iPRODUCE

Guideline on Life Cycle Assessment (LCA)

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Presentation/objective of the guideline

The aim of this guide is to introduce companies to Life Cycle Assessment methodology. This methodology aims at evaluating the environmental impacts of products, processes or sevices, on their whole life cycle and for a wide range of environmental impacts categories.

First the methodology will be presented, as well as its main applications (both for internal use in companies as external).
Then, the LCA process as defined in ISO standard will be described, precising the goal of each individual steps, what should be done and when possible how it can be done. This later part will be completed by additional information on the practical implementation of LCA, whether its should be outsourced to consulting companies or for internal implementation (developement of internal LCA skills).

Finally, examples of typical uses of LCA will be provided.

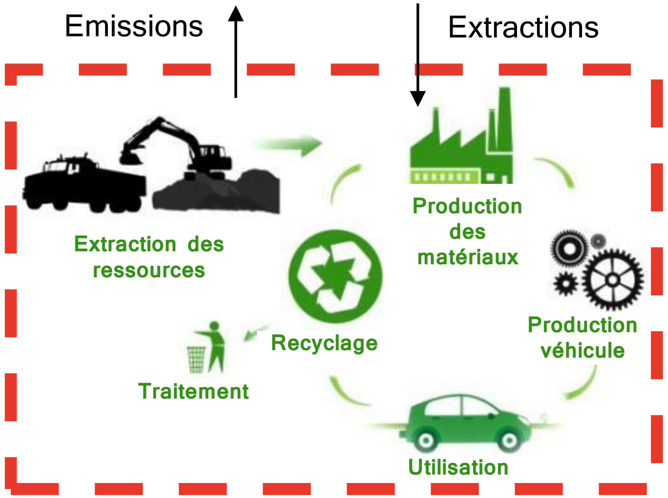
Guidelines Life Cycle Assessment – Table of contents

1. What is LCA?

Definition

LCA is a tool for environmental assessment, which is **standardized**, **global**, **multi-criteria** and **quantitative**. It can be applied to products as well a to processes and services.

Standardized: ISO 14 040-14 044



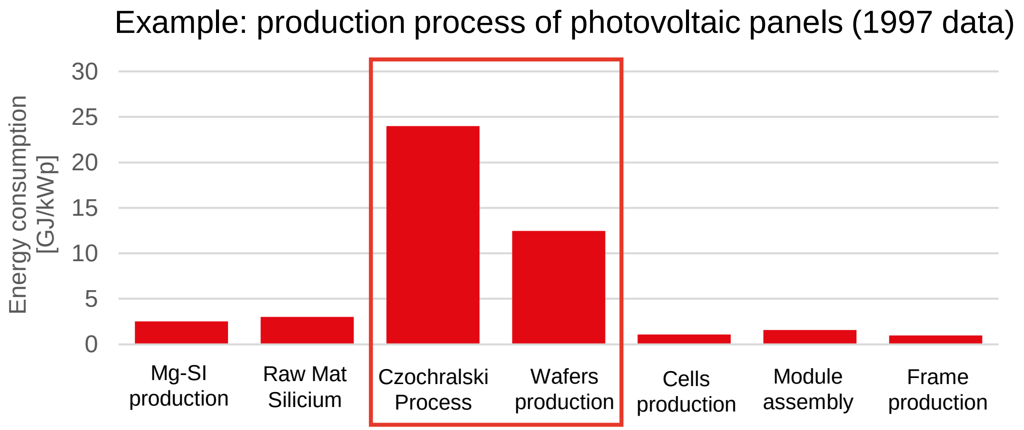
Global: « life cycle approach », environmental impacts from the extraction of the resources to the end of life treatment steps.

Multi-criteria: the results of an LCA are **quantitative** impacts on the ecosystems, on a broad range of environmental impact categories:

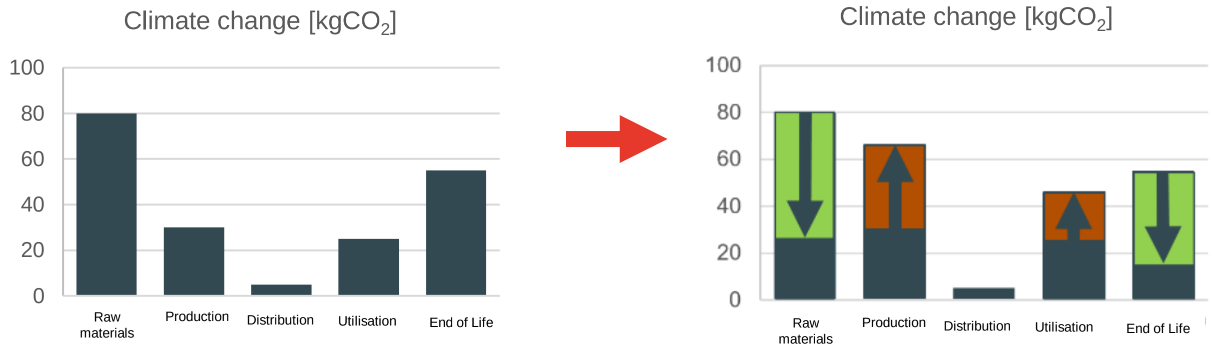
- Climate change,
- Acidification (« acid rains»),
- Ozone layer depletion,
- Eutrophication (« green algae»),
- Non-renewable energy consumption, etc.

Internal uses

- Identify/prioritize relevant processing steps to improve over a whole production process



- Optimize processes and products
- Compare strategies, technical solutions while preventing pollution transfers between life cycle steps or from one impact category to another

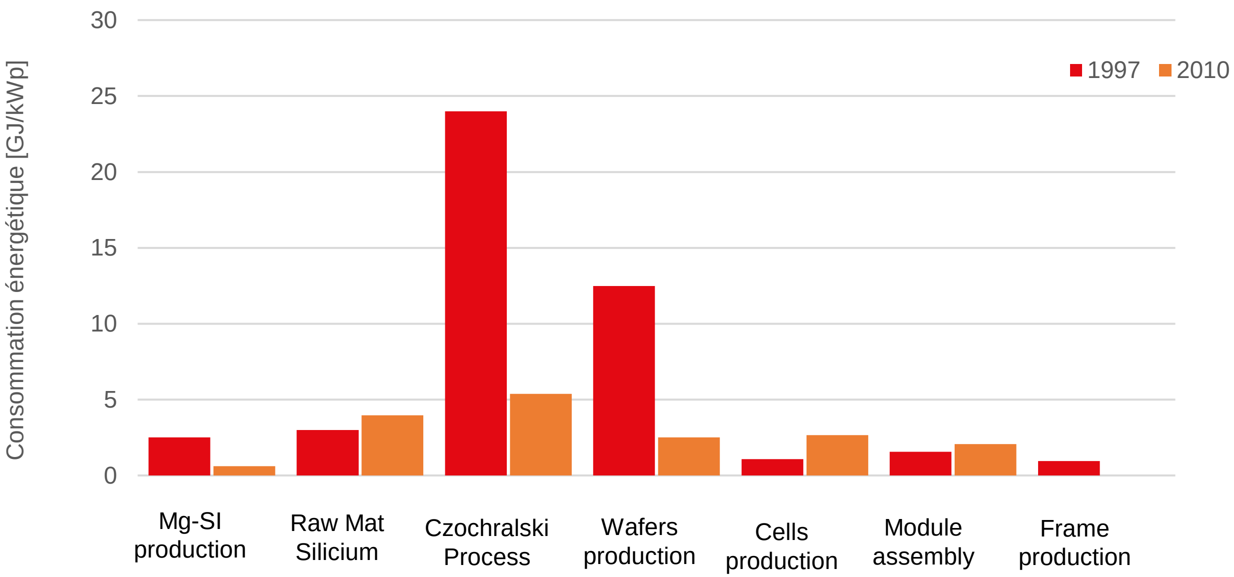


External uses

Currently, no regulation forces companies to perform LCA. It usually performed voluntarily either for:

- Define public policies
- External communication:
  - Apply for ecolabels, as long as the product verifies ecological requirements
  - Communicate about product environmental performances to client / customers (for example Environmental Product Declarations)
  - To select the strategies/potential improvements to be aplyed to a ecodesign and verify the improvement achieded versus the original design. (To learn about ecoesign see the related Guide).
- For lobbying using scientific arguments on environmental relevance of current or new regulations

Example: Evolution of photovoltaic(PV) cell production between 1997 and 2010

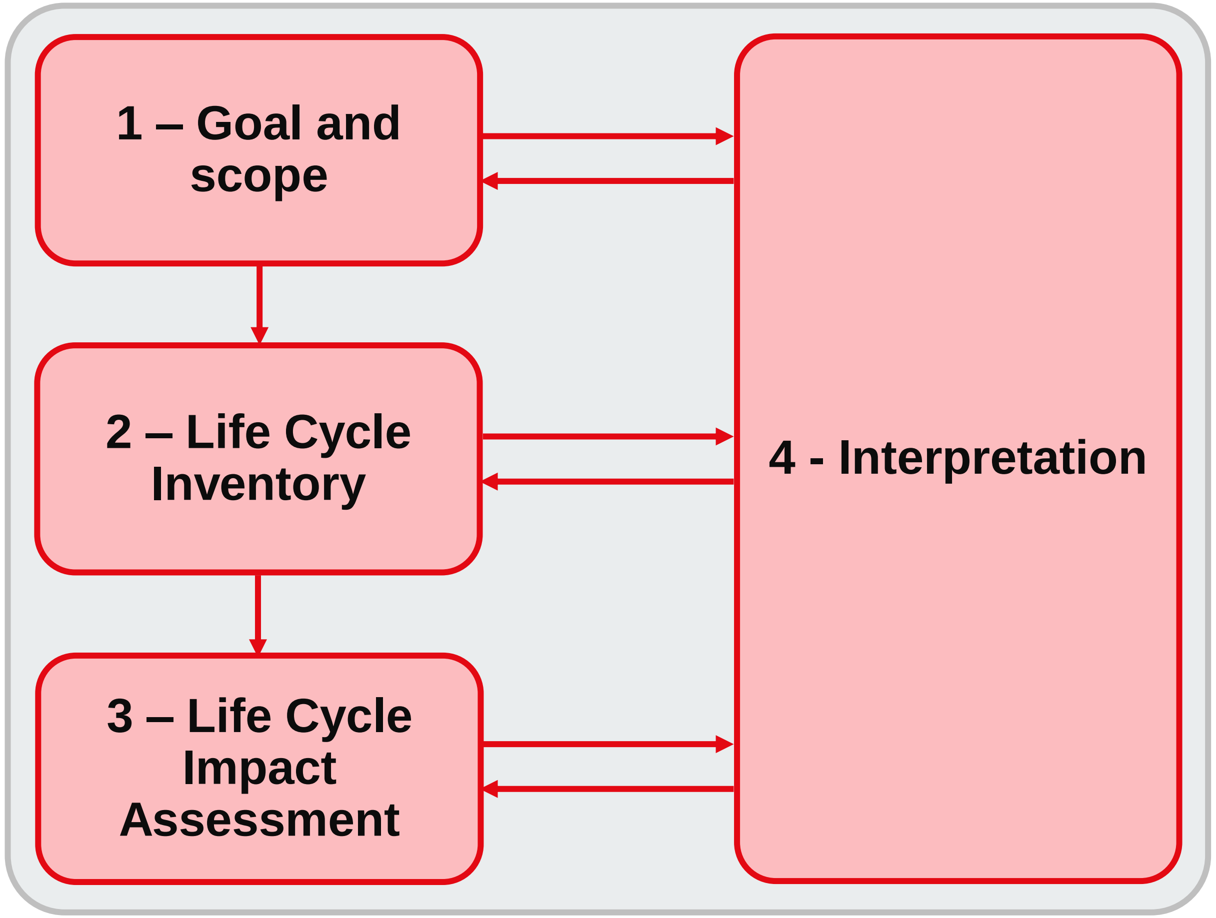


Results of LCA can be used to:

- Estimate Energy Return on Investment (EROI) :
  - *90s: between 8 and 20 years*
  - *2010: between 0,75 and 3,5 years*

2. Overview of LCA process

Methodology according to ISO 14 040 -14 044



Goal and scope definition

ISO 14040 recommends to define explicitly the goal and scope of an LCA study, for two main reasons:

- For transparency and to avoid bias
- Constrain the system

It usually requires to indicate many different information, such as:

- System for each products/scenarios
- Function(s) of the product(s)
- Functional unit
- System boundaries
- Allocation rules
- Impact evaluation method and impact categories evaluated
- Data quality requirements
- Main assumptions
- Main limitations
- ….

Important concepts listed here will be defined in a later part of this guideline (in practical implementation section)

Inventory of each flow

Identification and quantification of energy and material flows (incoming and outgoing) from the system.

Data can be collected using different technics and from different sources:

- Field data on industrial/production sites,
- Expert information/data,
- Scientific literature,
- Own models.

System boundaries, extend of the collect and quality of the data collected depend on the goals of the LCA study and on the means available for the study (time, budget, software, expertise…)

ISO 14 044 gives recommendation on quality data requirements for Life Cycle Inventory (LCI).

Goals:

Life Cycle Impact Assessment aims at translating consumptions and emissions identified during LCI into environmental impacts (climate change, ozone layer depletion, acidification, eutrophication, human toxicity, resource consumptions, etc.)

Process:

- Selection of impact categories
- Regrouping identified flows according to their role in the selected impact categories
- Translation of each flow into impact using specific “characterisation factors” / indicators

 Impact categories and associated indicators are selected in accordance with the goals of the study and in relationship with the type of technologies investigated. Ideally, impact categories should be selected at step 1 (goal and scope)

Goals:

- Analyse LCIA results
- Explain the limitations associated to previous steps (inventory or impact analysis)

 Provide clear and transparent guidelines on next steps

Referenced standard: ISO 14044

Questions to answer at interpretation step:

- What are the main contributors for each impact (what process step, which substances..)?
- What is the sensitivity of the results? If assumptions/system boundaries/calculation methods change, would the results vary? to what extent?
- Are the systems comprehensively modelled? (no step or sub-process missing, etc.)
- Are the systems coherent? (compared products, their functions/services…)

3. Practical implementation

Objectives of the study

In practice, one should ask and answer the Following question:

« Who wants to show what, to whom and why? »

Actors / stakeholders (identity)

- Sponsor/backer (who pays for the study)
- Practitioner who performs the LCA / subcontractor
- Critical review performer
- Other interested stakeholders

Objectives of the study

In practice, one should ask and answer the Following question:

« Who wants to show what, to whom and why? »

Considered application of the results/the study

- List different scenarios
- If possible, formulate into questions. For example:
  - What are the improvement potential in the life cycle of this product?
  - Which activities associated to this product lead to important impacts?
  - What would be the consequences of replacing a process by another one?
  - What would be the consequences of replacing a material by a recycled one?
  - Between options A, B and C, which one is the best from an environmental point of view?

Objectives of the study

In practice, one should ask and answer the Following question:

« Who wants to show what, to whom and why? »

Internal		Increase expertise/know-how and reduce the pollution associated to the products Environmental communication
Public authorities	Relationship	Reliable information for (future) regulation Encourage the respect of the environment
Consumer/client		Information

When LCA results are expected to be share to the public:

- Sponsor and subcontractor should be independent
- Sponsor and critical review performer should be independent

Scope of the study > Scenarios

For each question asked in the objectives, one or several scenario are defined and compared

Examples:

Product	Examples de scenarios
Pair of shoes	Good quality shoes
	Bad quality shoes
Hand dryer	Electric hand dryer
	Hand dryer with paper

Scope of the study > Function

The concept of **function** is essential in LCA**:**

- Is must be the SAME for all scenarios
- Some systems can be multifunctional (have several functions)
- There can be primary and secondary functions

Scope of the study > Functional unit

The functional unit (FU) is the quantified performance of a system of products, which will be used as a reference unit for the results.

Several definitions of functional unit exist:

According to ISO standard, the functional unit:

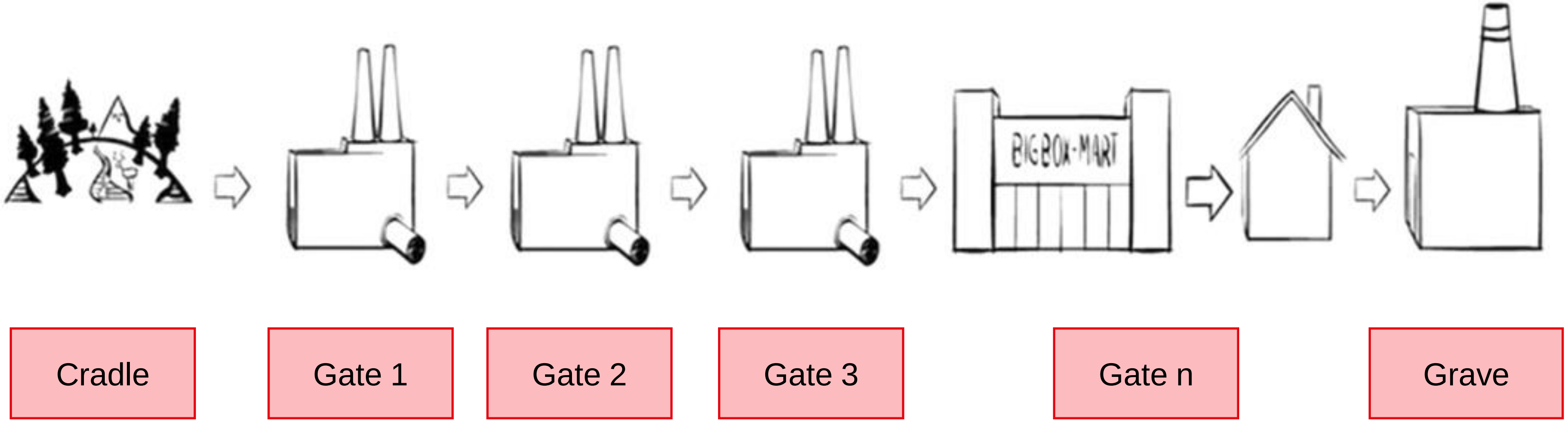
- Is a quantification of the function
- Must be measurable, precise and additive
- Must be the same for each scenario

According the ILCD Handbook (handbook edited by the European Commission), the functional unit must answer the questions: What? How much? How? For how long?

Environmental impacts will be expressed on the basis of this reference unit

Scope of the study > System

Boundaries of the system must be clearly defined:



Production of a product:	Cradle to gate
Utilisation of a product:	Cradle to grave
Waste treatment:	Gate to grave
Production process:	Gate to gate (when product inputs/outputs are identical)

Scope of the study > System

Warning! LCA is an iterative process: system boundaries can change in the course of the study!

Do not hesitate to:

- Exclude non-relevant processes
- Include external processes if their contribution is significant/relevant
- Include/exclude material/emission flows

Different ways to collect data for Life Cycle Inventory

Data collection from literature

- Online research / library / journals
- Scientific journals on LCA (Journal of LCA, Cleaner Production, Green Chemistry)
- LCA databases

Field data collection

- Phone calls / Field survey / personal or professional network
- Environmental reports
- Direct measurements on site
- Estimation / models

Field survey

- Using generic questionnaires
- Creating specific questionnaires

Questionnaire ICV

Choisir les données pour un site et renseigner les données relatives à une période (une campagne, une durée déterminée…)

Informations relatives à la société		Coordonnées de l'interlocuteur	
Société	Derichebourg	Nom-Prénom	
Adresse du site de production		Fonction	
		Téléphone	
Période de mesure		Email	

Produits/sorties du broyeur	Unité	Valeur	Incertitudes	Commentaire/qualité/recyclabilité
Ferraille	t			
Cuivre	t			
RB légers	t			
RB lourds	t			
produit 6	t			
produit 7	t			
produit 8	t			
produit 9	t			
produit 10	t			

Consommation de ressources énergétiques		Valeur	Incertitudes			Valeur
Gaz naturel	MJ (PCI)			Electricité	MJ elec	
Fioul léger/diesel	MJ (PCI)			Propane	MJ (PCI)	
Gaz de pétrole liquéfié (GPL)	MJ (PCI)			Fioul lourd	MJ (PCI)	
Autre, préciser.				Autre, préciser.		

Matières premières / entrant		Valeur	Incertitudes
Véhicules	t / nombre		
Agent lubrifiant	1		
	t		
	t		
	t		
	t		
	t		
	t		
	t		

Emissions dans l'air		Valeur	Incertitudes /commentaires			Valeur
Volume	Nm3			Poussières	g / Nm3	
COV	g / Nm3			PM0,1	g / Nm3	
CO_2	g / Nm3			PM1	g / Nm3	

PRODUCE

Using environmental reports (e.g. statutory reports)

Installation :	Broyeur	Désignation de l'essai :	annuel
Date des mesures :	23/11/12	Conditions de fonctionnement :	Nominal

Désignation	Unité	COFRAC	Essai 1	Essai 2	Essai 3	Moyenne	Blanc de site		VLE(1)	
		Oui/Non					Valeur	C/NC (2)	Valeur	C/NC (2)
Date des mesures	-	-	23-nov-12			-	-	-	-	-
Température fumées	°C	N	13,0			13	-	-	-	-
Teneur en oxygène (sur gaz sec)	%	N	20,90			20,90	-	-	-	-
Teneur en CO_2 (sur gaz sec)	%	N	0,0			0,0	-	-	-	-
Humidité volumique	%	N	1,0			1,0	-	-	-	-
Vitesse débitante (dans la section de mesure)	m/s	N	18,4			18	-	-	-	-
Vitesse au débouché	m/s	N	18,4			18		-		
Débit ramené aux conditions normales, sur sec sans correction d'O2 ou de CO2	m_0^3/h	N	97 034			97 034	-	-		
Composes			Concentration sur gaz sec sans correction d'oxygène et flux massique				Valeur	C/NC (2)	Valeur	C/NC (2)
Poussières totales	mg/m_0^3	N	0,9			0,9	<0,5	C	40,0	C
	Kg/h	N	0,084			0,084	-	-	5,00	C

(1) VL : Valeur Limite d'Emission

(2) C : Conforme, NC : Non Conforme

Direct onsite measurements

Paramètre	2 Emissaires : - Sortie broyeur - Sortie convoyeur		
	Nombre essais	Durée/ essai	Sous accréditation*
Température	1	ponctuel	O
Vitesse, débit	1	ponctuel	O
Humidité (H_2O)	1	1h30 à 2h selon la production	N
Composés Organiques Volatils Totaux (COVT)	1	1h30 à 2h selon la production	O
Méthane (CH_4)	3	1h30 à 2h selon la production	O
Poussières	1	1h30 à 2h selon la production	O
Métaux particulaires suivants : Cd, Tl, Hg, Sb, As, Pb, Cr, Co, Cu, Mn, Ni, V, Sn, Se, Te, Zn	1	1h30 à 2h selon la production	N
Dioxines et furanes (PCDD/PCDF)	1	1h30 à 2h selon la production	O

Déterminations optionnelles :

Paramètre	2 Emissaires : - Sortie broyeur - Sortie convoyeur		
	Nombre essais	Durée/ essai	Sous accréditation*
Oxyde de soufre (SO_x)	1	1h30 à 2h selon la production	O
Oxydes d'azote (NOx)	1	1h30 à 2h selon la production	O
Acide chlorhydrique (HCl)	1	1h30 à 2h selon la production	O
Ammoniac (NH_3)	1	1h30 à 2h selon la production	O
Formaldéhyde (CH2O)	1	1h30 à 2h selon la production	N
Phénol (C6H5OH)	1	1h30 à 2h selon la production	N

**Les mesures seront réalisées sous accréditation COFRAC sous réserve que les écarts éventuels aux prescriptions normatives ne remettent pas en cause la validité des résultats.*

Modeling LCA data

Data from SDS:

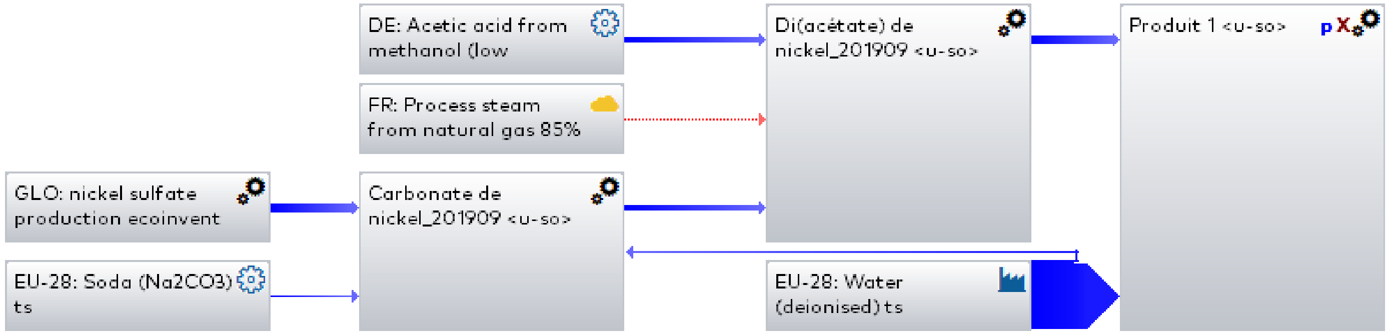
Di(acétate) de nickel		5 - <25%
No CAS : 373-02-4	No CE : 206-761-7	Numéro D'Enregistrement: 01-2119488197-24

From chemistry bibliography (Willey's Encyclopaedia):
Nickel di(acetate) can be prepared from Nickel(II) acetate tetrahydrate by a dehydration process

Nickel(II) acetate tetrahydrate is produced from nickel carbonate (with acetic acid), and is obtained by evaporation at room temperature.

Finally, nickel carbonate (basic) can be produced by the reaction of nickel sulphate and sodium carbonate.

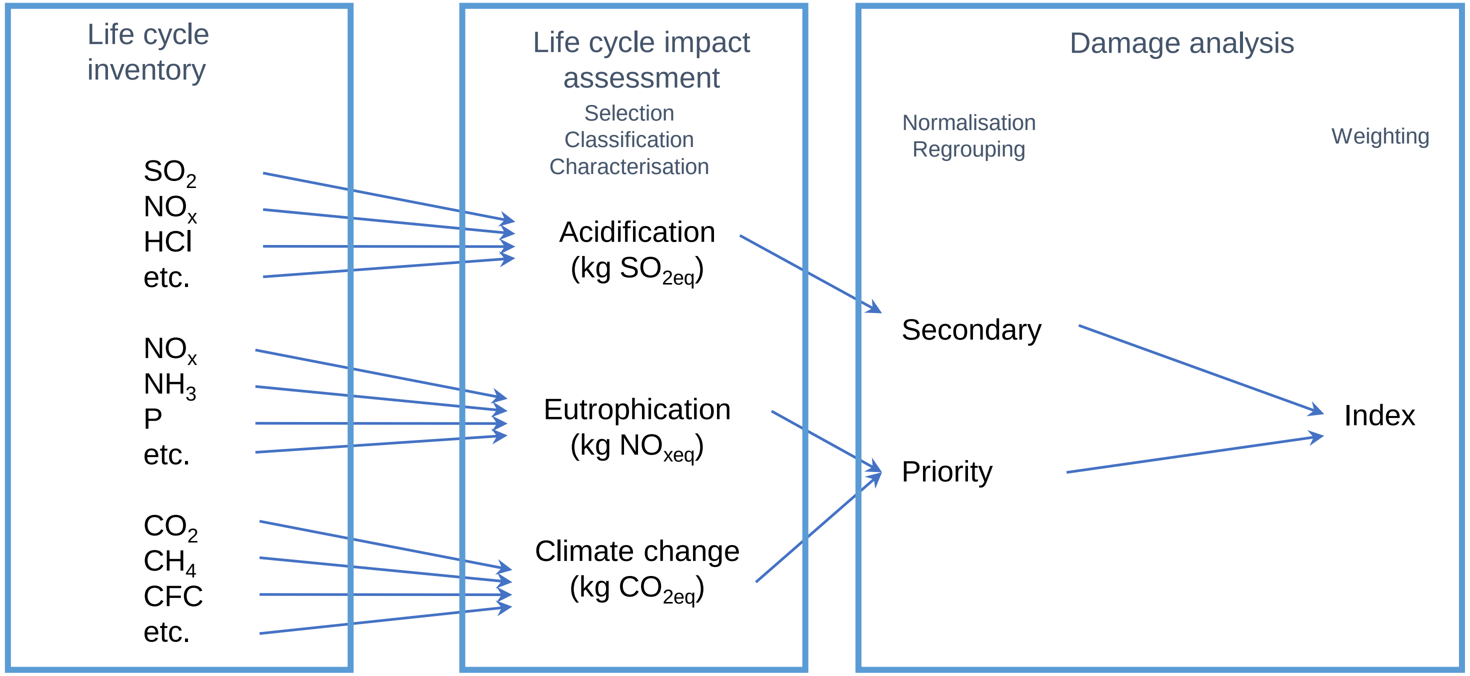
- A first model is considering all the reactions as complete (100% reaction rate)
- Energy consumption at each step evaluate from rough energy balance (thermodynamics)
- Impacts of other input production (acetic acid, energy, nickel sulphate, sodium carbonate) are taken from LCA databases



A few tips to help onsite data collection

- Establish communication (explain the methodology, the goals, process…)
- Understand the vocabulary and the means used/available within the company to collect the data (visit production sites, meet the stakeholders…)
- Create specific questionnaires/surveys
- Differentiate site and company data
- When possible avoid asking background data (confidentiality issues)
- Prepare specific questions to verify the coherence of collected data
- Some questions can be misunderstood
- Provide a feedback once the study is finished
- Do not hesitate to iterate and precise the questions
- When confidential data need collecting, create black box processes (no information on what happens inside, only inputs/outputs are known)
- Only collect data which can be processed by the chosen impact method

Translation of life cycle inventory into potential impacts and damages



List of substances, materials, elements emitted and consumed by the system

Quantification of impacts on ecosystems, for each impact category

Estimation of the damages as one single score

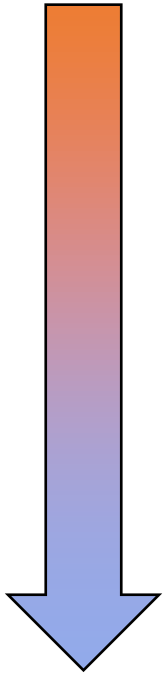
Example: $m_{GHG} = m_{CO2} + m_{CH4}*CF_{CH4} + m_{CFC}*CF_{CFC}$

CF_i = characterization factors, regrouped within characterization methods (usually directly available in LCA software)

Impact categories available

- Global warming potential
- Ozone layer depletion
- Smog formation
- Resource depletion
- Land use
- Acidification
- Toxicity
- Ionizing radiation

Well known / used



Less used / less documented

Tools for Life Cycle Impact Assessment

Tools for simplified approach: (to be completed)

- Carbon accounting (ISO 14064 standard provides tools for greenhouse gas accounting must be performed follwoing)
- Micosoft Excel (or other spreadsheet software)
- Labo1point5 – laboratory oriented evaluation – (in French!)
- Most ecodesign tools (see guideline for ecodesign) - https://www.ecoinvent.org/partners/ecodesign-tools/ecodesign-tools.html

Free & commercial LCA tools

- GaBi – commercial (~15000 €) - https://gabi.sphera.com
- Simapro – commercial (~7000 to 15000 €) - https://simapro.com
- OpenLCA – free - https://www.openlca.org
- EIME – Commercial (1000 to 4500 €) - https://codde.fr/en/our-software/eime-presentation

Tools for Life Cycle Impact Assessment

Free & commercial databases

- GaBi – commercial (~5000 €) – many basic processes (material, electricity, energy carriers, industry data, ...) - https://gabi.sphera.com/databases/gabi-databases
- Ecoinvent – commercial (~3000 €) – many basic processes (material, electricity, energy carriers, industry data, ...) - https://www.ecoinvent.org/database/database.html
- ELCD – free
- Material associations (European Aluminium, Worldsteel, Eurofer, Plasticseurope...)
- Psilca – commercial – include social data
- *+ many other specific databases (from 0 to > 2000€)*

List of existing databases : https://www.lifecycleinitiative.org/applying-lca/lca-databases-map/

Sensitivity analysis

Goals:

- Assess the robustness of LCA results
- Inform whether conclusions can be drawn directly from these results or not
- List parameters associated to high sensitivity and whose values should be improved for current or future studies

Process:

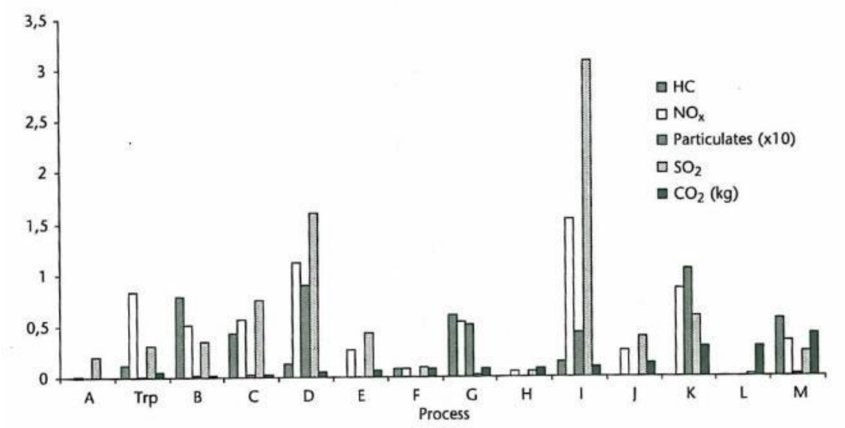
- Identify all parameters/assumptions associated to uncertainties, whether the uncertainty is known or not
- Quantify all the uncertainties/min-max (when not already known)
- Calculate the impacts for minimum and maximum values for each identified parameter
- List parameters with high influence on the results (>>5%)

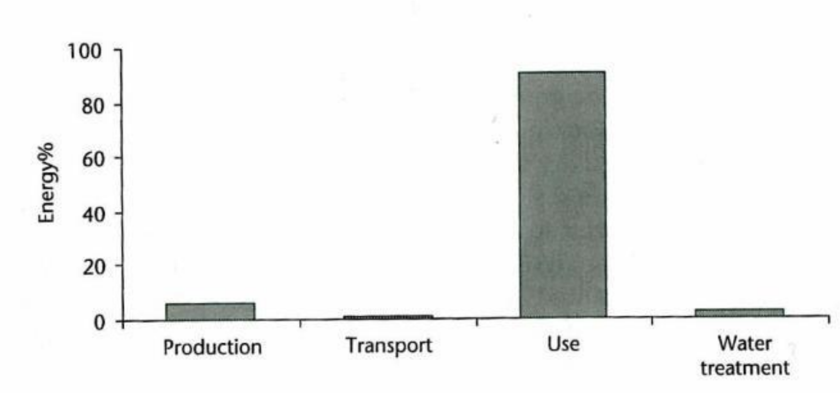
Dominance analysis

Most common analysis within LCA is the dominance analysis, which consists in identifying the life cycle steps/phases contributing the impacts.

Usually, and depending on the size of the system, less than 10 phases should be identified. For small systems it usually consists 1 or 2 phases

When there are too many processes/phases, it is possible to regroup them in order to have a clearer view.



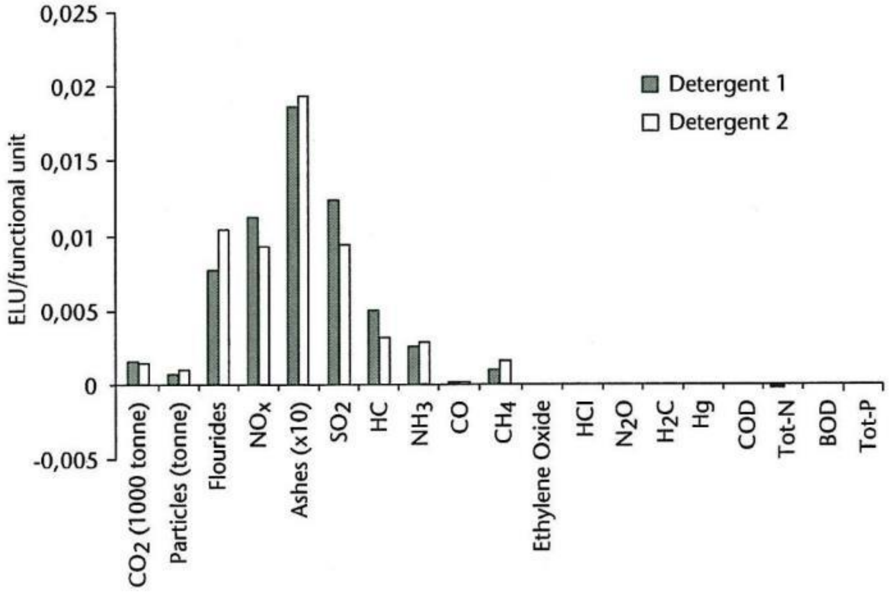


- Dominance analysis helps define the most critical points for future improvements
- Important not to neglect phases with little/medium impacts but which can be easily/economically improved

Contribution analysis

Like dominance analysis, contribution analysis aims at identifying the main contributors, but here focusing on the substances emitted or consumed by the system

This analysis can be performed at whole life cycle level or at specific phases level

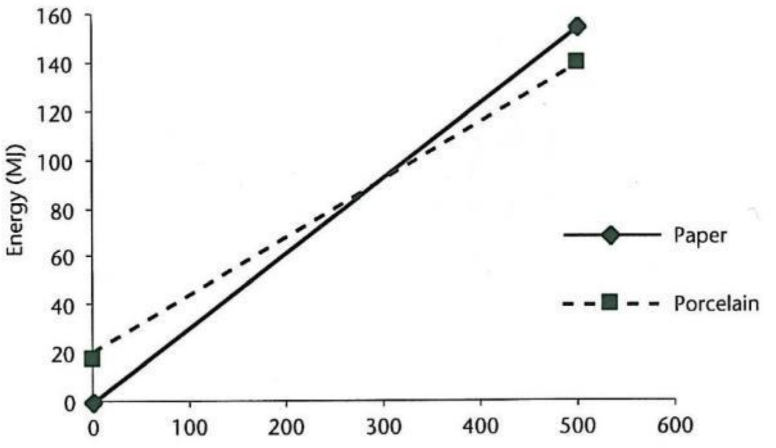


It can help identifying replacement alternatives for very impactful substances

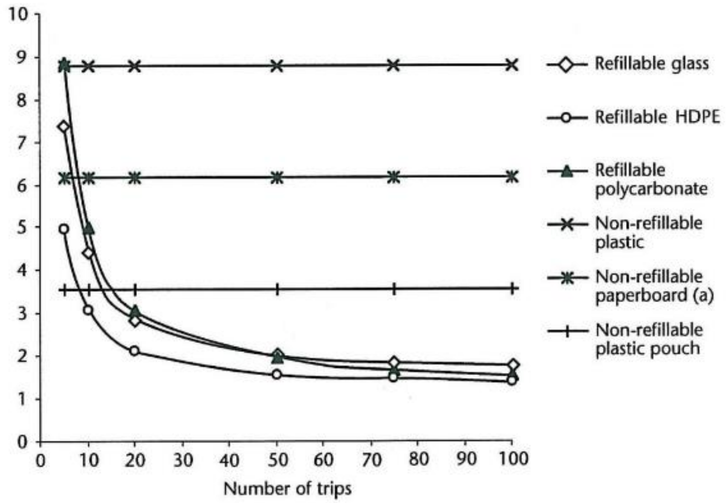
Amortization assessment

Aims at answering question such as: From how many uses, which lifetime, how many passengers a product or a service becomes environmentally profitable?

Can be associated to cost analysis



Comparison of the energy consumption associated to the use of single use paper cup vs reusable porcelain mug as a function of the number of uses



Comparison of the impact (unit not defined) associated to the use of single vs reusable product as a function of the number of uses

Absolute representation

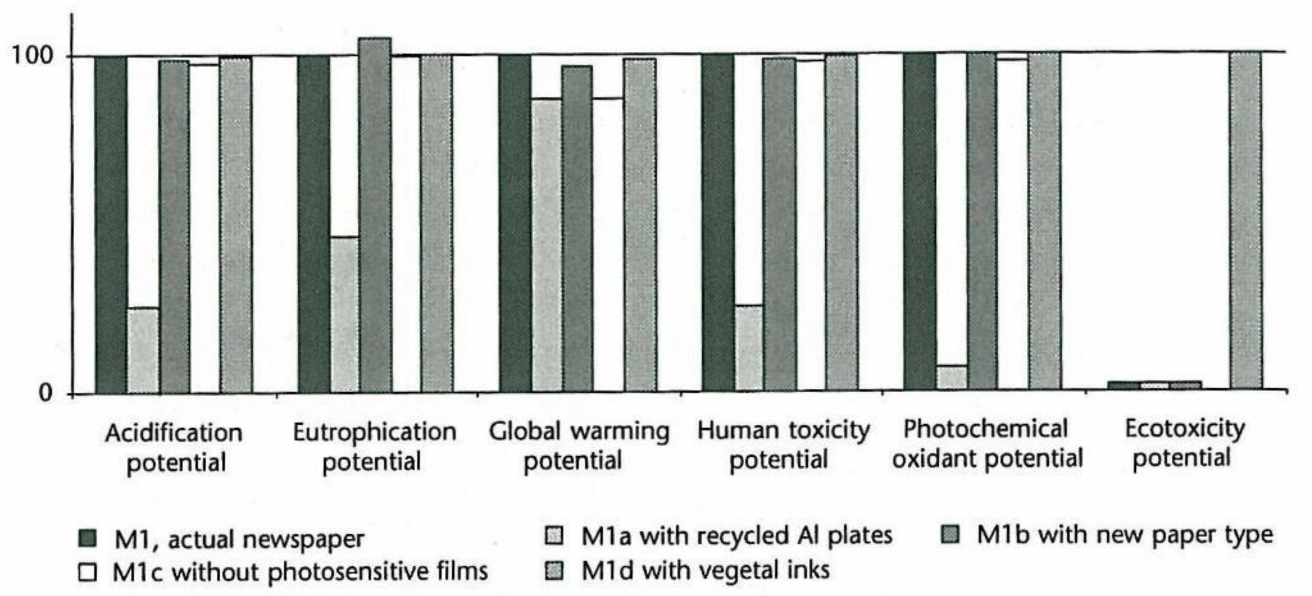
Relative representation

Variational analysis

Consists in changing the scope of the study to investigate other potential scenarios

- Extrapolation to other countries (see the influence of different energy grid mix, supply and transportation…)
- Modification of production processes, raw material, waste treatment processes…

Example for a paper mill



Advice

For LCA performed in order to assess the current environmental performances of one product or service

- Important to chose carefuly which results and how they are presented

- If possible use comparison to give an idea of the orders of magnutide of each impact (comparing to other similar products/services *if information is available*, to a certain distance traveled by car..)

If it is the LCA result tend to show “good” environmental performances and it is decided that communication should be made on these results: ISO standard 14 044 asks that a critical review is performed by an independant third party (it costs around 10% of the cost of a study)

Main items for each LCA step

Step 1 – Objective and scope definition

- List of objectives
- Definition of the perimeter / system(s) boundaries
- Function of the product(s)/system(s)
- Functional unit
- Impact categories

Step 2 - Life Cycle Inventory

- Material breakdown of the product(s) (nature of material and quantities)
- Logistic information (transport distances and transport modes for each material, product, wastes...)
- Energy and resource consumption for each production process (nature and quantities)
- Product, by-product, emissions, effluent and wastes for each production process (nature and quantities)
- Geographical information (location of production, for each process and each material, location of use of the product)
- Life profile of the products (energy/resource consumption associated to the use of the products, lifespan, maintenance..)

Main items for each LCA step

Step 3 – Life Cycle Impact Assessment

- Implementation in LCA software
- Use of the relevant databases (free or commercial)

Step 4 - Interpretation

- Dominance analysis
- Contribution analysis
- Sensitivity analysis
    - Identify parameter related to significant assumptions/uncertainties
    - Performed sensitivity analysis for each individual parameter
    - Identify the parameter having the most influence over the results
    - Quantify the overall result uncertainty and show overall influence on the results (errors bars on diagrams)
- Conclude (chose the best scenario / identify the phase with the most potential of improvement / identify possible technical /social means of improvement)

Example of a comparative LCA

Your company wants to renew the hand dryers from the bathroom and you are in charge of choosing the most environmentally friendly solutions between 3 solutions provided by your suppliers:

- Standard thermal hand dryer ;
- High tech thermal dryer ;
- Paper dispenser.

As an LCA expert, you decide to use the methodology to select the best solution.

 Solution next slides

Example of a comparative LCA (solution)

First task- Step 1 – definition of the scope and objectives of the study

Objectives:

- Identify the best solution from 3 alternatives
- Identify the possible area of improvement for the best solution

Scope : cradle to gate – from the extraction of the resources needed to manufacture the hand dryer as well as the consumables (energy, paper…) to the end of life treatment of the product (and wastes)

Function of the products: drying hands
Functional unit: drying one pair of hands

Impact categories: Global warming potential ; Acidification ; non-renewable energy resources; Mineral resources
Ozone layer depletion ; Human health, Carcinogen

Method: IMPACT 2002+

Example of a comparative LCA (solution)

Step 2 – Life Cycle Inventory (1) – Manufacturing of the products

The supplier(s) of the products are consulted to identify materials and their respective weights, as well as the weight of the packaging. (If the suppliers can’t provide this information, it is also possible to take each product apart and weight each elements separately).

The list of materials has to be confronted to the LCA databases available to make sure that no material production has to be modelled specifically.

	Unité	Thermal standard	Thermal high tech	Paper dispenser
Stainless steel (body and motor)	[kg]	4,6875	2,25	
ABS (body)	[kg]	0	5	1,2
PP (propeller)	[kg]	0,15	0,25	
Nichrome (resistor)	[kg]	0,3	0,5	
Copper (wire and motor)	[kg]	0,4625	1,1	
PVC (wires)	[kg]	0,6	0,85	
PS (packaging)	[kg]	0,85	1,5	0,6
Carton (packaging)	[kg]	0,4	0,5	0,3
Wiring board	[cm^2]	10	10	

Example of a comparative LCA (solution)

Step 2 – Life Cycle Inventory (2) – Manufacturing of the products

For each material and each product, the elaboration or forming processes must be defined

	Thermal standard	Thermal high tech	Paper dispenser
Stainless steel (body and motor)	Rolling	Rolling	
ABS (body)		Extrusion	Extrusion
PP (propeller)	Injection	Injection	
Nichrome (resistor)	-	-	-
Copper (wire and motor)	Wire drawing	Wire drawing	
PVC (wires)	Extrusion	Extrusion	
PS (packaging)	Extrusion	Extrusion	Extrusion
Carton (packaging)	-	-	-
Wiring board	Wire drawing	Wire drawing	-

Example of a comparative LCA (solution)

Step 2 – Life Cycle Inventory (3) – rest of the life cycle

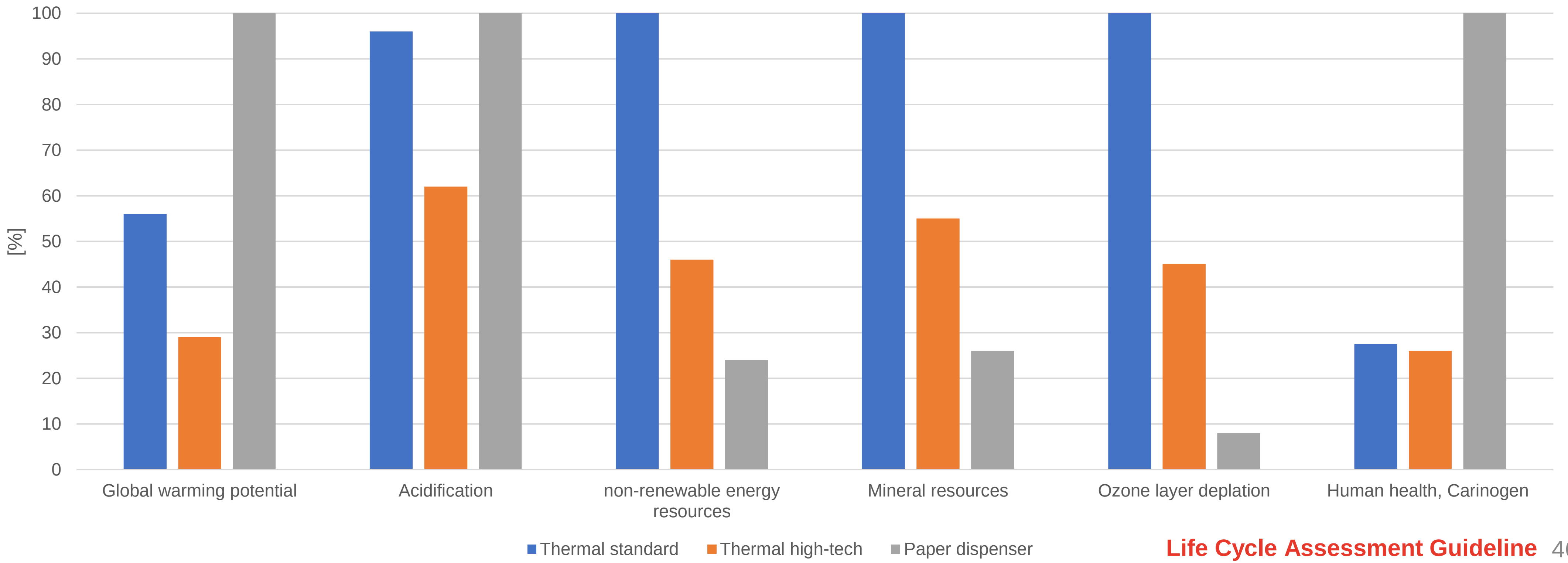
For each scenario, information on the rest of life cycle steps are collected or assumptions are made

Life cycle step	Thermal standard	Thermal high tech	Paper dispenser
Raw materials	China	China	France
Transport	China □ France (15 000 km boat + 500 km truck)	China □ Germany (15 000 km boat + 500 km truck)	France □ France (200 km boat)
Manufacture	China	Germany	France
Transport	0 km	Germany □ France 800 km	0 km
Utilization	3 years 50 utilisations per day 250 days per year	5 years 50 utilisations per day 250 days per year	6 years 150 sheets per days 250 days per year
End of life	Metals are recycled, plastics are incinerated	Metals are recycled, plastics are incinerated	Metals are recycled, plastics are incinerated

Example of a comparative LCA (solution)

Step 3 – Life Cycle Impact Assessment

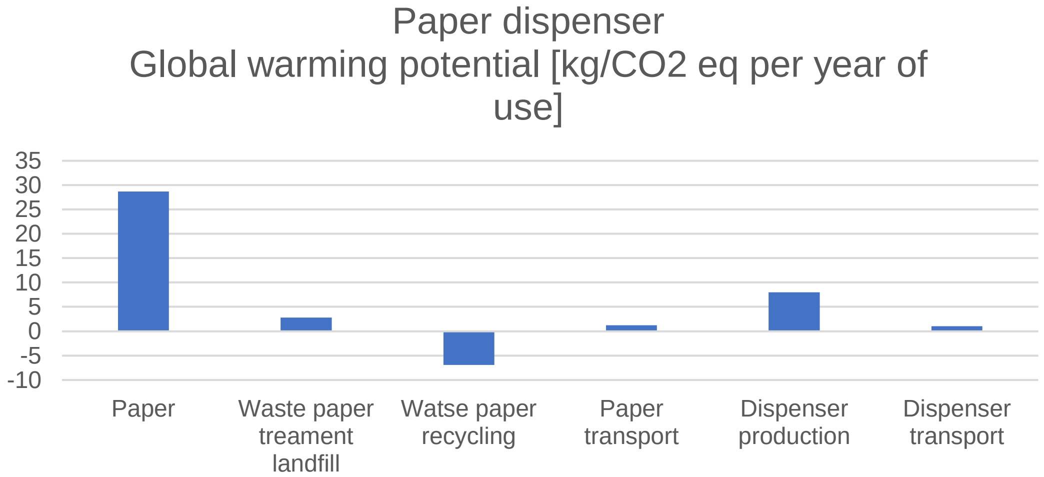
All the data collected previously are implemented in a commercial LCA software and make possible the assessment of the impacts on the 6 categories chosen at step 1.

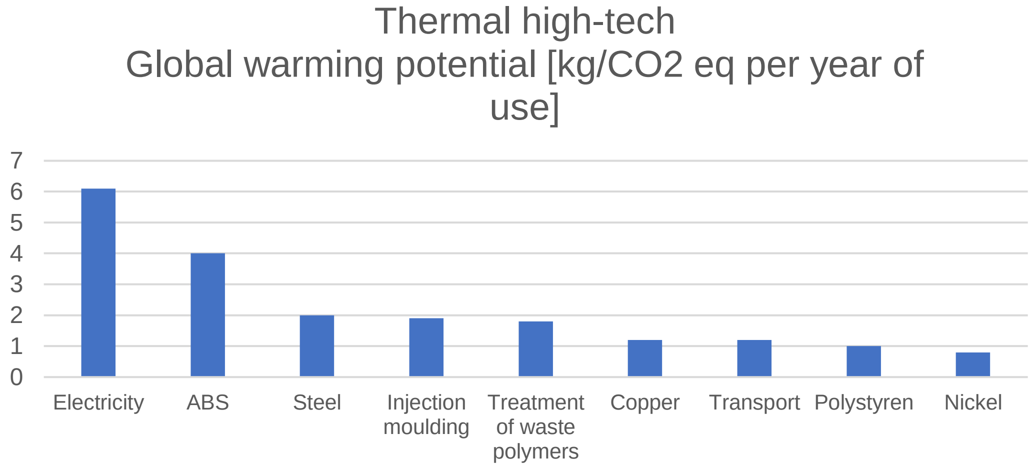


Example of a comparative LCA (solution)

Step 4 – Interpretation

Two products show greater impacts on these categories (paper dispenser and thermal standard), the best solution seems to be the high-tech thermal hand dryer. We can look a bit closely at each life cycle (only two are chosen here).





For the paper dispenser, the impacts are mainly due to the important use of paper (150 per day), consuming resources but also needing waste treatment afterward. The product (dispenser) doesn't have a big impact over the life cycle as it is used other many years.

The thermal solutions, and more particularly the high-tech product, show better performances as the only consume electricity. The impact of the production of the product is however greater over the whole life cycle, first because it requires many different materials, secondly because the lifespan is considered here to be shorter than the paper dispenser.

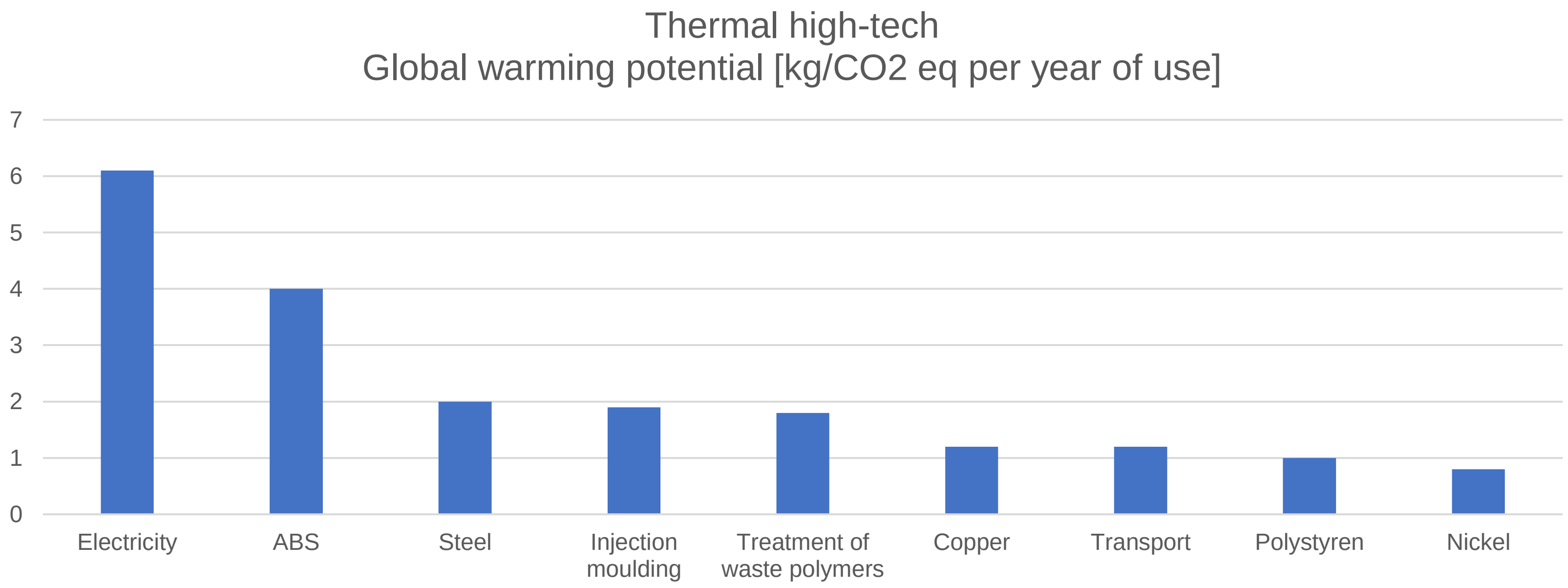
- Part of these conclusions depend strongly on assumptions made (such as the lifespan and the number of uses)
- This analysis should be performed for other impact categories…

Example of a comparative LCA (solution)

Step 4 – Interpretation

If we focus on the best solution, most impact come from the use of electricity. One simple way to reduce the impact would be to change the energy mix used (here French grid mix, with already low GHG emissions level), it would mean to use solar, wind or hydro electricity only.

One other way to reduce the impact would be to make sure that the product lifespan exceed the assumption (5 years). Doubling its lifespan could reduce the impact by 35%.



Outsourcing LCA

Many consulting companies as well as research centers (RTOs) can perform LCA studies.

Depending on the extend and complexity of the scope and on the number of scenarios, LCA studies costs ranges between 15 000 and more than 50 000 €

However, even for outsourced LCA studies, internal resources are required. Indeed, LCA requires time for data collection (inventory) and resources (Human resources ~ 2 to 4 weeks for a study, depending on the scope) for:

- Identification of relevant internal contacts
    - production manager,
    - environmental manager,...
- Identification of available data on internal processes
- Discussion with suppliers on the possibility to have information on their products / processes and with customers on their practices with the product (lifespan, consumption habits...)

Developing internal LCA skills

If LCA should be done internaly with own resources:

Need for Human resources: 1,5 to >3 months FTE (depends on the scope and the number of scenarios to be compared)

- Internal human resources
  - production manager,
  - environmental manager,...
- Collection of data on internal processes
- Collection of data from suppliers and customers
- Modelling the processes on LCA software (need some knowledge on processes, physics, chemistry..)

Software and databases: between 5 and 15 000 €/year depending on the databases (overall cost is then reduced if several studies are performed each year) + computer with 2 screens

Miscellaneous:

- Travel expenses (optional)
- Access to scientific journal for process modelling
- Access to LCA forum to ask for tips (LCAList - https://support.simapro.com/articles/Article/LCA-Discussion-List)

4. How LCA result can be used?

Contribution of “dominance analysis” (step 4 – interpretation)

It can help identify and prioritize which improvements can be made at certain points of the life cycle and how they can be set:

1. Global dominance analysis indicates the most impactful life stage(s) (raw material extraction, material production, manufacturing, distribution, utilization, end of life treatment)
2. Refined dominance analysis, focused on relevant life stage(s), should indicate the unitary process step(s) responsible for the main impact(s):
   - energy production processes:
     - identity the processes responsible for energy consumption. Can energy efficiency be improved? Can these processes be modified/replaced by new technologies/less consuming technologies?
     - Can the electricity mix be changed?
   - specific resources (materials) consumption (extraction):
     - identity the processes using these resources. Can their material efficiency be improved? Can these processes be modified/replaced by new technologies/less consuming technologies?
     - Can the materials be replaced by less polluting ones?
   - specific technological processes are there new technologies available?
   - utilization stage: can the product be modify to reduce its consumption/emissions?
   - end of life stage:
     - Can the material composition of the product be changed for recyclable ones?
     - Can the design be changed to reduce the material intensity of the product?
     - Is it possible to work with treatment facilities to develop new treatment processes?

Contribution of “contribution analysis” (step 4 – interpretation)

It can help identify the substances responsible for the impacts and find suitable substitutes (raw materials, energy carriers or technological processes):

1. Global and specific dominance analysis (previous slide) indicate the most impactful life stage(s) or processes
2. Contribution analysis focused on these processes will help identity the substances responsible for each impact categories. **Warning ! There’s usually a couple substances responible for most impact on global warming, acidification, eutrophication... But there can be many for impact categories such as human toxicity...**
3. For each substances, identify their source:
    - Combustion of fossile fuel can the fuel be replaced? The process substituted by an electric one?
    - Dust from production process, from product wear (e.g. Car tires)
    - Can filters be implemented on the processes? Can the design of the product/material be improved?
    - Effluent from specific processes (end of life treatment, water intensive process...)
    - can the effluent be contained and treated? Recycled onsite/offsite?

Identification possible actions / strategies

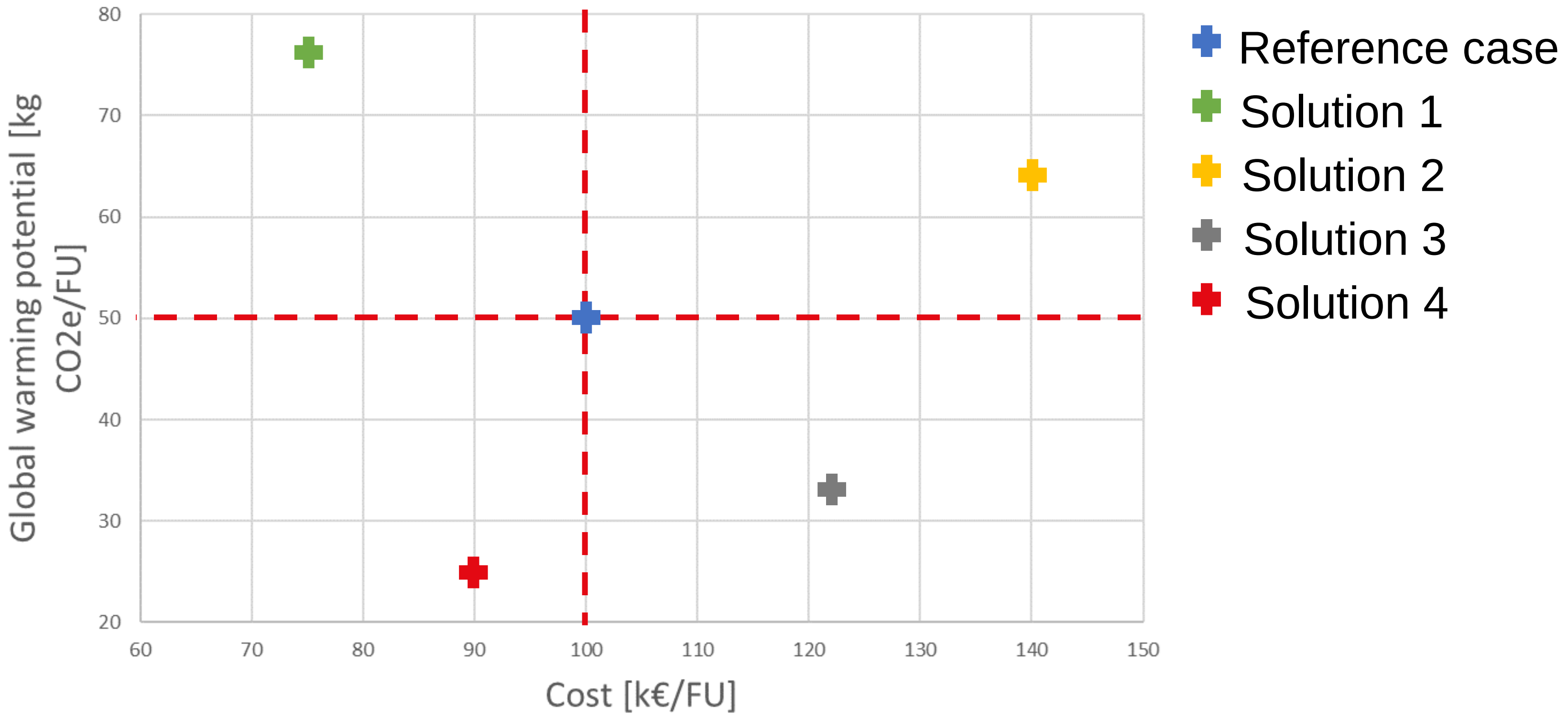
Once all potential improvements are identified

- If possible (if time and/or budget allows it) assess the impact of their implementations by defining new scenarios for each change and perfom a complementary comparative LCA
- Compare these scenarios to reference situation and assess the actual impact
  - Are there pollution transfers? What are the environmental gains
  - Use a sensitivity analysis to assess the uncertainties associated to the new scenarios

Of course, all scenarios / technical choices have to be studied from a technical and economical point of view to ensure their feasibility (using a classic design/development approach)

If several improvement scenarios are investigated, they can be ploted in cost vs environmental impact diagram to identify the best solutions (see next slide)

Contribution of cost vs environmental impact diagram



Plotting cost vs impact for each solution can help identify the best solution, from an economic and environmental point of view

Environmental Product Declaration

Manufacturers can create a EPD (Environmental Product Declaration) for each of their products. These declarations quantify the environmental information on the life cycle of a product, to help compare products with the same function. EPD are performed following the ISO 14025 standard – a process based on LCA.

ISO 14025 clarifies certain aspects of the methodology (in comparison to ISO 14044 for LCA). In that regard, Product Category Rules (PCR) are defined for each type of product providing methodological guidance for the definition of objective and scope, functional unit, impacts categories, calculation procedures...

- Less choices left to the practician than for regular LCA.
- Enables fairer comparison between products in a same product category.

In Europe, EPD it is regulatory to perform EPD before making any environmental claim for construction product ; a specific standard has been created for EPD in the construction sector (EN 15804).

Environmental Product Declaration

Manu EPD are available online (especially for the constuction sector) and can be consulted on several websites:
https://www.ecomatters.nl/services/lca-epd/epd/
https://www.environdec.com/

List of PCR:
https://www.environdec.com/product-category-rules-pcr0/find-your-pcr

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