies will be based on the same hypotheses, data sources and boundaries.

SAVE TIME, SAVE RESOURCES

The results of an LCA depend on a series of decisions that must be made in the earliest phase, when setting out the scope of the study. At the start of a new study, significant efforts will focus on correctly defining the elements that will be account for, the data sources and their quality and the environmental impact calculation methods. These guidelines help to establish the rules for these first steps, leading to practical results in a shorter time and curbing the costs for businesses that choose to carry out LCA studies.

LCA AND ENVIRONMENTAL COMMUNICATION

In terms of environmental communication, environmental life cycle assessment will support your environmental labelling efforts. There are several types of standard labelling options and environmental claims under the ISO 14020 series: environmental labels (type I – ISO 14024), self-declarations (type II – ISO 14021) and environmental declarations (type III – ISO 14025).

Ecolabels ensure the recognition of a product’s ecological attributes based on predefined environmental criteria and functional features. They are verified by a certifying organization based on the life cycle approach.

Self-declarations are freely made and under the responsibility of producers, manufacturers or retailers. They support an environmental effort made for a specific aspect of a product. Self-declarations may be documented as technical bulletins, advertisements or electronic submissions.

Environmental declarations translate the effects of the environmental impacts generated by a product based on the results of an LCA reviewed and revised by a third-party. While rarely submitted in North America, environmental declarations that contain standardized product information are generally set out in an effort to inform consumers and guide product comparisons.

LCA, STANDARDS AND OTHER ENVIRONMENTAL INITIATIVES

ISO is currently working on a preliminary **water footprint** project (ISO 14046) to set out principles, requirements and guidelines to assess the water footprints of products, processes and organizations. In LCA, fresh water is rarely included as an impact category, and the eventual framework could bridge the gap in existing environmental management standards. In fact, two projects are currently underway: ISO 14067 and ISO 14069 on the requirements for the quantification and communication of the carbon footprints of products and organizations, respectively.

LCA is a holistic approach and therefore has the advantage of simultaneously assessing several impact categories of interest throughout a product's life cycle. As such, several national and international standards and initiatives may prove complementary and useful to enhancing LCA methodology.

The Interuniversity Research Centre for the Life Cycle of Products, Processes and Services (CIRAIG) is currently leading the development of Québec's first life cycle inventory database (**Québec LCI database**). The main objective is to adapt and enhance the Swiss database ecoinvent, Europe's largest LCA record. A similar initiative to develop a Canadian database is also underway.

The **Global Reporting Initiative** (GRI) brings together a wide range of experts in some 10 countries and aims to set out sustainable development accounting guidelines (economic, environmental and social performances) for businesses, governments and non-government organizations.

The **Carbon Disclosure Project** (CDP) is a non-profit independent organization and works in collaboration with several institutions to develop tools to detect and measure GHG emissions. It also incites businesses to release data on their carbon footprints and information on the measures implemented to reduce their climate change risks.

INITIATIVES IN THE PACKAGING INDUSTRY

The **Voluntary Code** for the optimization of containers, packaging and printed matter released by Éco Entreprises Québec (2011) is the first voluntary initiative driven by life cycle thinking. The objective is to incite businesses to adopt best practices in packaged product and printed matter design. Developed to meet the needs of various sectors, the first part of the Voluntary Code is aimed at specific industries, including the food sector.

The **Canadian Council of Ministers of the Environment** (CCME) has carried out several initiatives in the packaging industry, including the Canada-Wide Action Plan for Extended Producer Responsibility (EPR), which sets out guidelines to consolidate and foster the harmonization of environmental risk management programs across the country. The plan especially aims to encourage producers to account for the total cost of their products throughout their life cycles.

With the 2009 **Canada-Wide Strategy for Sustainable Packaging**, the CCME released a guide for all stakeholders in the packaging industry. The main goal was to create a coherent nationwide EPR approach for the industry, foster a reduction in the total amount of packaging products that are produced and point industry members towards more ecological choices based on the complete packaging life cycle.

The **Global Packaging Project** (GPP) launched by the **Consumer Goods Forum** strives to standardize the sustainability benchmarks of packaging by developing a global approach that aims to define a common language and a series of standardized life cycle-based indicators. The goal of the initiative is to facilitate eco-design and information sharing between all stakeholders in the supply chain.

GUIDELINES FOR LIFE CYCLE ASSESSMENT

QUÉBEC PACKAGING INDUSTRY

FOR CONSULTANTS

1 Guidelines for packaging

In the food processing industry, packaging challenges are recurrent. In an effort to better establish the impacts of these challenges, Éco Entreprises Québec (ÉEQ) and the Conseil de la transformation agroalimentaire et des produits de consommation (CTAC) jointly developed an environmental life cycle framework for Québec's packaging industry.

So as to assess the issues relevant to the entire food product contained in a studied packaging, guidelines specific to certain food processing sectors will be made available.

Because LCA methodology is in constant development, certain components such as the large-scale national and international initiatives, allocation methods, data sources and life cycle impact assessment (LCIA) methods may evolve. The guidelines must therefore be reassessed and revised every two or three years to account for the relevant improvements and changes brought to the processing technology systems.

A summary of studies documented in the literature on life cycle assessment and the packaging industry is presented in Appendix A.

Any deviations from the rules described in the following section must be clearly detailed and justified in the LCA.

1.1 ISO requirements

The environmental component of the guidelines is based on the ISO 14040-14044 (2006) standards. Its principles are similar to those outlined in the Product Category Rules (PCR).

For labelling purposes, the content of any environmental declaration must be based on the results of a complete life cycle assessment of a product, as defined in the guidelines outlined herein. In addition, environmental declarations must be communicated according to the principles and methods outlined for type III environmental declarations, as set out in ISO 14025 (2006).

Appendix B provides an overview of the LCA and type III environmental declaration requirements.

1.2 Definition of the targeted product

Packaging is used to preserve, protect, contain, transport, promote and sell a product. It is defined by Éco Entreprises Québec (2011) as "products made of any materials of any nature to be used for the containment, protection, handling, delivery and presentation of goods, from raw materials to processed goods, from the producer to the user or the consumer. "Non-returnable" items used for the same purposes shall also be considered to constitute packaging."

The term packaging may also be used for a container, as used in the following section in an effort to simply the text.

1.3 Packaging system

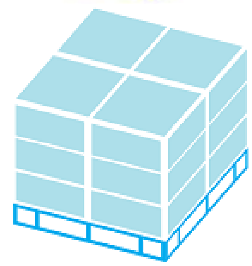
A packaging system is made up of different levels of packaging, which each serve a specific function for the product/content (Éco Entreprises Québec, 2011).

- The **primary package** (or consumer sales unit) is meant for the consumer or final user. It is in direct contact with the product and contains, ensures hygiene and protects against external risks that could lead to contamination.

  Any component added or included with the consumer sales unit to finalize the packaging is part of the primary package (e.g. cap, seal, label).

- The **secondary package** is the grouped packaging used to package several primary packages. It serves a logistical purpose by facilitating distribution for bundling. A multipack used to bundle several units or serve as a display is also considered as a secondary package.

- The **tertiary package** is the shipping container or logistic packaging used to protect and transport packaged products from a distributor to a retailer. It facilitates and accelerates the handling operations and protects the warehoused products and the environment against any risk of pollution or contamination.



Images: Éco Entreprises Québec

1.4 Types of packaging

In the food packaging industry, there are several types of packaging based on the material from which they are made (e.g. corrugated cardboard, plastic laminate, polyethylene terephthalate (PET), high-density polyethylene (HDPE) or glass). The packaging options fall into five sub-categories: (1) cardboard, (2) plastic, (3) steel, (4) aluminium and (5) glass. In addition to the packaging made up of one material, there are also multi-material packaging options made from several materials (e.g. different types of plastics). Table C.1 in Appendix C was developed to provide a comprehensive categorization of the packaging types. The table details the list of materials targeted by the Québec compensation plan for containers and packaging.

2 Function and functional unit

In order to assess the environmental performance of a packaging type throughout its entire life cycle, the function and functional unit—the quantitative reference to which the inventory calculations and impact assessment apply—must be determined.

The system's main function is to *preserve, protect and contain a food product*.

It may also fulfill secondary functions: facilitate manipulation throughout the supply chain, enhance logistics, simplify product use and consumption, inform people and promote a food product.

The functional unit is therefore as follows:

Preserve, protect and contain 1 [volume or mass unit] of [food product], distribute it to [geographic location] and preserve it until its use.

3 Ingredients and chemical substances

The elements that compose the main materials used in each packaging life cycle system must be communicated in order to establish the inventory and assess the impacts associated with the product. The list must also include the chemical substances and their weight percent relative to the total mass of the studied product unit.

While they are not an integral part of the general LCA framework, the regulatory aspects of food packaging must be taken into account by all stakeholders involved in the supply chain. It is therefore critical to ensure that all packaging materials meet the food safety requirements outlined in section 23 of the Food and Drugs Regulations and Act (B.23.001). For more information, refer to Health Canada (Packaging Materials) and the Canadian Food Inspection Agency (CFIA).

4 Units and quantities

In order to compare the LCA with other studies, the International System of Units (SI) is recommended for data collection, calculation and inventory results communications.

5 System boundaries

It is essential to define the system boundaries in order to determine the life cycle stages and processes that will be included and excluded. System boundaries will also help determine the activities that must be considered and which are required in order to carry out the function set out earlier.

The boundaries of a system include (but are not limited to) the various sub-systems presented in Figure 5-1 and described in the following paragraphs. Sub-figures for the production and shaping stages are available in Appendix D.

All additional process sub-systems relevant to the study must be included in the system boundaries and clearly documented.

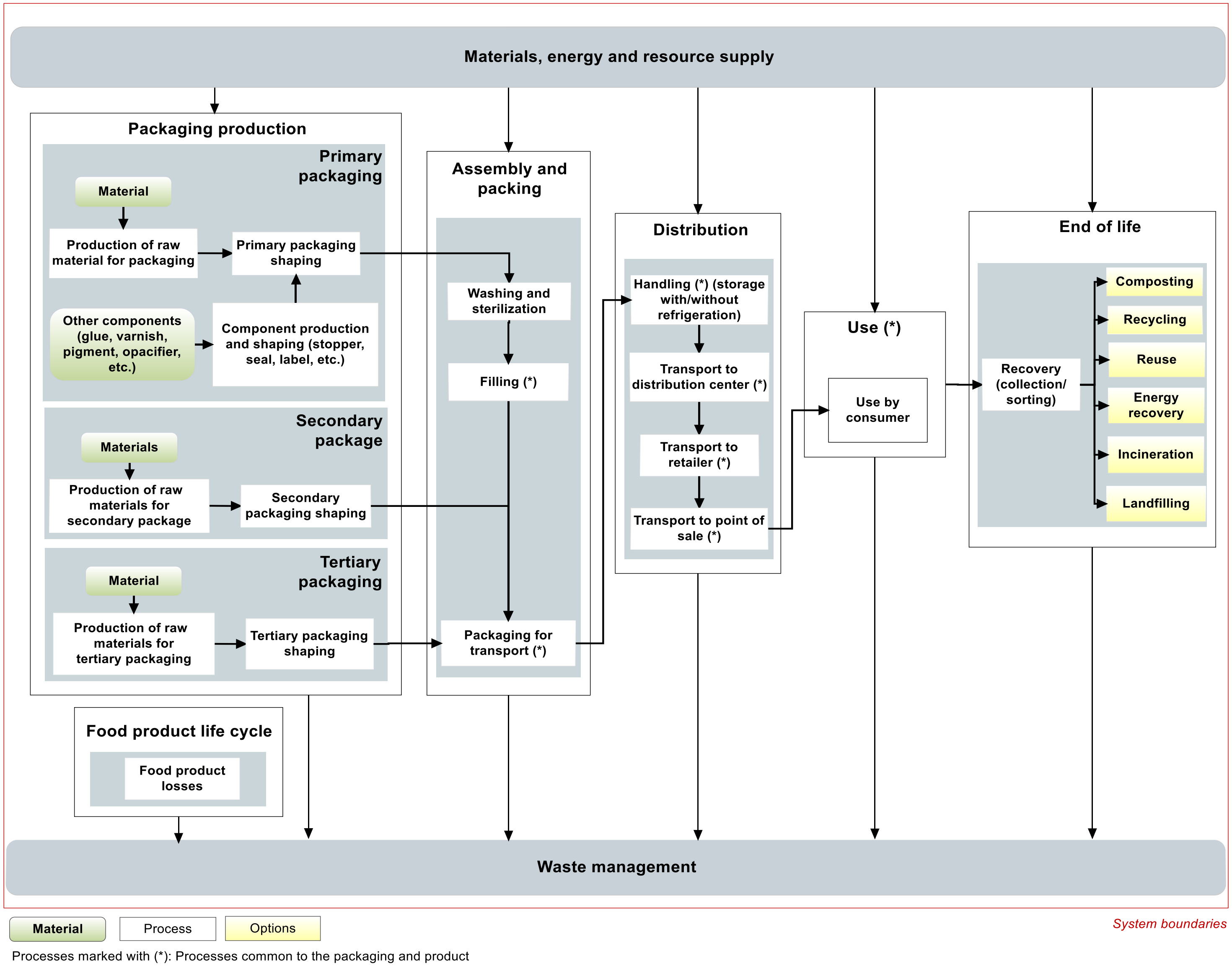


Figure 5-1: Packaging life cycle system boundaries

Materials supply, energy and resource extraction includes water, energy, chemicals and materials.

Packaging production includes

- the production and transport of the raw materials required for the primary, secondary and tertiary packages;
- the production and transport of raw materials for additional components (e.g. cap, seal, label, etc.);
- the shaping process or package transformation (e.g. injection, extrusion, thermoforming, fusion, corrugation, sheeting, drawing, etc.).

Assembly and packing include

- filling activities;
- packaging to transport and ship the finished product.

Distribution includes

- handling when refrigeration is required;
- transport from the packaging producer and the distribution centre;
- transport from the distribution centre and the retailer's warehouse;
- transport from the retailer's warehouse to the final product's point of sale;
- refrigeration during transport and warehousing.

Use includes

- storage, refrigeration and freezing by the consumer.

End-of-life and **waste management** include

- end-of-life transport;
- end-of-life packaging management, considering municipal and/or regional waste management practices:
  - transportation (collection);
  - sorting;
  - recycling, reuse, incineration, energy recovery (gasification, pyrolysis, incineration with energy recovery), landfilling, (with and without biogas recovery) and composting;
- wastewater management.

The **food product losses** brought about by the type of packaging used and product returns include

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

The excluded processes include

- the construction and dismantling of the production and distribution infrastructures as well as the capital goods (e.g. buildings, machines, roads). The impacts of these processes allocated to the production of the packaging are considered negligible.
- the activities related to marketing the packaging (e.g. employee transportation, use of hygiene-related equipment).

5.1 System description

An overview of the processes and sub-processes included within the system boundaries is provided in Table 5-1.

Table 5-1: Processes included within the system boundaries

Process / sub-process		Description
Packaging production		
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
	Cardboard packaging	Cardboard production Electricity and fuel consumption and water use
	Plastic packaging	Resin production Collection and transformation of biomass (for plastics made from biomass, such as PLA) Electricity and fuel consumption and water use
	Steel packaging	Steel sheet production Electricity and fuel consumption and water use
	Aluminium packaging	Aluminium ingot production Electricity and fuel consumption and water use
	Glass packaging	Glass melting Electricity and fuel consumption and water use
Production of additional components (cap, label, seal, etc.)		Raw materials extraction Component production and shaping Electricity and fuel consumption and water use
Supply transport		Transport of all raw materials required to produce and shape the packaging and additional components Transport of recycled materials (fibres, resins, metals, etc.) to the production plant
Packaging processing and shaping		Processes to shape each packaging type sub-category Energy consumption of machinery and equipment (e.g. ovens, shears, crimpers, tying machines, printers, etc.)
Washing and maintenance		Washing and sterilization between transformation processes Electricity and fuel consumption and water use
Assembly and packing		
Storage and warehousing		Energy consumption
Filling the packaging		Primary package filling Sterilization and cleaning
Sealing and assembly of the additional components		Assembly
Packaging for transport (tertiary package)		Packaging for shipping

Process / sub-process	Description
Inter-plant transport	Transport when the shaping, assembly and filling activities are carried out on different sites
Distribution	
Transport to the distribution centre	Transport
Transport from the distribution centre to the retailer/point of sale	Transport
Refrigeration	Energy consumption in the transport and warehousing stages at the point of sale
Use	
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	
End-of-life transport and recovery	Waste (packaging) transport and sorting (if applicable) to the waste management facility
End-of-life management of the packaging	Processes such as recycling, reuse, incineration, energy recovery, landfilling and composting
Waste management	Management of contaminated or rejected packaging Industrial production, product losses and additional material waste management Management of the effluents and wastewater (cleaning and disinfection) generated at all life cycle stages

6 Allocation rules

The life cycle stages of a packaging system generally lead to the co-production of energy and/or materials for other outlets. As such, from a methodological standpoint, it is important to coherently and relevantly allocate the fraction pertaining 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 through related multifunctional processes.

The allocation of the emissions and environmental impacts of each co-product must be based on logical methodological choices. Several allocation rules are required, and their approaches may significantly impact the interpretation of the study scenarios and conclusions.

6.1 General procedure based on ISO

In keeping with the ISO 14044 (2006) standard, the general procedure is as follows:

- First, it is important to determine the shared processes. Whenever possible, the elementary processes associated with a specific co-product should be subdivided, thus determining the processes that are not directly involved in the production chain of the studied product and which can be excluded.

- If it is not possible to subdivide the processes into sub-systems, the system boundaries should be expanded to include the additional functions. However, this process requires an understanding of the uses of the co-products and products they substitute (see section 6.2.1 for a more detailed description of the method).
- Finally, when allocation is inevitable, an approach that attributes a fraction of the shared processes system input and output flows to all of the co-products produced out of an underlying causal relationship must be implemented. A causal relationship helps illustrate the ways in which the inputs and outputs evolve according to the quantitative changes to the products generated by the system.

An allocation rule driven by an economic rationale is not generally recommended in the case of the production of two or more independent products. Should the rule be influenced by the market situation, which may vary considerably over time, it will not adequately reflect the incidences on the physico-chemical relations between the input and output flows and processes. However, for a production system in which the ratio between the co-products is directly linked to the content of a raw material (e.g. gluten versus wheat straw for PLA production), an economic allocation is recommended.

6.2 Allocation rules specific to the packaging industry

In terms of the packaging industry and its specific study objectives, it is key to justify the choice of approach and describe it transparently. For a comparative LCA, the same method must be used for all types of packaging so as to ensure coherence. Also, it is strongly recommended that experts carry out a sensitivity analysis and an assessment of the ways in which the methodological choices impact the results.

The following paragraphs describe the approaches recommended for end-of-life and other stages in the life cycle of a packaging product.

6.2.1 General end-of-life approach

The end-of-life management of packaging is a critical step that must reflect Québec market practices. A significant challenge becomes recurrent when a packaging made from an input constituted of recycled materials (recycled content) is then recycled or recovered in end-of-life (recycling rate). In such cases, several methodological approaches and choices must be made in order to allocate a fair fraction of the production impacts or end-of-life management benefits to the studied product.

<u>Method 1: System expansion</u>

End-of-life management systems such as energy recovery and recycling generally lead to consequences that are beneficial to the environment. In certain cases, energy recovery may substitute the production of energy from fossil resources. Relying on a simplified approach, recycling offsets the production of virgin materials. The system expansion approach illustrated in Figure 6-1 makes it possible to account for the benefits generated by such end-of-life management systems. These benefits are then allocated to the end-of-life stage, translating the impacts that are potentially avoided because a given amount of virgin material or energy will not need to be produced. Consequently, the product must be considered as constituted of 100% virgin materials. In addition, the impacts of the recycling and recovery processes must also be allocated to the end-of-life stage of the packaging.

This approach tends to favour materials that post high end-of-life recycling rates.

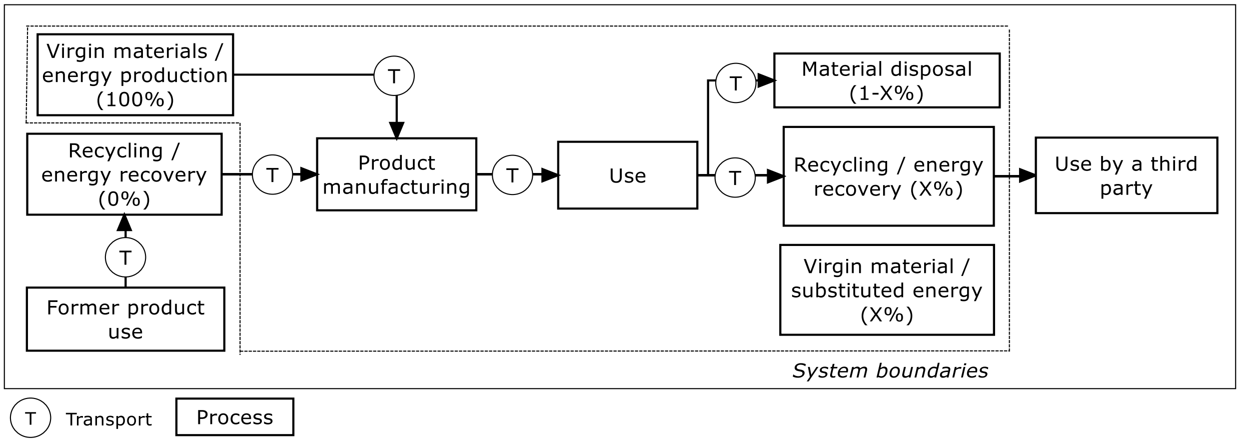


Figure 6-1:System expansion approach

Method 2: Cut-off approach

Illustrated in Figure 6-2, this approach accounts for the benefits of the use of recycled materials allocated to the materials production stage.

First, the impacts of extracting and producing the initial virgin material used to manufacture the recycled material are entirely allocated to the product that the resource served to generate: the initial system (former product in Figure 6-2) that led to its production. These impacts are therefore not allocated to a studied product that contains recycled material.

Second, all of the impacts of recyclable materials collection and the recycling and recovery processes required to produce the recycled material upstream of its use in the studied product system (studied product in Figure 6-2) are included. However, no environmental credits will be attributed to the recycled product in the end-of-life stage for the eventual reduced consumption of virgin materials in the life cycle of the recycled material.

This method does not require any additional information on the finality of the fraction that is recycled in the end-of-life stage since it is excluded from the boundaries of the studied system. However, the fraction that is eliminated in the end-of-life stage must be taken into account. This approach tends to favour materials with high recycled content.

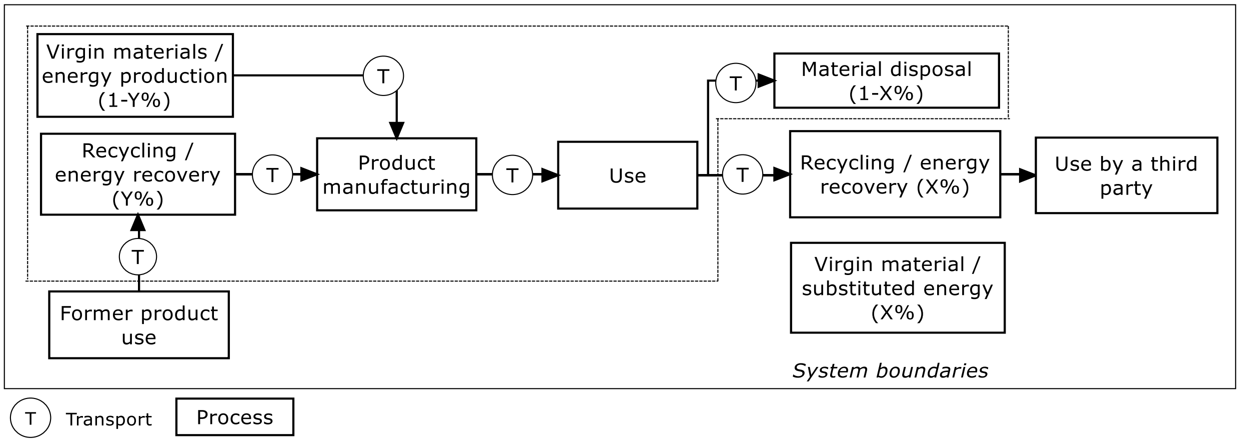


Figure 6-2: Cut-off approach

<u>Method 3: 50/50 allocation</u>

The 50/50 allocation method allocates equal portions of the benefits of end-of-life recycling and the use of the recycled material in the production stage as follows: on one hand, 50% of the benefits of recycling includes the total impacts of the end-of-life management of the recycling as well as the avoided impacts of virgin material production. On the other hand, 50% of the benefits of using recycled material includes the impacts of producing the recycled material upstream of its use in the studied product system as well as the avoided impacts of the use of virgin material in the production stage.

6.2.2 Life cycle stage allocation methods

The life cycle stage allocation methods are described in the following pages.

Raw materials production and assembly

- For material and energy co-products that are reused in the **same studied product system process** (e.g. vapour or recycled material), the system boundaries must be defined to include all of the processes and elements that will enable the recirculation loop (closed loop system).
- For material and energy co-products that are **recovered and meant for internal uses that are not related to the study project**, it is best to use a cut-off. The environmental impacts will then only be attributed to the study processes in which they are involved. The environmental impacts of raw materials production will all be allocated to the initial product, and the impacts of the intermediary recovery processes (e.g. washing, sterilization, shredding, etc.) will be attributed to the next product.
- In cases in which the co-products are **sold or simply reclaimed by a third party**, it is best to expand the system boundaries. In addition to considering the impacts of the third party's procurement (e.g. transport and distribution processes to the place of use), the benefits of the impacts avoided through the use of the recovered co-product must be credited to the supplier, since use may substitute energy or virgin material production.

Distribution

- The impacts of supply transport must be attributed to the packaging according to a mass or volume criterion based on size. The criterion will depend on the type of material that is transported, and the allocation criterion must reflect the impacts of a change in the packaging's shape (i.e. volume) or mass in transport. The choice between the two criteria must be driven by the maximum transport capacity: a mass criterion must be used when the maximum limit is reached, even if the space available (volume of the truck) is not full, and a volume criterion must be used when the space is full before the mass limit is reached. The maximum mass limit may be defined based on established national or regional standards.
- In product distribution, truck transport is generally limited by a mass constraint. Fuel consumption will increase with the product load contained in the packaging and the packaging itself. The transport impacts may be proportionately allocated to the distance traveled and the transported load (tonnes*km) (Figure 6-3).

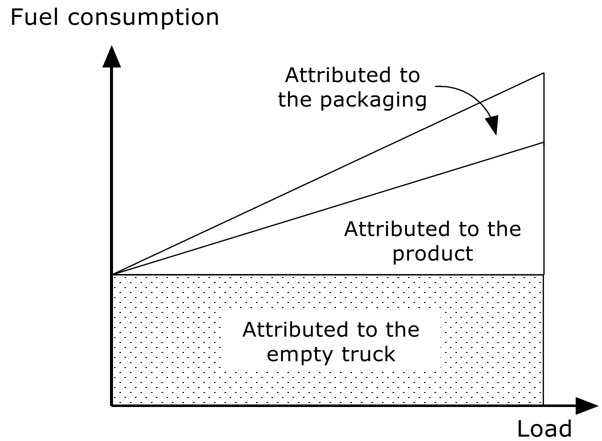


Figure 6-3: Transport modeling approach

- In the case of refrigerated transport, consumption will depend on the total distance and the transportation time during which refrigeration is required, including stopovers (e.g. at night). The transport impacts must therefore be allocated according to a volume criteria and total refrigeration time (m3*h).

<u>Warehousing by the distribution centre or retailer</u>

Packaged product warehousing time must be considered to distinguish between packaging that requires product refrigeration and packaging that does not.

- In the warehousing stage, the impacts of the consumption required for refrigeration are allocated to the packaging according to a volume criterion (e.g. space occupied in the cooler). However, heat transfer properties differ from one packaging material to the next. When these properties become a limiting factor, the choice of allocation criterion may be based on the physical characteristics of the packaging (i.e. the thermal conductivity of the material).

7 Cut-off rule

All of the processes whose contribution to the total environmental impacts in any category is less than 1% may be excluded. Any cut-off criteria based on another definition must be clearly detailed in the study.

8 Data collection

8.1 Data collection and sources

First, primary data on all of the manufacturing stages included in the packaging production system must be collected. Also referred to as specific data, the information must be collected directly from packaging producers, their suppliers and any other related businesses. The data may 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 evaluations, literature reviews and published study reports. However, the data must be used with caution and adapted to ensure representativeness.

The ecoinvent database *(*www.ecoinvent.ch/*)*, which is commonly used in LCA and recognized by the international scientific community, is especially complete since it covers a wide range of production processes. Based on technological averages, ecoinvent advances generic data that may be adjusted to enhance the representativeness of the system and compensate for missing information. There are several other sources of interest, including the Waste & Resources Action Programme (WRAP), which includes packaging studies, as well as Éco Entreprises Québec, Eco-Emballages, Fost Plus and RECYC-QUÉBEC.

Finally, when no data are available, the study must clearly state and justify all of the hypotheses on the studied system. In such cases, the impacts of the data's shortcomings in terms of quality and representativeness as well as the limits of the study must be discussed.

8.2 Quality of the inventory data

Data collection is an important step that must meet the data quality requirements driven by the goal of the study.

While there is no specific method recommended in the ISO standards at this time, the quality of the inventory data should be assessed. It is possible to refer to a pedigree matrix, which is widely used in LCA to describe the quality of a data based on its origin, collection and geographic, temporal and technological representativeness (Weidema et Suhr Wesnæs, 1996). In fact, these types of evaluations are generally established based on various reliability and representativeness criteria, more specifically:

- temporal, geographic and technological representativeness;
- a collection method that ensures that the data is a little aggregated as possible;
- completeness in view of all the existing and available data;
- documentation based on best available practices.

In keeping with the scope of the study, the collected data must be representative of the geographic, temporal and technological boundaries of the studied system. The data that are used must therefore correspond to the Québec context, reflect average production technologies and refer to the current production year, which is considered the reference year (or up to three years prior to the current year if the data is deemed sufficiently reliable and representative of the current situation).

To enhance representativeness, it is strongly recommended that experts quantify and model all of the generic data processes within the system boundaries by adapting them to the Québec context as much as possible and especially to the specific energy context in North America and Québec.

The type of data and sources required to model the main study processes and input flows are outlined in Table 8-1 and Table 8-2.

Table 8-1: Main sources of inventory data

Process/sub-process	Description of input flows	Data type	Possible source
Packaging production			
Production of the raw materials required to produce the primary, secondary and tertiary packages	- Type of material - Recycled material content (pre-consumer/post-consumer) - Non-renewable resource extraction and refining - Raw materials extraction - Energy consumption - Machinery and fuel - Water use	Generic Average data	ecoinvent, Material-based sources (Table 8-2) Literature
Production of additional components (cap, label, seal, etc.)	- Type of additional components (pigment, glue, varnish, additive, etc.) - Raw materials extraction - Energy consumption - Machinery and fuel - Water use	Generic Average data	ecoinvent
Supply transport	- Raw materials transport - Plastic resin pellet, aluminium ingot and steel sheet transport - Additional component transport - Payload and carrying capacity - Distance of raw material plants - Transport type - Fuel consumption	Generic Average data	ecoinvent Literature Estimations using a mileage calculator
Packaging processing and shaping	- Type of material, mass and volume of the primary, secondary and tertiary packages - Shaping processes (injection, extrusion, thermoforming, fusion, corrugation, sheeting, drawing, etc.) - Energy consumption - Machinery and fuel - Water use - Washing and sterilization	Specific	Communicated by the industry ecoinvent Source estimations by material type (Table 8-2)
Assembly and packing			
Washing and maintenance	- Washing and sterilization - Amount of chemical products - Energy consumption - Water use	Specific	Communicated by the industry
Filling primary package	- Loss rates of the filling and packaging chains - Energy consumption - Machinery and fuel - Washing and sterilization	Specific	Communicated by the industry Estimated by experts
Sealing and packaging the additional components	- Energy consumption - Machinery and fuel - Loss rate	Specific	Communicated by the industry Estimated by experts

Process/sub-process	Description of input flows	Data type	Possible source
Packaging for transport (tertiary package)	- Energy consumption - Machinery and fuel (if applicable)	Specific	Communicated by the industry Estimated by experts
Inter-plant transport	- Mode of transport - Average inter-site distances - Payload and carrying capacity - Fuel consumption (including refrigeration)	Specific	Communicated by the industry Estimated by experts
Handling package	- Marginal energy consumption required for refrigeration and freezing	Specific	Communicated by the industry Estimated by experts Literature ecoinvent
Washing and maintenance	- Washing process, amount of chemicals - Energy consumption - Water use	Specific	Communicated by the industry
Distribution			
Transport to the distribution centre/retailer	- Transport mode - Payload and carrying capacity - Average distance - Fuel consumption (including refrigeration) - Transport and warehousing times	Generic Average data adapted to the Québec transport context	ecoinvent Literature Estimated by experts
Warehousing and handling at the warehouse and retailer	- Energy consumption - Warehoused mass/volume - Warehousing time - Warehousing temperature	Generic Average data	ecoinvent Literature Estimated by experts
Transport to the consumer (place of use)	- Transport mode - Average fuel consumption - Average distance	Generic Average data adapted to the Québec transport context	ecoinvent
Use			
Refrigeration	- Energy consumption	Generic Average data adapted to the Québec context	Estimated by experts Literature Natural Resources Canada (Office of Energy Efficiency)
End-of-life and waste management			
End-of-life transport to the waste management and recycling centre (collection and sorting)	- Transport mode - Payload and carrying capacity - Fuel consumption - Average distance	Generic Average data	ecoinvent Estimated by experts Literature

Process/sub-process	Description of input flows	Data type	Possible source
End-of-life management of the packaging	- Management processes: recycling, reuse, energy recovery, composting and/or landfilling - Energy efficiency rate - Recover rate - Sorting centre discard rate - Contamination rate	Generic Average data	MDDEP, ÉEQ, regional municipality[1] and RECYC-QUÉBEC ecoinvent Estimated by experts

Table 8-2: Data sources for packaging types

Material	Possible source
Aluminium	- European Aluminium Association (EAA) - Aluminum Association (AA) - Aluminium Association of Canada (AAC) - International Aluminium Institute (IAI)
Steel	- ecoinvent
Plastic	- Canadian Plastics Industry Association (CPIA) - Federation of Plastics and Alliance Composites (FEPAC) - Plastics Europe - American Chemistry Council (ACC, Franklin Associates study (2010)) (HDPE, LDPE, LLDPE, PP, PET, PS, PVC, ABS, PU, rPET and rHDPE plastics) - NatureWorks (PLA plastics)
Glass	- ecoinvent - European Container Glass Federation (ECGF) - Energy and Environmental Profile of the U.S. Glass Industry (US Department of Energy report) - British Glass Manufacturer Confederation - Glass Association of North America (GANA) - Canadian Glass Association - Owens-Illinois (recent data on glass)
Cardboard	- ecoinvent - US LCI - The Paper and Paperboard Packaging Environmental Council (PPEC)

9 Information on environmental performance

The extent of the environmental impacts must be assessed for all stages in the life cycle of the studied product. The results of the assessment must be communicated on the basis of the functional unit.

[1] Data provided by regional municipalities make it possible to adapt consumer profiles, which may differ from one region to the next.

9.1 Impact categories

The characterization phase is carried out to quantify the contribution of each inventory result. At minimum, it must account for the following impact categories:

- **Non-renewable resources**: The use of non-renewable energy sources and minerals extraction, quantified in megajoules (MJ) of primary energy.
- **Water resources**: The use of water from underground freshwater, surface and ocean sources for all types of needs (e.g. irrigation, process water, drinking water, etc.), calculated as part of the inventory and measured in equivalent litres of water (L or m^3 equivalent).
- **Land use**: The total surface of land, calculated as part of the inventory and measured in unit area used during a specific time period (m^2*year). The reduction in biodiversity brought about by land use is also calculated and measured in the potentially disappeared fraction (PDF) of the species per surface unit used during a specific time period (PDF*m^2*year).
- **Global warming**: The global warming potential of greenhouse gases (GHG), calculated in kilograms of carbon dioxide (CO_2) equivalent and based on infrared radiative forcing data.
- **Human toxicity**: The impacts associated with the carcinogenic and non-carcinogenic impacts caused by pollutants released into the environment and coming into contact with humans through breathing, eating or drinking, measured in kg chloroethylene equivalent.
- **Aquatic eutrophication**: The emissions of nitrogenous or phosphate substances into aquatic environments that foster the proliferation of microalgae and plankton and which lead to oxygen depletion, measured in kg PO_4^{3-} equivalent.
- **Acidification**: The impacts of the sulphur compounds in the lower atmosphere, measured based on the acidification potential of a given substance and expressed in kg SO^{2-} equivalent.
- **Ecotoxicity**: The impacts on terrestrial and aquatic ecosystems in terms of biodiversity loss caused by ecotoxic environmental emissions, measured in kg triethylene glycol equivalent.
- **Photochemical oxidation**: All complex phenomena leading to the formation of ozone and other precursor oxidizing compounds in the ozone layer, measured in kg ethylene equivalent.
- **Ozone layer depletion**: The impacts caused by the reactions between the stratospheric ozone and chlorofluorocarbons (CFC) leading to ozone layer depletion and reduced ultraviolet ray filtration, measured in kg CFC equivalent.

These impact categories pertain to global environmental issues and may be aggregated into impact scores for:

- **Climate change:** Accounts for all of the substances known to contribute to global warming and adjusted based on their global warming potential (GWP). The impacts are expressed in kilograms of carbon dioxide (CO_2) equivalent. In keeping with the recommendations of the Intergovernmental Panel on Climate Change (IPCC, 2007), the impacts must be assessed over 100 years.

- **Human health:** Accounts for substances that present toxic (carcinogenic and non-carcinogenic) and respiratory effects, measured based on the gravity of potential illness in disability-adjusted life years (DALY), which reflects human health damage.

- **Ecosystem quality**: Accounts for the impacts on the natural environment, measured in the potentially disappeared fraction (PDF) of the species per surface unit used during a specific time period (PDF*m2*year).

For further information, please refer to the internationally recognized and peer reviewed IMPACT 2002+ life cycle impact assessment method (Jolliet et al. 2003, updated Humbert et al. 2011).

10 Presentation and interpretation of the results

Interpretation chiefly aims to put the study results into perspective in light of the initial objectives. It also serves to determine the limitations of the study and the options to enhance the studied product.

First, the results of the assessment of the potential environmental impacts must be presented for the selected impact categories for the entire life cycle of the packaging. Then, the results may be disaggregated to present the contribution of each stage in the life cycle of the packaging.

This type of assessment makes it possible to identify the impact sources that are the greatest contributors to the overall impact. It elucidates the system's environmental performances to determine the priority actions of better impact reduction strategies throughout the supply chain. The interpretation phase must remain coherent with the objectives and scope of the study.

Finally, to increase the robustness of the results, it is recommended that practitioners evaluate the quality of the data—a mandatory step for studies that will be made public. In terms of the processes that significantly contribute to the impacts generated by the studied system, the influence of the data could modify the results and, consequently, the conclusions of the study. If the data are considered limited and insufficient, of average or poor quality, then additional collection efforts must be determined. Doing so will also enhance the qualification criteria described in section 8.2 on data reliability and representativeness.

10.1 Simplified tools

Though certain tools such as the Packaging Impact Quick Evaluation Tool (PIQUET) and Comparative Packaging Assessment (COMPASS) are commonly used to compare the environmental performances of packaging systems, they do not take the place of a complete LCA. Developed based on a simplified approach, these tools do not account for business- or technology-specific realities. They often provide little or no methodological choices in terms of the scope of the study or inventory data and therefore cannot be adapted. In addition, though they use aggregated data that provide an overview of a product system's impacts, the tools remain limited by the level of detail required to interpret the results. However, they quickly provide interesting information that can be used, for example, to prioritize LCA needs with minimum effort and knowledge of LCA.

10.2 Sensitivity analysis

Practitioners should always carry out a sensitivity analysis of the parameters that retain uncertainty due to the use of generic data or the hypotheses that were set out. The analysis will help validate the results and evaluate their robustness.

As part of LCA studies on packaging, it is especially interesting to assess food product losses and the choice of allocation method, as described in section 6.

Also, an additional impact assessment must be carried out using a life cycle impact assessment method that is different from the one chosen for the study in an effort to verify whether the results are sensitive to the methodological choice and whether the conclusions are significantly influenced by method variability, validating the robustness of the initial method.

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12 Appendices

APPENDIX A: OVERVIEW OF EXISTING INFORMATION

In an effort to reduce the impacts generated by packaging, management strategies must be implemented to ensure that decision-making is focused on informed sales and logistics choices. In fact, many LCAs of various types of food product packaging options are documented in the literature. However, study systems are not always equivalent, making direct comparisons difficult due to differences in the framework of the analysis, system boundaries, functional unit (Peacock et al. 2011), geographic and industrial context or the choice of impact assessment method (involving different impact factors). Results must therefore be compared cautiously (Falkenstein et al. 2010).

To offset these challenges, the LCA process for the food packaging industry must be standardized by setting out methodological frameworks and common guidelines to determine the root of the differences between the results.

Study objective

In LCA, food packaging impact assessment may be taken into account in two ways:

1. in an LCA of all or part of the life cycle of a food product, including its packaging;
2. in an LCA of the life cycle of a food packaging only (excluding the food product it contains).

The first approach will evaluate the environmental profile of a food product throughout its life cycle: food production and processing, packaging manufacturing and end-of-life management (Hospido et al. 2003 et 2006, Labouze et al. 2008, Büsser et al. 2009).

The second approach excludes the food product from the study system and only evaluates the impacts of the packaging (Magaud et al. 2010, Labouze et al. 2009, Humbert et al. 2009, CPA 2010, Detzel et al. 2009, Da Silva et al. 2010, RDC environment 2010, Eriksson et al. 2009). This method is generally used in studies to compare packaging types or solutions for a specific food product.

Functional unit

Defining the functional unit is a critical step in establishing the study scope to which the inventory flows pertain. The functional unit meets the requirements of the function that must be carried out and is determined based on the study objectives. In the literature, the main function of a food product packaging is to enable the transport of the food product from the production site to the consumption site. It is also attributed the functions of protecting and preserving the food product it contains.

Based on the LCA studies cited earlier, the functional unit generally refers to an amount of packaged food product that is ready for market distribution or consumption: to make available an amount [mass or volume unit] of solid/liquid food product. This is especially the case of the LCA approaches that aim to assess the complete environmental profile of a food product.

In a comparative LCA, in light of the packaging's main function to preserve, protect and contain, the functional unit may also be to preserve, protect and contain a specific amount [mass or volume unit] of food product (WRAP 2010).

System boundaries

To establish the complete environment profile of a packaged food product, all life cycle stages within the system must be taken into account, such as packaging manufacturing, including raw materials extraction and production and supply transport, the production and processing of the food product, the distribution of the packaged products to distribution centres and to the various points of sale as well as the end-of-life of the packaging and generated and processed waste (Hospido et al. 2003 et 2006, Labouze et al. 2008, Büsser et al. 2009). Though the practice is not recommended when setting out a complete environmental profile, certain studies exclude the distribution sub-systems (e.g. transport to the distribution centre and retailer), which are considered to have little influence on the study objectives.

When comparing several types of packaging, the food product production and processing stages as well as the food product use stage, including transport, refrigerated storage and cooking by the consumer, are generally excluded from the system, since the production steps are considered identical for all compared systems and the impacts of the use stage are often considered equivalent and negligible (Labouze et al. 2008).

Allocation rules

Very often, the end-of-life management processes for packaging are multifunctional. When comparing management options, it is critical to ensure that the systems are functionally equivalent. This is typically the case for recycling and incineration with energy recovery, which respectively produce virgin material and energy/fuel, generating secondary package material for use in new products.

This leads to significant methodological questions in an LCA to determine how the fraction of the potential impacts of raw materials production for packaging, packaging collection and packaging processing will be allocated.

Three approaches are outlined in the literature to tackle this methodological impact allocation issue (Klöpffer 1996; Ekvall 2000; Frischknecht 2010; Yamada et al. 2006; RDC environnement 2010; AFNOR 2009).

The first method is the cut-off approach in the North American context (Magaud et al. 2010, Da Silva et al. 2010), which consists in allocating the impacts of virgin materials extraction to the manufactured product, while the impacts of recyclable material collection and recycling are allocated to the product manufactured from the secondary material. No credits are allocated to a product that will be recycled at the end of its life cycle. This approach therefore tends to foster the use of recycled material rather than encourage producers to provide recyclable material.

The second approach to expand the system boundaries (Humbert et al. 2009, Eriksson et al. 2009, Magaud et al. 2010) considers products as if they were made from 100% primary material and accounts for the impacts associated with the collection and recycling processes in the end–of-life stage as well as the impacts avoided by substituting virgin material with secondary material.

The third method, the 50/50 allocation approach, seeks the middle ground. It is recommended in France by the AFNOR (2010) and Eco-Emballages for plastic and paper/cardboard packaging (Labouze et al. 2009).

The allocation rule from the packaging to its food content in the distribution and transport stage is generally based on a mass criterion (WRAP). Though some studies account for impacts based on an economic criterion (Hospido et al. 2006) (i.e. based on the economic value of the various transported products), the practice is not recommended. In fact, the value is affected by the economic situation of the market, which varies considerably over time and therefore does not adequately reflect the incidence on the physico-chemical relationships between the process input and output flows.

While there is no scientific consensus on the optimal allocation method, it is important to note that the choice of method is quite important to the environmental profile of a packaging. It is therefore critical to justify and clearly describe the choice of a coherent allocation method based on the study context. At this particular step, as in Magaud et al. (2010), it is strongly recommended that a sensitivity analysis of the allocation approach be carried out in order to evaluate the incidence of the methodological choices.

Environmental performance

The literature review of food industry sector LCA studies made it possible to draw several conclusions on the relevance of the environmental impacts that were assessed. The impact categories that are commonly taken into account by the food processing industry are outlined in Table A.1 (Paecock et al. 2011) along with specific studies on food packaging (Falkenstein et al. 2010).

Table A.1: Common impact categories

Type of effect	Impact category	Indicator
Global	Climate change	Potential global warming caused by greenhouse gases emitted into the atmosphere
	Ozone layer depletion	Potential stratospheric ozone layer depletion and increase in ultraviolet rays
	Non-renewable resources (energy)	Consumption of fossil fuel resources
Regional	Aquatic eutrophication	Gradual nutrient increase and stoichiometry in aquatic environments
	Acidification	Change in nutrients and acidity levels in soils
	Photochemical oxidation	Tropospheric ozone formation (smog)
Local	Ecotoxicity	Toxic effects caused by emissions to ecosystems (terrestrial/aquatic)

Type of effect	Impact category	Indicator
	Human toxicity	Measureable carcinogenic and non-carcinogenic impacts
	Land use	Total amount of land area used during a specific time period
	Water resource use	Volume of water used for all needs

While certain relevant impact categories merit more detailed assessment, their characterization methods are still under development in order to determine consensual results, especially as they pertain to land and water use. Currently, the impacts associated with these categories are only reported as simple indicators, referring to inventory data in terms of occupied land area (m^2 in a year) and litres of water consumed.

Predominant life cycle stages

The contributions of the various life cycle stages of a food product packaging to the considered impact categories vary considerably depending on the main material in the studied packaging system (Detzel et al. 2009, Humbert et al. 2009).

First, the stage to produce and shape the containers is generally the greatest contributor to most impact categories (Detzel et al. 2006, Detzel et al. 2009, Humbert et al. 2009, Labouze et al. 2009, Roy et al. 2009, Da Silva et al. 2010, WRAP 2010). When the production and processing of the food is included within the system boundaries, the stage significantly contributes to the overall environmental profile in terms of climate change (up to approximately 80% of the total product impact (Hospido et al. 2006; Labouze et al. 2008)).

The secondary and tertiary packages for product packing and transport may also significantly contribute to the total impacts of the studied system (Detzel et al. 2009; Magaud et al. 2010; Büsser et al. 2009).

While end-of-life transport is not generally considered to be a determining factor overall, the distribution transport distance from the production plant to the point of sale may also significantly contribute to the impacts of the energy resource consumption, climate change, acidification, photochemical oxidation and eutrophication impact categories (Detzel et al. 2009, Labouze et al. 2009, Humbert et al. 2009).

Based on an analysis of the end-of-life management scenarios evaluated in the literature, it is clear that recycling as an end-of-life management option for plastics remains more favourable than incineration with energy recovery, which is preferable to landfilling for all considered impact categories (WRAP 2008). In addition, the benefits of recycling are all the more important, since they lead to the substitution of virgin material, especially with regards to plastics.

Influential parameters

The type of packaging greatly influences packaged food losses in the packing, distribution and consumption stages (Williams et al. 2007 et 2010). This must be accounted for when carrying out an LCA by considering all stages in the life cycle of the packaged food product so as to be sure to assess the incidence of these losses on the environmental profile or in a comparative study. For example, a Québec beer container study showed that a 10% loss in glass containers increased climate change, resources and human health damages by 10 to 15% and ecosystem quality damages by 25 to 35%.

This type of data is specific to businesses and can sometimes be difficult to obtain, but a study by the Swedish Institute for Food and Biotechnology (SIK) commissioned by the Food and Agriculture Organization of the United Nations (FAO) led to an edifying depiction of worldwide food losses and waste along the supply chain (Gustavsson et al. 2011). Results showed that, in North America, over 40% of losses occur at the retailer and the consumer, where most packaged product handling and distribution takes place.

An increase in the recovery for recycling rate of plastic bottles (HDPE) reduces potential resources, climate and photochemical oxidation impacts by approximately 30% (WRAP 2010). This also applies to Tetra Pak type cardboard packaging, for which an increase in the recovery rate from 2 to 22% leads to reduced emissions at all life cycle stages and a 14% reduction in global warming potential (Mourad et al. 2008). Also, comparing the environmental profiles of a bottle made from virgin plastic (100% HDPE) and one made from recycled content (recycled HDPE) showed that increases of 30 and 50% in recycled content reduce potential climate change impacts by 8.6 and 14%, respectively (WRAP 2010).

The amount of packaging used by the food industry is a critical parameter. While it remains a challenge to preserve the quality of a packaging's contents, a reduction in the amount of materials used in the packaging curbs its production and leads to savings in terms of required energy (Sonesson et Berlin, 2003, Roy et al. 2009). In addition to the impacts for the primary package, reductions and modifications to the secondary and tertiary packages will also lead to better environmental profiles.

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APPENDIX B: ISO STANDARDS REQUIREMENTS

Table B.1: Summary of requirements under ISO 14040, 14044, 14025

ISO 14040/14044/14025 requirement	Description	
Intended use ISO 14040 :5.2.1.1 ; 14044 : 4.2.2	An LCA of packaging types in Québec's food processing industry	
Purpose of the study ISO 14040 :5.2.1.1 ; 14044 : 4.2.2	Evaluate the environmental profile of the entire life cycles of packaging options Determine processes to enhance environmental performances	
Target audience (i.e. groups to which the study results will be communicated) ISO 14040 :5.2.1.1; 14044 :4.2.2; 14025 :9.1	Businesses in Québec's food processing industry	
If the results are to be used in comparative affirmations released to the general public ISO 14040 :5.2.1.1; 14044 :4.2.2	Decision to be made by the food processing companies	
Studied product system ISO 14040 :5.2.1.2; 14044 :4.2.3.1	A product constituted of material of any nature designed to contain and protect merchandise in order to ensure its handling and transport from the producer to the consumer or user as well as its presentation.	
Product system functions ISO 14040 :5.2.1.2; 14044 :4.2.3.1; 14025 :6.7.1	Preserve, protect and contain 1 [volume or mass unit] of [food product], distribute it [geographic location] and preserve it until it is used.	
Functional unit ISO 14040 :5.2.1.2; 14040 :5.2.2; 14044 :4.2.3.1; 14044 :4.2.3.2; 14025 :6.7.1	Preserve, protect and contain 1 [volume or mass unit] of [food product], distribute it [geographic location] and preserve it until it is used.	
System boundaries ISO 14040 :5.2.1.2; 14040 :5.2.3; 14044 :4.2.3.1; 14044 :4.2.3.3.1; 14025 :6.7.1	See .3	
Included life cycle stages	All life cycle stages (cradle-to-grave approach)	
Elementary processes ISO 14044 :4.2.3.3.2	Material and energy supply and resource extraction; raw materials production; primary, secondary and tertiary package manufacturing; additional component manufacturing (e.g. caps, seals, labels, etc.); supply transport; washing and maintenance; filling; assembly and packing; inter-plant transport; distribution; transport and refrigeration; use and end-of-life and waste management (see Table 5-1)	
Allocation rules ISO 14040 :5.2.1.2; 14040 : 5.3.4; 14044 :4.2.3.1; 14025 :6.7.1	See section 6	
Cut-off criteria ISO 14044 :4.2.3.3.3	All of the processes whose contribution to the total environmental impacts in any category is less than 1% may be excluded. Any cut-off criteria based on another definition must be clearly detailed in the study.	
Selected impact categories and impact assessment methodology and interpretation method ISO 14040 :5.2.1.2; 14044 :4.2.3.1; 14044 :4.2.3.4;	Impact category	Model
	Non-renewable resources	See the IMPACT 2002+ life cycle impact
	Water resources	

ISO 14040/14044/14025 requirement	Description	
14025 :6.7.1	Land use Climate change Human toxicity Aquatic eutrophication Acidification Ecotoxicity Photochemical oxidation Ozone layer depletion Human health Ecosystem quality	assessment method, section 9.1
Units ISO 14025 :6.7.1	International System of Units (SI)	
Interpretation ISO 14040 :5.2.1.2; 14044 :4.2.3.1	Present and discuss the results based on an analysis of the contributions of each life cycle stage to the potential environmental impacts, in keeping with the objectives and scope of the study.	
Data types and sources ISO 14044 :4.2.3.5	See Table 8-1and Table 8-2	
Data quality requirements ISO 14040 :5.2.1.2; 14044 :4.2.3.1; 14044 :4.2.3.6.2; 14025 :6.7.1		
Temporal representativeness	Current production year, considered as the reference year (or up to three years prior to the current year if the data is sufficiently reliable and representative of the current situation)	
Geographic representativeness	Québec for production and processing (especially in terms of the North American and Québec energy context)	
Technological representativeness	Average production technology or the best available technology must be detailed (equivalent technology involving similar physico-chemical processes)	
Additional environmental information ISO 14025 :6.7.1	None	
Materials and substances that must be declared ISO 14025 :6.7.1	The composition of the main materials used in each packaging life cycle system	
Content and format of the statement ISO 14025 :6.7.1	The information that is released is in keeping with the content of the guidelines and PCR	
Hypotheses ISO 14040 :5.2.1.2; 14044 :4.2.3.1	• The construction and dismantling of the production and distribution infrastructures as well as the capital goods (e.g. buildings, machines, roads). The impacts of these processes allocated to the production of the packaging are considered negligible.	

ISO 14040/14044/14025 requirement	Description
	• The activities related to marketing the packages (e.g. personnel and employee transportation, use of hygiene-related equipment).
Choice of values ISO 14044 :4.2.3.1	No choice of values in terms of the optional LCA steps
Limitations ISO 14040 :5.2.1.2; 14044 :4.2.3.1	Application framework only applies to packaging in the food processing industry
Statement validity period ISO 14025 :6.7.1	The guidelines must be reassessed and revised until relevant improvements and modifications to the processing technology systems are made; approximate period before an update: 2-3 years.
Critical review ISO 14040 :5.2.1.2; 14044 :4.2.3.1; 14044 :4.2.3.8; 14025 :5.7	In order to release the results to the public, a panel of experts including an independent LCA expert and food processing experts, must review the study.

APPENDIX C: MATERIALS TARGETED BY THE QUÉBEC COMPENSATION PLAN FOR CONTAINERS AND PACKAGING

For the most part, companies and organizations that own a brand or name that markets containers, packaging or printed matter in Québec (“brandowners”) are subject to the law and must contribute to the compensation plan.

The compensation plan came into effect on March 1, 2005, and stems from the Environment Quality Act (EQA) and the Regulation respecting compensation for municipal services provided to recover and reclaim residual materials. Each year, a Schedule of Contributions must be established by recognized bodies, including Éco Entreprises Québec, and approved by the Québec government.

Table A1.1 provides an overview of the various materials targeted by the plan for the containers and packaging category, as released by Éco Entreprises Québec for contributing companies. The document is updated regularly, and it is best to refer to ÉEQ’s website for the most up-to-date information.

Note: The examples outlined in the table are for illustrative purposes only and are not exhaustive.

Table C.1: Materials targeted by the compensation plan, containers and packaging category (Éco Entreprises Québec, 2011)

Sub-class	Materials	Definition
Paperboard	Corrugated cardboard	**Includes**: all corrugated packaging and kraft paper bags not added at the point of sale. **Examples**: non laminated boxes for televisions or for pizza, bags for flour, sugar, potatoes or oatmeal, beer packs (12 and 24).
	Kraft paper bags	**Includes**: all kraft paper bags provided at the point of sale or at the cash register, to contain purchases that were made, whether sold or otherwise provided. **Examples**: Brown grocery bags, prescription bags, paper take-out bags.
	Kraft paper packaging	**Includes**: all kraft paper packaging provided at the point of sale or used as ancillary packaging to protect, wrap or present a product or a set of products. **Examples**: egg cartons, meat wrapping paper, ancillary paper in shoe boxes.
	Gable-top containers	**Includes**: polycoated gable-top cartons. **Examples**: milk, juice and molasses cartons, tethrahedral packaging.
	Aseptic containers	**Includes**: polycoated and aluminum-coated boxes (Tetrapak). **Examples**: juice boxes, soup or wine containers.
	Paper laminants	**Includes**: laminated paper packaging in which paper is the main component, but is not included with other materials in the

Sub-class	Materials	Definition
		paperboard sub-class. This includes paperboard materials combined with foil, plastic or other materials. **Examples**: fibre cans (with metal/plastic bottom and lid), granola bar wrappers, battery blister packaging, ice cream carton containers, bubble envelopes, cookie bags, instant oatmeal envelopes, frozen food containers, bags for flour, dessert mixes, or popcorn, paper hot drink cups.
	Boxboard and other paper packaging	**Includes**: boxboard or fibre board containers, molded pulp paper packaging as well as other paper packaging and fibre products other than from a wood source (ex. bamboo, bagasse, eucalyptus). **Examples**: cereal boxes, formed trays, tissue paper box, clothing hangtags, newsprint used as packaging material (i.e. in shoe boxes or gift packaging), paper bags for bread other than non-laminated brown bags, tissue paper, bathroom tissue or paper towels, beer pack (6).
Plastic	PET bottles	**Includes only** transparent, light green or light blue #1 bottles and jars. PET containers should be entered as "PET containers" and all other forms of PET should be entered as "Other plastics." **Examples**: energy drink or water bottles, salad dressings and edible oil bottles, peanut butter jars, dish soap or mouthwash bottles.
	HDPE bottles	**Includes only** #2 bottles, jugs and jars. All other forms of HDPE containers should be entered as "Other rigid plastics." **Examples**: jugs for laundry detergent, bleach, vinegar, windshield washer fluid, milk containers, shampoo bottles. **Excludes:** LDPE bottles reported under "Other rigid plastics."
	Expanded polystyrene	**Includes**: all types of #6 rigid polystyrene foam. **Examples**: meat trays, hot drink cups, egg containers, foam packaging "peanuts," polystyrene sheets, foam packaging (i.e. for appliances).
	Non-expanded polystyrene	**Includes**: all types of #6 rigid plastic. **Examples**: small yogurt containers, trays for cookies or croissant, small milk or cream containers for coffee.
	HDPE and LDPE plastic film	**Includes only** polyethylene film other than shopping bags – typically stretchable and more porous than other types of film. All other non-HDPE/LDPE film should be reported in the "Plastic laminants" category. **Examples**: fresh and frozen vegetable bags, milk bags and pouches, bread bags, shrink wrap film (e.g. around a tray of 24 water bottles), dry cleaner's bags, soil and fertilizer bags.

Sub-class	Materials	Definition
	Shopping bags made of HDPE, LDPE and other film	**Includes only** plastic shopping bags, provided at the point of sale or at the cash register to contain purchases that were made, whether sold or otherwise provided. **Examples:** grocery bags, drug store bags, bags for clothing or other purchases. **Excludes:** durable bags.
	Plastic laminants	**Includes**: other flexible wraps, bags and formed plastic packaging as well as multilayered and laminated flexible packaging in which plastic is the main component, but not included with other materials in the plastics sub-class. This includes plastic materials combined with foil, paperboard or other materials. **Examples**: pouches for fresh pasta, dry pasta packaging, candy wrappers, coffee pouches, cheese wraps, cereal liner bags, pre-packaged deli meat pouches, yogurt stick packs, vacuum packaging products, blister packs for medication or gum, chip bags, bubble wrap.
	PET containers	**Includes only** transparent, light green or light blue #1 containers. All other forms of PET should be entered as "Other plastics polymers and polyurethane." **Examples**: **transparent** containers for hand soap or all-purpose cleaners, gable-top containers for muffins, croissants, berries or lettuce.
	Other plastics, polymers and polyurethane	**Includes**: all #3, #5 and non-coded plastics as well as all plastic #1, #2, #4, #6 and #7 containers and packaging excluded for other plastics sub-classes. Also includes polymers and polyurethane of all types (e.g. PHA/PHB) and polyurethane. **Examples**: margarine and yogurt tubs, hand cream tubes, microwaveable trays, pudding cups, plastic blister packaging, netting for citrus fruit, vitamin containers, opaque PET trays.
	Polylactic Acid (PLA)	**Includes:** all PLA containers and packaging. **Example:** cookie trays, blister packaging for croissant or muffins.
Steel	Aerosol containers	**Includes**: all aerosol containers that are more than 50% by weight of steel. **Examples**: air freshener, deodorant and hairspray cans.
	Other steel containers	**Includes**: all other containers that are more than 50% by weight of steel. **Examples**: food cans (e.g. soup, tuna), large juice cans, lids and closures, cookie, coffee and tea boxes.

Sub-class	Materials	Definition
Aluminium	Aluminum containers for foods and beverages	**Includes**: sealed containers for food products and beverages. **Examples**: non-deposit single-serve juice cans, small pet food cans, sardine cans.
	Other aluminium packaging	**Includes** semi-rigid foil trays, lids, seals and aluminium tubes, caps, screw-on lids and aluminium aerosol containers. **Examples**: foil wrap, pie plates, yogurt/sour cream seals, frozen lasagna trays, aluminium cans for hairspray and mousse.
Glass	Clear glass	**Includes**: clear glass container packaging with the exception of Pyrex, ceramics and crystal. **Examples**: white wine bottles, water bottles, pickle, salsa or pasta sauce jars.
	Coloured glass	**Includes:** coloured (e.g. green, brown, blue) glass packaging with the exception of Pyrex, ceramics and crystal. **Examples**: red wine bottles, certain sparkling water bottles, olive oil and balsamic vinegar bottles.

Reference

Éco Entreprises Québec (2011) *Description des catégories et des sous-catégories de matières visées*, révision 13, 13 juin 2011

APPENDIX D: PRODUCT SYSTEMS

This section details the production and shaping systems of five broad packaging categories based on processes described in the literature in published LCA studies as well as on information provided by manufacturers and the Canadian Council of Ministers of the Environment (CCME, 1994).

The processes are for information purposes only. They represent typical industry manufacturing techniques. However, all additional sub-systems deemed appropriate in a study must be included within the boundaries of the system and clearly documented.

Reference

CCME (1994). Sources de données pour l'analyse du cycle de vie des produits d'emballage canadien , http://www.ccme.ca/publications/index.fr.html, consulté en mars 2011.

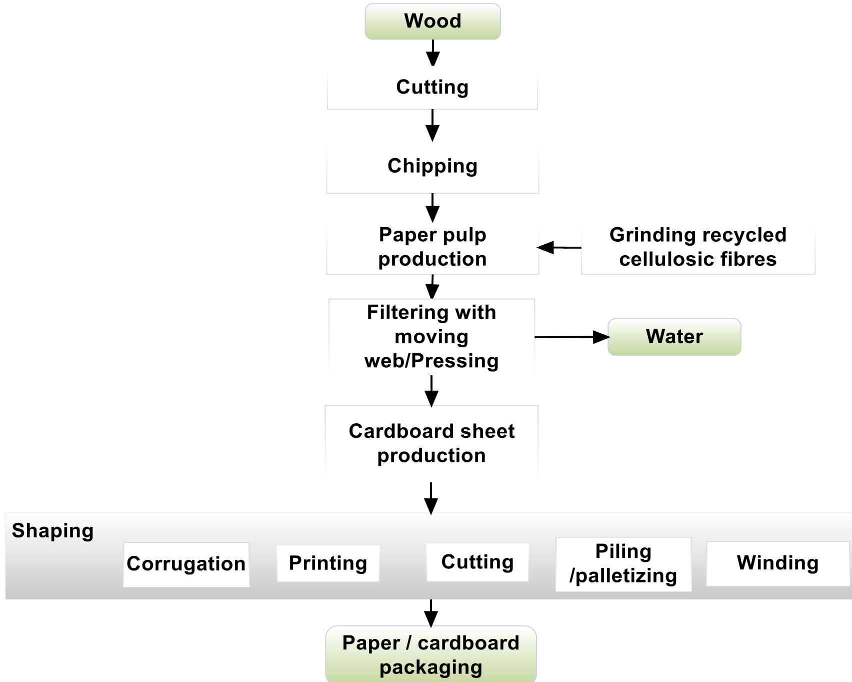

Figure D.1: Cardboard packaging production process

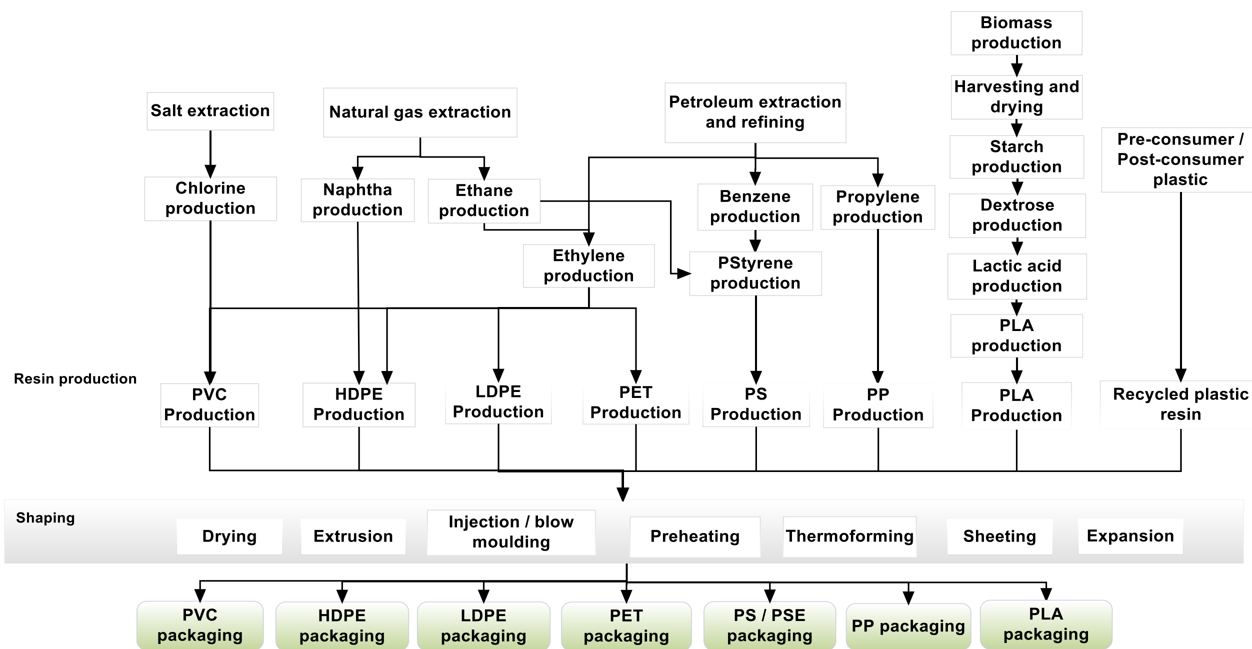

Figure D.2: Plastic packaging production process

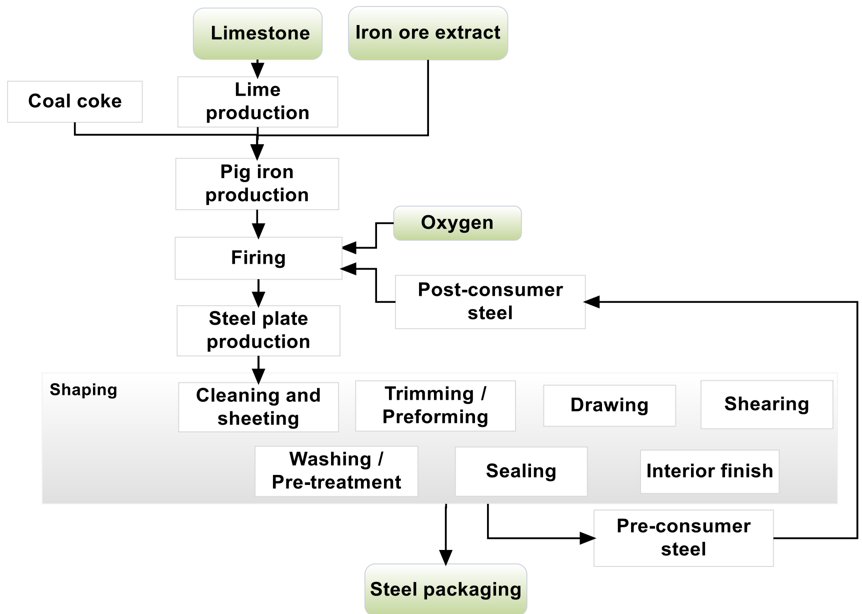

Figure D.3: Steel packaging production process

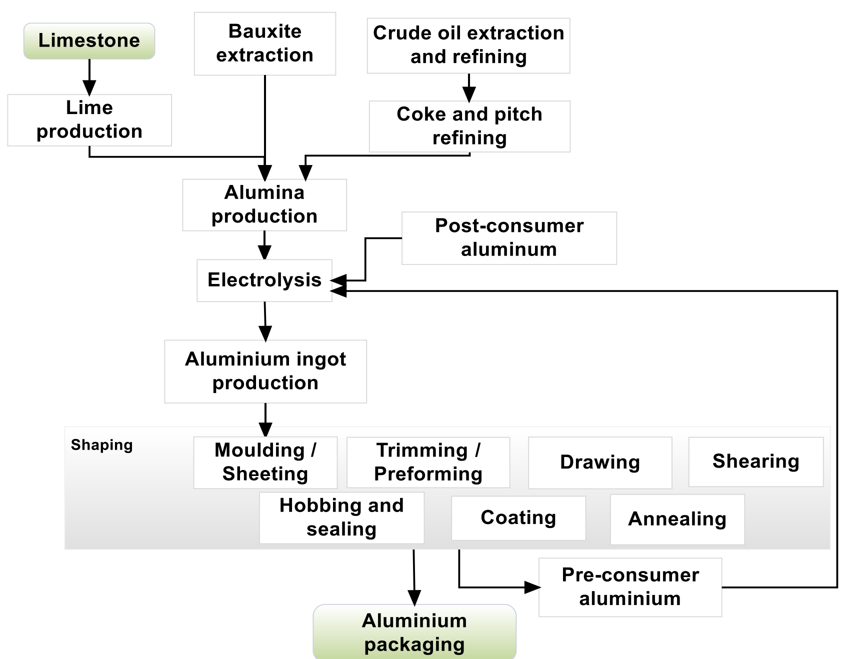

Figure D.4: Aluminum packaging production process

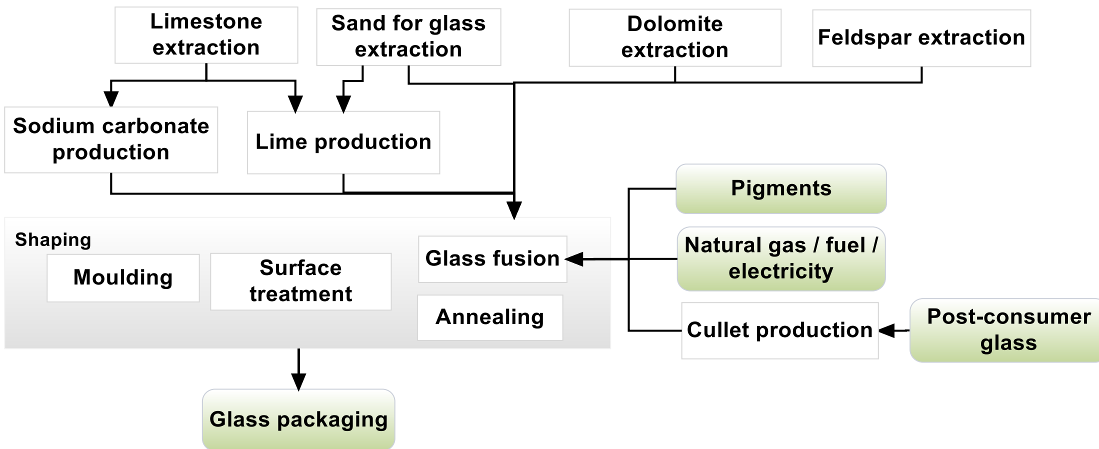

Figure D.5: Glass packaging production process