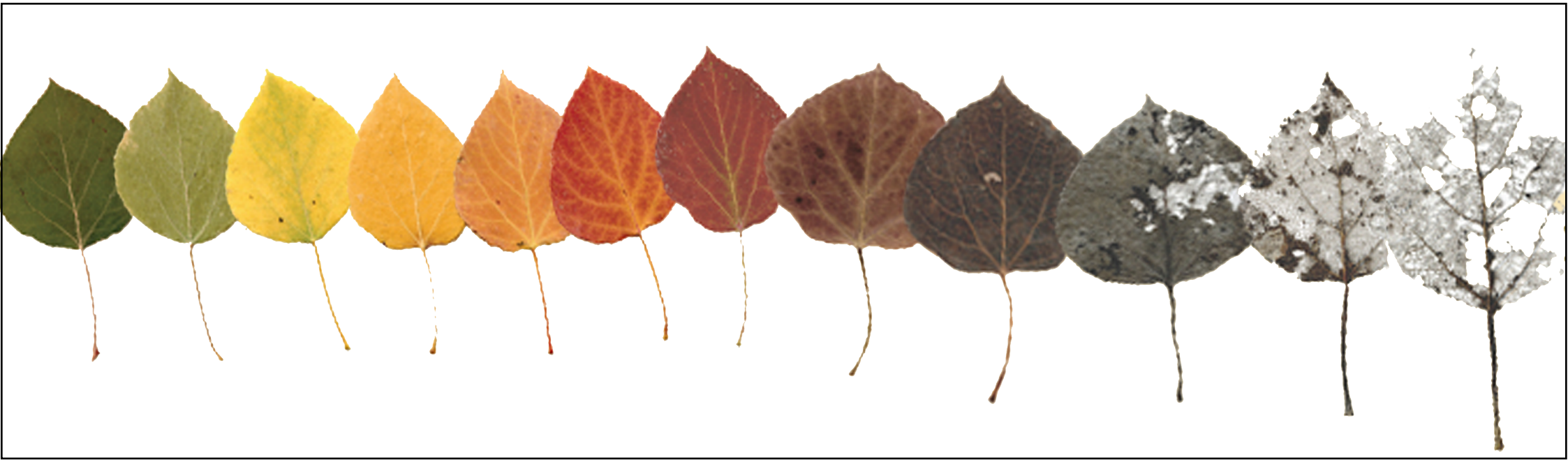
LIFECYCLE ANALYSIS

Knowing and understanding the role of product lifecycle analysis during the design and development process.



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Introduction

Life Cycle Assessment is a tool used in the Design for Environment methodology for new products. It also used for the environmental analysis of processes and services. It was originally proposed by the SETAC-Society of Environmental Toxicology and Chemistry in 1990 and its use has been widely accepted within many sectors. It can assess the environmental impact of a product, service or process in its entire life, ‘cradle-to-cradle’.

The course will outline the basic steps in performing a Life Cycle Analysis and it will highlight its usefulness, limitations and problems involved in performing the analysis. Finally, a few existing published analysis will be given.
The learning objectives are to acquaint the reader with the process, the required information to perform the analysis and the type of output that you he gets from the analysis.

LCA is a tool for assessing the environmental footprint of a product, service or process and through the analysis to discover/ classify the factors contributing to the footprint. It van be used for strategic decisions in planning for a product/ service / process and for comparing different alternative development solutions.
It was originally proposed by SETAC and currently it has been standardized in ISO Standards no. 14040 to 14043.

Keywords

Lifecycle, textile, LCA, smart textiles, inventory, ISO standards

Goals of the resource

- To acquaint the reader with the LCA methodology
- To perform the basic steps of the assessment process
- To properly evaluate and use the results of the assessment

Learning Outcomes

Learning Outcomes

The student is expected to obtain:

Knowledge

- The general principles for an LCA Analysis
- The main problem in the process and the limitations of the methodology
- The evaluation of the results
- References to existing and published LCA for the textile sector

Skills

- Organise an LCA Analysis
- Appreciate the necessary data for the analysis

Competencies

- Be able to access the working environment and needs for performing the analysis
- Be able to reflect the impact of the results on the analysed processes
- Give guidelines for process improvements

Terminology

LCA ISO Definitions

Life Cycle Assessment:

"A systematic set of procedures for compiling and examining the inputs and outputs of materials and energy and the associated environmental impacts directly attributable to the functioning of a product or service system throughout its life cycle")*ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines)*[1]

Life Cycle:

"Consecutive and interlinked stages of a product or service system, from the extraction of natural resources to the final disposal" (*ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guidelines)*[1*]

1. https://www.gdrc.org/uem/lca/lca-define.html

1. What is a lifecycle?

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What is LCA?

"Life Cycle Assessment (LCA) is a technique for assessing the potential environmental aspects and potential aspects associated with a product (or service), by:

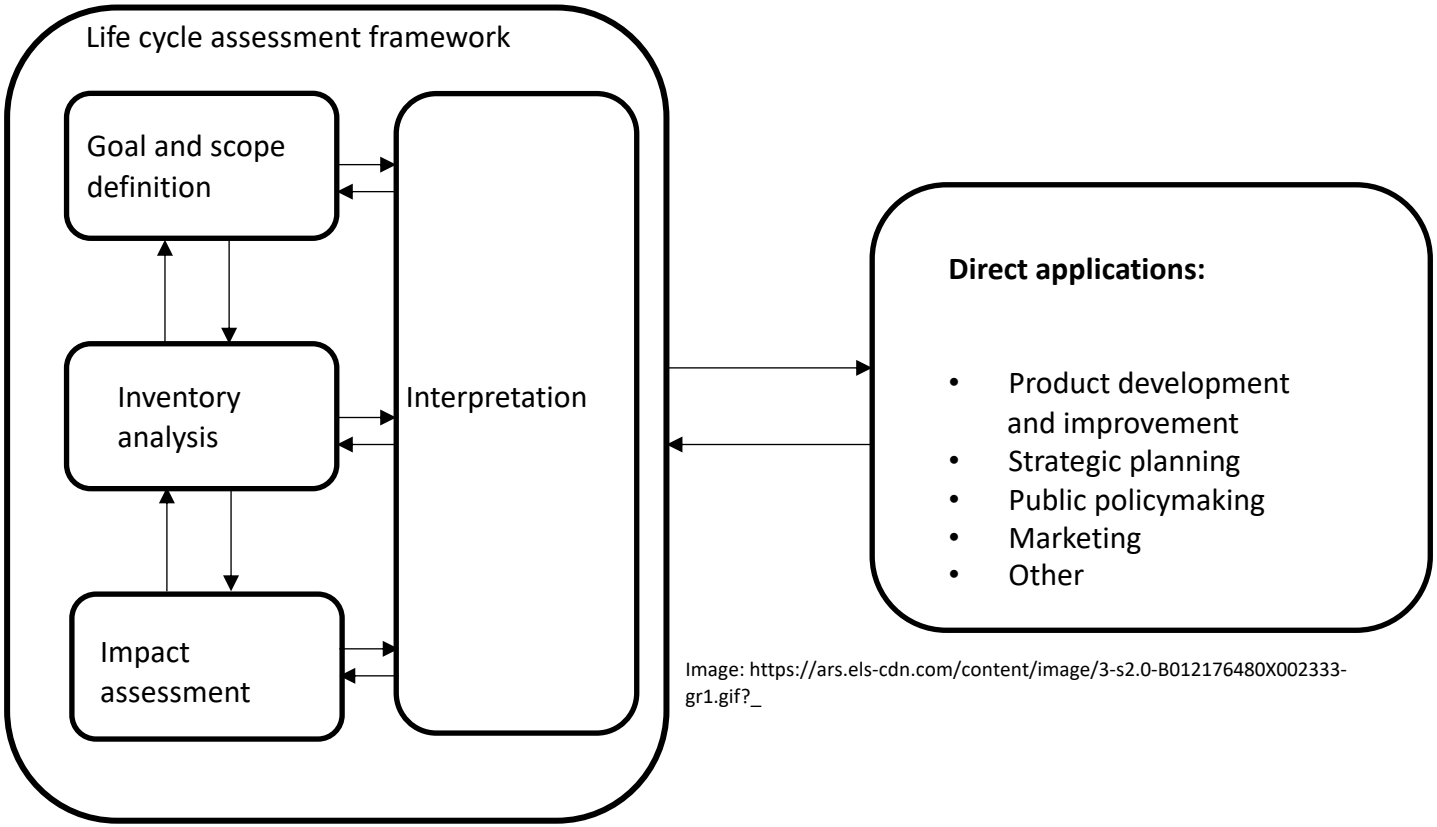
- compiling an inventory of relevant inputs and outputs,
- evaluating the potential environmental impacts associated with those inputs and outputs,
- interpreting the results of the inventory and impact phases in relation to the objectives of the study" *(ISO 14040.2 Draft: Life Cycle Assessment - Principles and Guideline)*[2]

2. https://www.gdrc.org/uem/lca/lca-define.html

1.1 LCA Field of use

The LCA methodology is applied in many fields and for various purposes. Its use is central in environmental management. It has been used for:[3]

- Global Lifecycle Impacts of Consumer Products, where it was originated
- Carbon Footprint. Originally for product or services and lately even for cities, although it is a time consuming task and it requires a lot of data
- Creating Design Solutions, as it takes into account all stages of product life cycle, from the early stages
- Assessing waste Management systems, to identify and evaluate alternatives with low environmental impacts
- Energy and nitrogen footprint
- Sustainable Development



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3. https://www.sciencedirect.com/topics/earth-and-planetary-sciences/life-cycle-assessment

1.2 LCA Case Studies in the Textile Sector

There are many studies that have been performed of LCA applications in the textiles sector. Some of them have been published, but the most of them are only for internal use.

1. Resource and Environmental Profile Analysis of a Man-Made Apparel Product: Woman's Knit Polyester Blouse; Franklin Associates Ltd, USA, (Franklin, 1993)
2. The ecology of hotel textiles and textile services – an LCA study on best available applications and technologies (Kalliala, 1997)
3. Comparative LCA of Three Textile Dyestuffs, Switzerland (Weidenhaupt et al, 1996)
4. Textile Products, Impact assessment and Criteria for Eco-labelling (draft) (Astrup Jensen et al,1994)
5. Life cycle assessment – five garments, http://mistrafuturefashion.com/output/lca-five-garments/
6. Recycling textile waste into secondary material: Can it lower the global environmental impacts? The answer through Life Cycle Assessment, http://resyntex.eu/images//downloads/Life_Cycle_Analysis_of_the_bio-chemical_textile_recycling_technologies.pdf

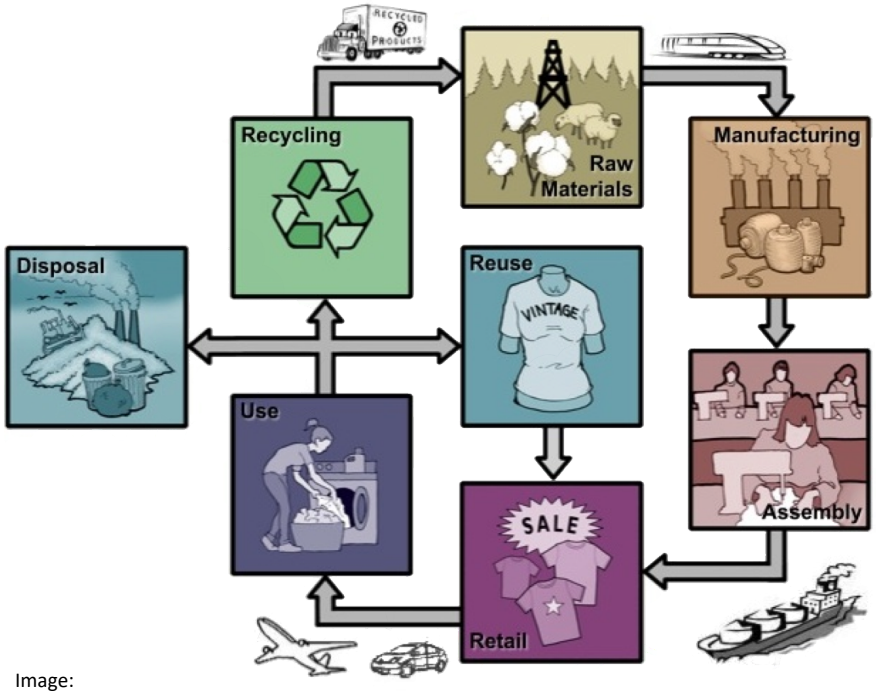


Image: https://oroeco.files.wordpress.com/2011/09/textile_lca_flow.jpg

In order to further understand the LCA, there is no simple process, on the contrary, the understanding and analysis of the LCA requires a wide series of information concerning the important factors that harm the environment. Similar case studies are :

1. Lisbeth Dahllöf, "Life Cycle Assessment (LCA) applied in the Textile Sector: the Usefulness, Limitations and Methodological Problems – A Literature Review", https://core.ac.uk/download/pdf/70570760.pdf.
2. Ecodesign in the Textile Sector, http://www.ecosign-project.eu/.
3. European Platform on Life Cycle Assessment (LCA), https://ec.europa.eu/environment/ipp/lca.htm.

2. LCA Method Presentation

The 4 Phases of a Life Cycle Assessment

ISO standards 14040 and 14044 define the phases of a Life Cycle Assessment.

These are:

1. Definition of Goal and Scope
2. Inventory Analysis
3. Impact Assessment
4. Interpretation

LCA phases			
Goal & scope	Life Cycle Inventory LCI	Impact assessmenet LCIA	Interpretation
Definition of goal and scope Intented application audience, publicity, etc. Boundaries Functional unit Allocations Assumptions and limitations Data quality requirements Type of critical review	Inputs and outputs of the system unit processes Energy inputs Raw material inputs Other physical inputs Products, co-products and waste Emissions to air Discharge to water and soil	Selection of impact assessment method i.e. ReCiPe, EcoIndicator 99 etc. Selection of impact categories Category indicators Characterisation models LCI- results classification Calculation of category indicators results i.e. characterisation Grouping and normalisation Weighting	Interpretation of reseults and usability Significance, limitations, comprehensive Opportunitites to improve Strategic decision making Selecting indicators Product and process development Environmental information Marketing

Image: https://www.researchgate.net/profile/Sebastian_Scholze/publication/261239853/figure/fig3/AS:296862826418179@1447789021243/Four-Phases-of-LCA-based-on-ISO-14040-standard-series_W640.jpgadipiscing elit.

2.1 Phase 1: Goal Definition

A very important part of the analysis. Defines the purpose of the environmental analysis and the depth of the analysis. In this phase it is defined what to collect and measure. Typical studies aim at

- Reduce CO_2 emissions
- Meet certification
- Reduce energy use
- Reduce component toxicity

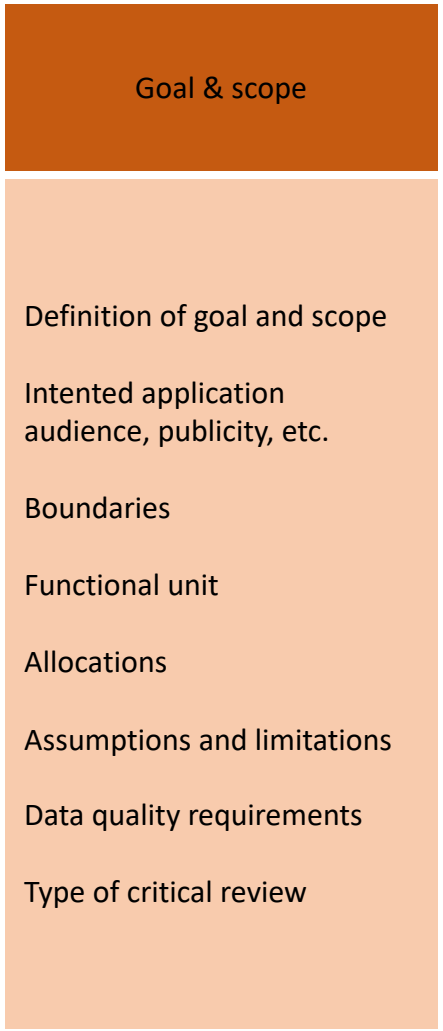
The goal should be defined and revisited.

The next step is the choice of the functional unit and the boundaries of the analysis.

- Is it the product or the system that will be assessed?
- Define the limits or depth of the analysis, is it its use phase only, is the manufacturing, is the recycling, or all of the stages?

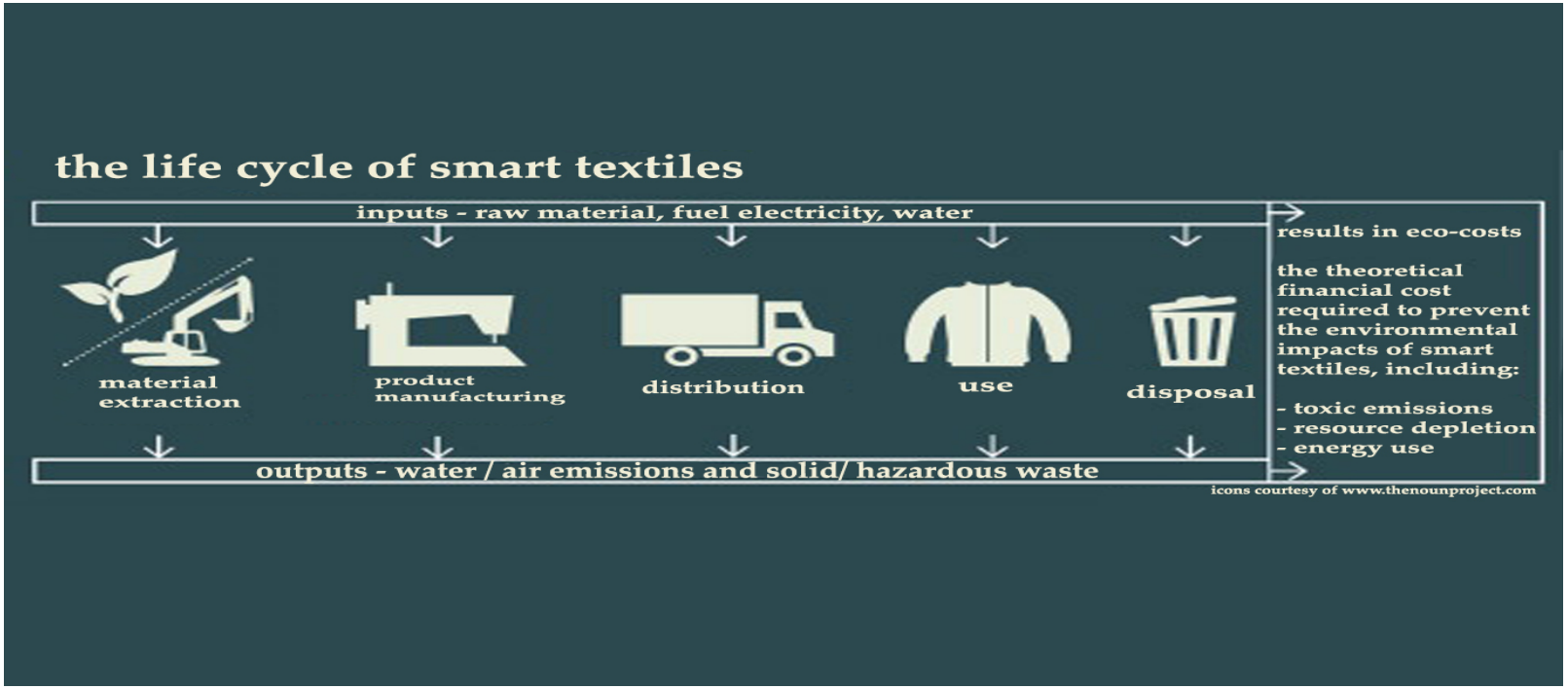
Data Quality for the analysis is very important. According to ISO standards data parameters are

- Reliability
- Completeness
- Temporal correlation
- Geographical correlation
- Technological correlation



2.2 Phase 2: Inventory Analysis

This is the data collection phase of the analysis. It Is based on the material and energy flow in the technical product system and the environment. Data are collected and structured.
This stage is highly assisted by relevant software and it should be run by an experienced user.
A flow diagram of the Life Cycle Inventory is mandatory. Each unit in the flow diagram must be explicitly described in order to ensure understanding between the LCA actors and avoid overlaps.
"Therefore, materials and energy flows regarding the process as a whole, as well as environmental releases must often be allocated to the different products".[4]



Life Cycle Inventory LCI

Inputs and outputs of the system unit processes

Energy inputs

Raw material inputs

Other physical inputs

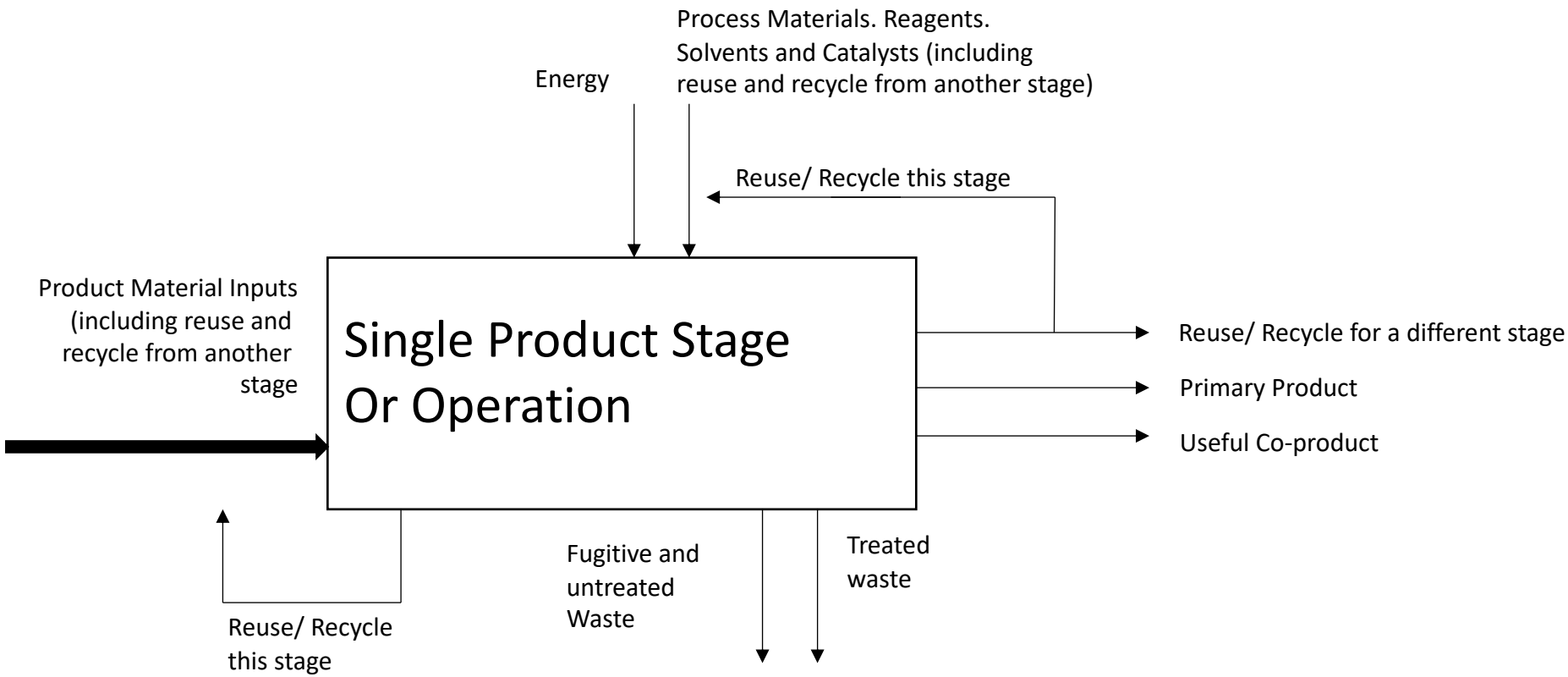
Products, co-products and waste

Emissions to air

Discharge to water and soil

4. Natascha M.van der Velden, KristiKuusk, Andreas R.Köhler, Life cycle assessment and eco-design of smart textiles: The importance of material selection demonstrated through e-textile product redesign, https://doi.org/10.1016/j.matdes.2015.06.129.

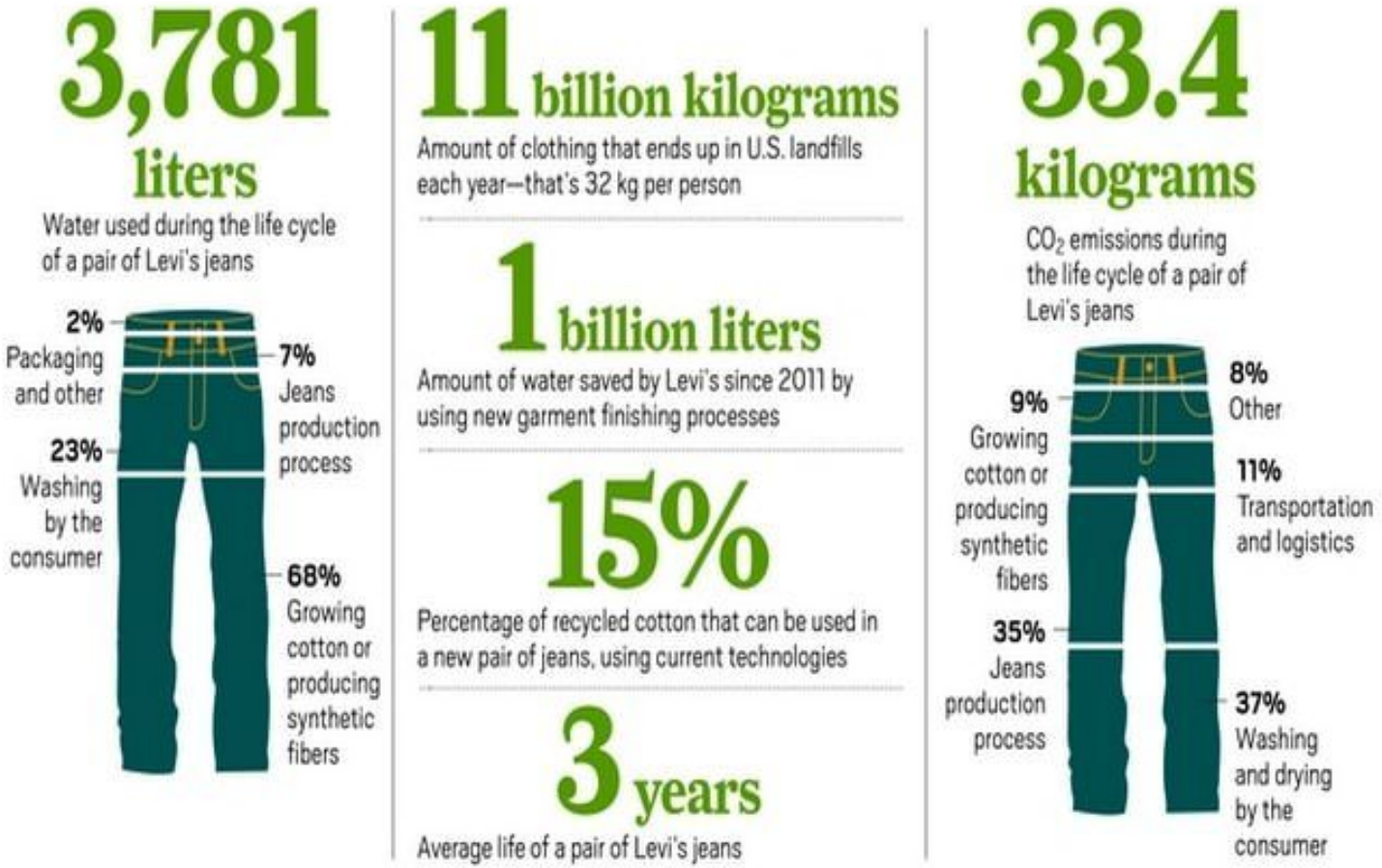
Each single stage in the flow diagram is described as shown in the diagram.



2.3 Phase 3: Impact Assessment

In this stage we are evaluating the significance of the impacts. It usually consist of 3 key tasks:

- Selection of indicators and models. Common impact categories Human toxicity, Global warming potential, Ecotoxicity, Acidification, Eutrophication
- Classification , where every stage in the flow diagram is classified in every indicator
- Impact measurement, where all equivalents are calculated



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Impact assessmenet LCIA
Selection of impact assessment method i.e. ReCiPe, EcoIndicator 99 etc.
Selection of impact categories
Category indicators
Characterisation models
LCI- results classification
Calculation of category indicators results i.e. characterisation
Grouping and normalisation
Weighting

2.4 Phase 4: Interpretation

It is the decisions phase. The results are interrogated and opportunities are sought to change the design and improve the environmental footprint and also to compare solutions from the environment point of view.

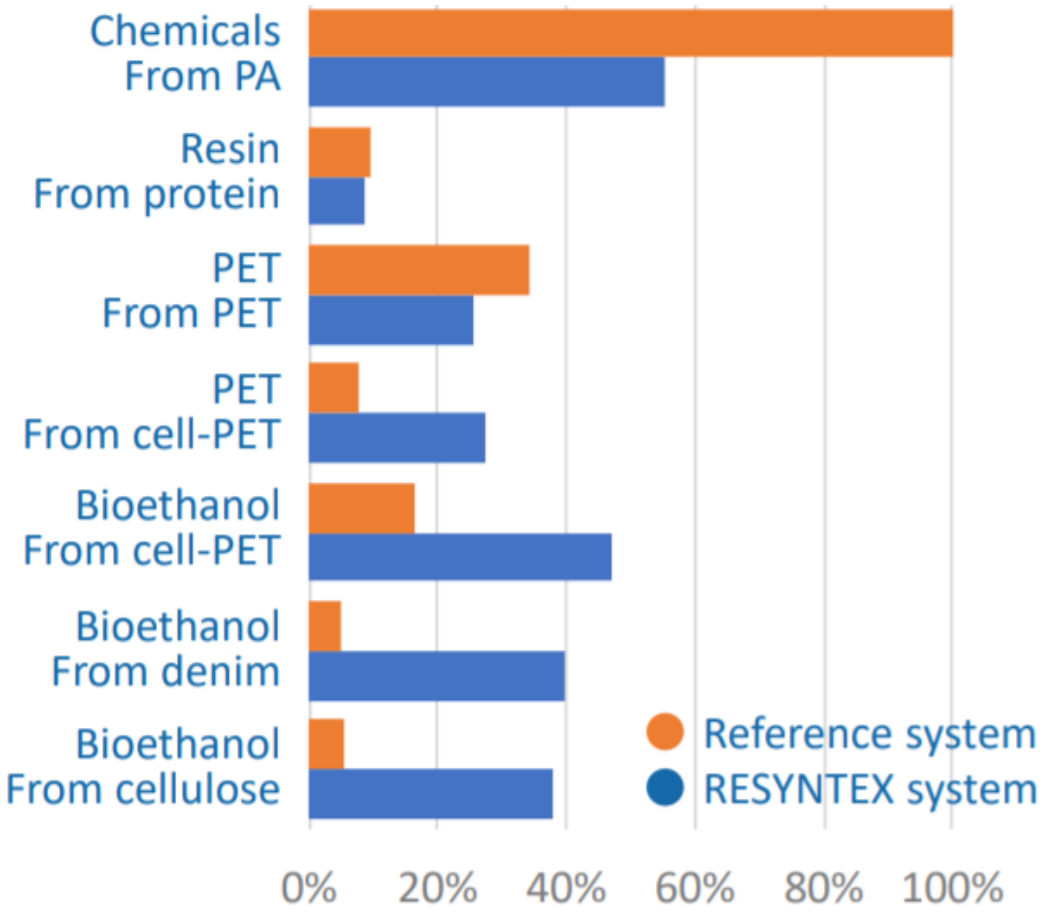


Image: http://resyntex.eu/images//downloads/Life_Cycle_Analysis_of_the_bio-chemical_textile_recycling_technologies.pdf

Interpretation
Interpretation of reseults and usability
Significance, limitations, comprehensive
Opportunitites to improve
Strategic decision making
Selecting indicators
Product and process development
Environmental information
Marketing

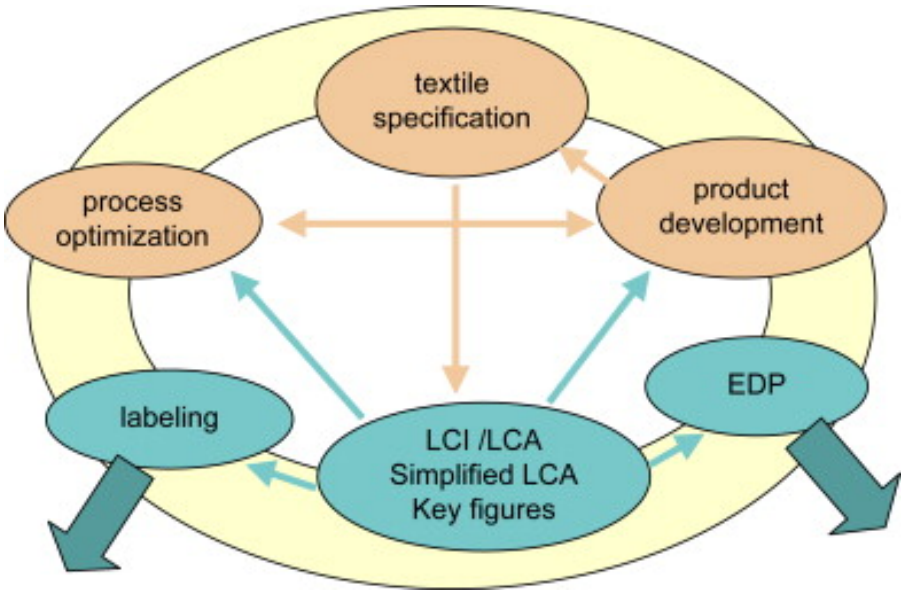
Conclusions

In this OER we have presented the LCA methodology for assessing the environmental foot print of products, services and processes. The subject has been extensively reported in the bibliography and it is used in many applications.

There are many studies related to the textiles sector and as textiles are the 2nd most polluting sector, the use of LCA will always be important.

It should be made clear that a good and accurate LCA requires a lot of effort and expertise to be accomplished and it should always be considered in any product or process related developments and it can assist decision making.

The method is not self optimized and it needs human intervention in order to access alternative solutions or to drive towards optimal choices.



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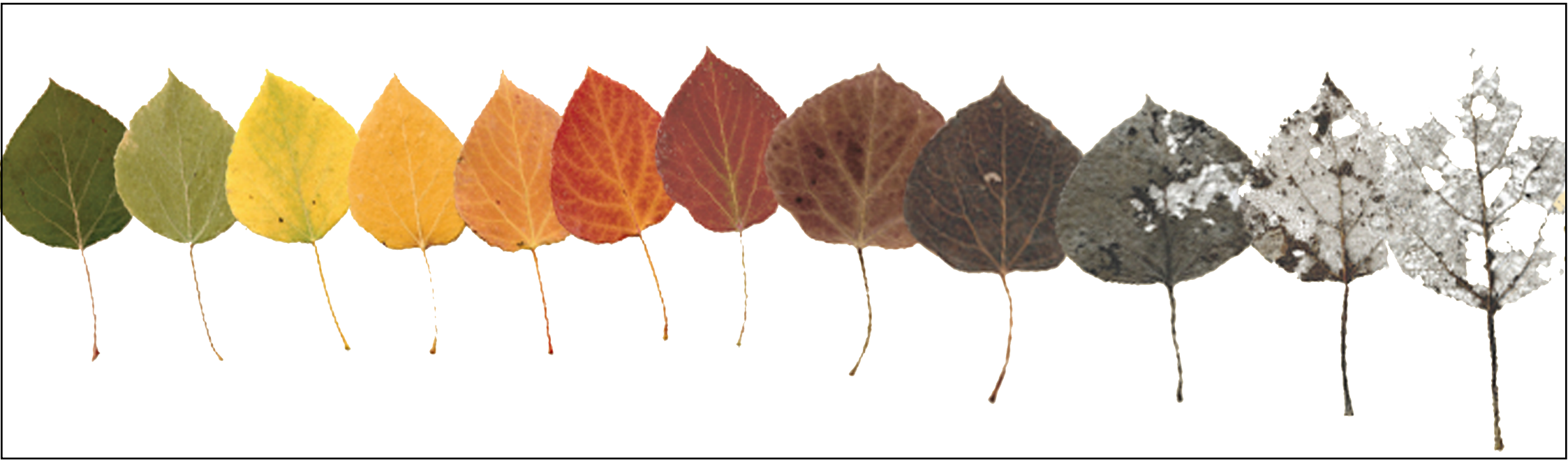

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