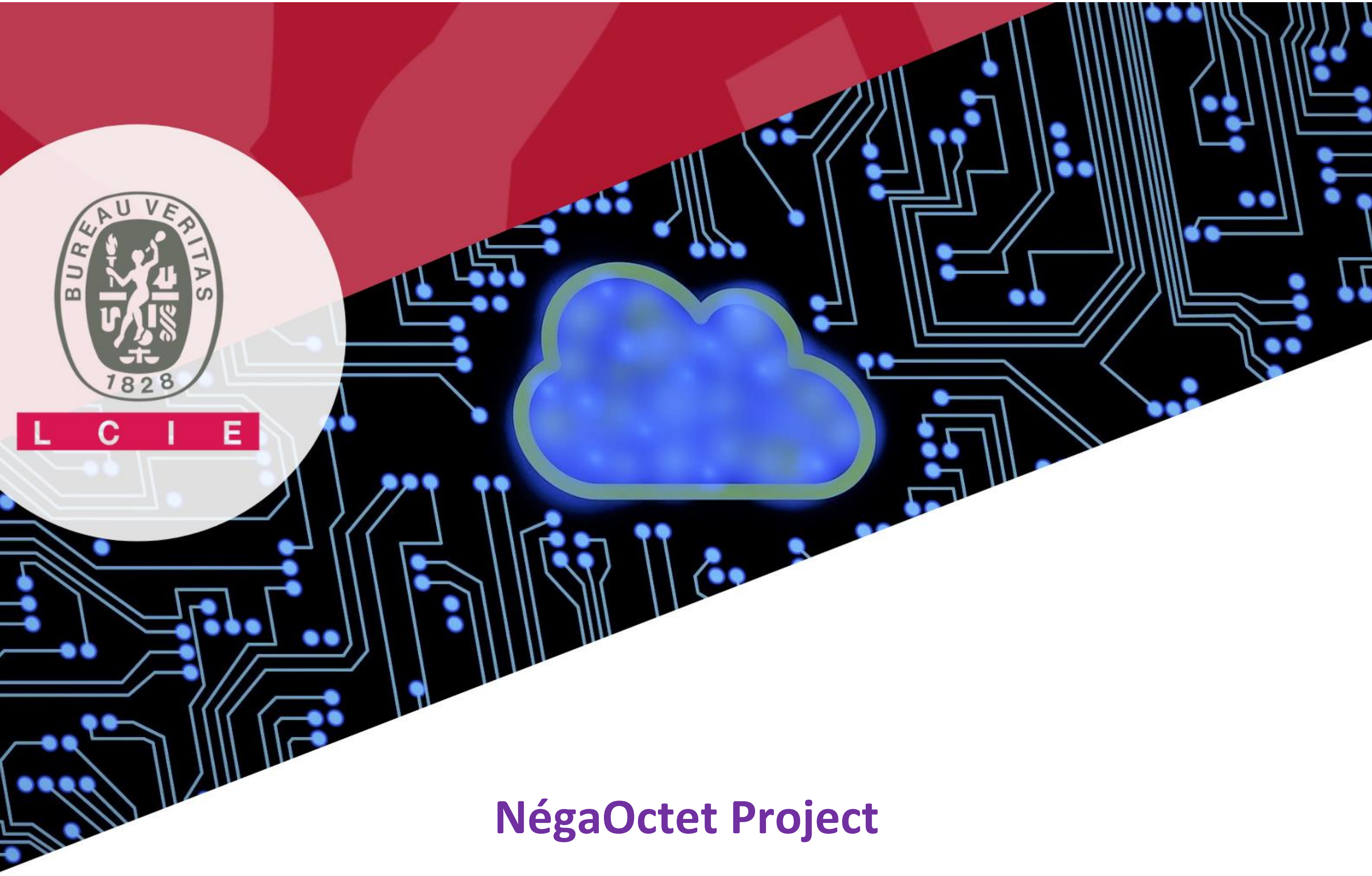

NégaOctet Project

Methodological report of

LCI data creation

Subventionné par

ADEME

Agence de l'Environnement
et de la Maîtrise de l'Energie

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1. INTRODUCTION

This document details the methodology for producing LCI data (also called modules in this report) as part of the NegaOctet project, carried out by the consortium composed of LCIE Bureau Veritas, APL, DDemain and GreenIT.fr, and subsidized by ADEME. It is intended for project data developers, auditors, and project report readers.

This methodology is established in accordance with the EF 3.0 format and nomenclature, as well as the ISO 14048 standard. Also, this report contains only project-specific elements, but does not include all the recommendations of the normative documents.

The data is carried out using EIME v.5.8 software, developed by Bureau Veritas' LCIE company, and then transformed into an ILCD node in accordance with the EF 3.0 method.

2. GENERAL OVERVIEW OF THE LIFE CYCLE INVENTORY CREATION PROCESS OF EIME SOFTWARE

This part describes the stages of developing an LCI data. The creation takes place in 6 steps that are shown Figure 1. On the right, the percentages of time required for each step are indicated. This diagram shows that at least 3 different actors are involved in the creation of the module: the author, the validator, and the database manager.

- The first step includes system description, data collection, system modeling.
- The second step consists of a validation of the research and modelling carried out.
- The third step is modulification (aggregation of the case study within the EIME software)
- In the fourth step, the validator verifies that the modulification of the case study has been properly carried out.
- In the fifth step, the module is published in the database and made accessible to all.
- In the sixth step, the author of the modulification verifies that the module appears correctly in the database and evaluates the quality of the released module.

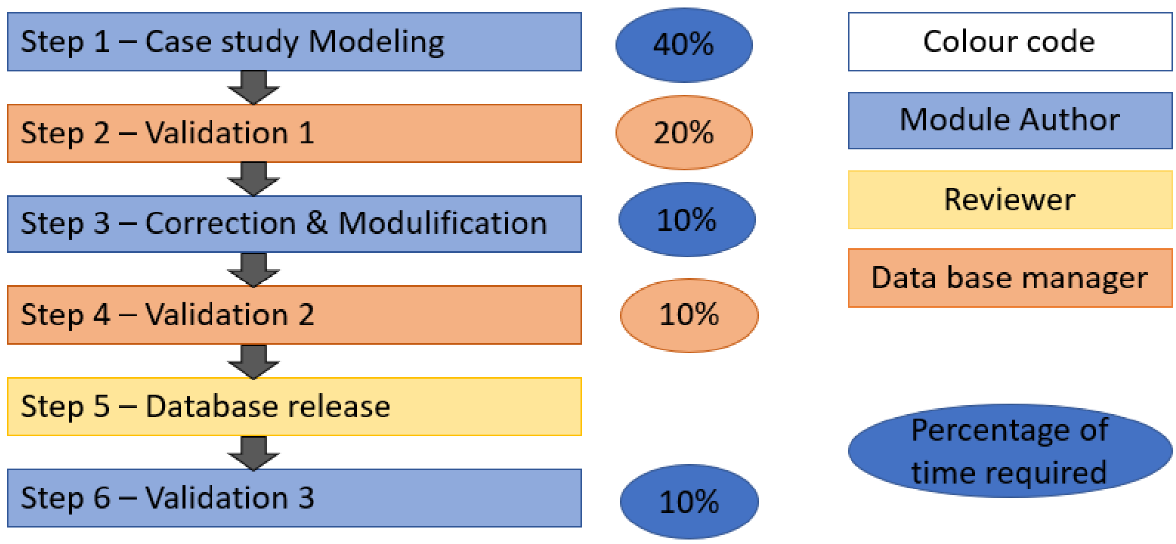

Figure 1 - Steps to create a module and time assessment

Following the creation of the data, it is converted to ILCD node format in accordance with EF 3.0.

3. OVERVIEW OF THE LIFE CYCLE INVENTORY CREATION PROCESS OF EIME SOFTWARE

It is during step 1 of modeling that most of the methodological choices are made. Modelling includes:

- the description of the system including the definition of the boundaries of the system,
- data collection,
- scaling the data against the reference flow etc.

The steps for developing an LCI set in accordance with ISO 14040 and the ILCD manual are described in Figure 2 (European Commission, 2010). The steps included in the modeling are framed in green. All bibliographic research and part of the documentation (in red) and referencing are done at this stage.

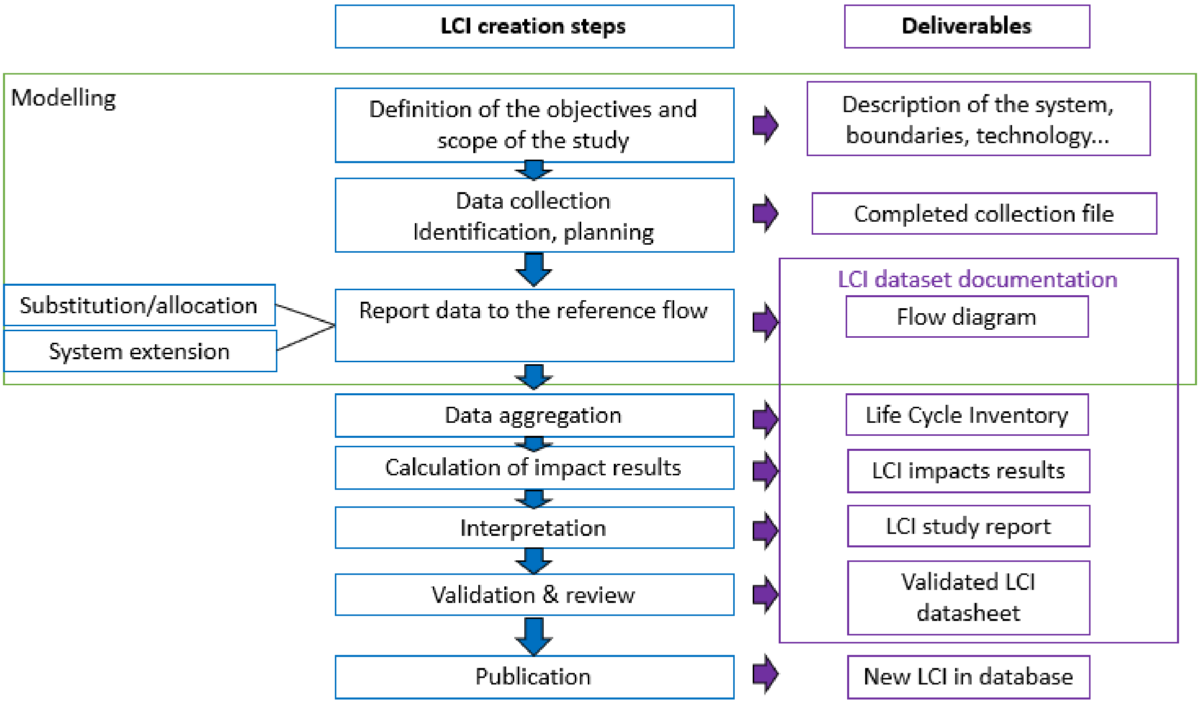

Figure 2 – Steps in developing an LCI in accordance with ILCD

The project has a unique methodology for the development of all its modules. This allows a homogeneity of the scope of the study. Examples include not taking infrastructure or staff-related impacts into account.

Part 2.1 presents the different collection methods. Then, in Part 2.2, the adopted boundaries and system structures are described. Part 2.3 presents the possibilities for applying the cut-off rules and the exclusion rules for the construction of LCIs. Part 2.4 presents the assignment rules adopted in EIME. Part 2.5 describes how aspects of geographical, technological, and temporal representativeness are managed. Finally, Part 2.6 describes how the quality of a LCI is assessed.

3.1. COLLECTION METHODS AND SELECTION OF SOURCES

For data collection, the project relies on different sources:

- Data collected from manufacturers, manufacturers and trade unions or from product dismantling
- Journaux et articles scientifiques (International journal of LCA, Journal of cleaner production, etc.)
- Previous studies carried out by consortium members

Depending on the collection source, the modelling methods applied are not the same.

Une même donnée peut se baser sur l'une, ou plusieurs, de ses sources.

The same data can be based on one or more of its sources.

The LCI developed for the project are built by combining different LCIs of elementary processes or "black box" type. An elementary process corresponds to a specific technology operated at a given site (e.g. coal mining and coal-fired power generation). A "black box" process corresponds to a set of technologies intervening successively or in parallel.

3.1.1. DATA COLLECTED FROM MANUFACTURERS OR FROM PRODUCT DISMANTLING

In the case of on-site data collection or dismantling, a collection file corresponding to the activity of the manufacturer, or the product has been designed. It identifies the elementary processes and flows included within the system. Documentation of the collection must be provided to facilitate archiving and validation by a third party.

A flow diagram of the process can be sketched out before the environmental data collection file is established. The functional unit (production of the reference flow) of the operational system is clearly defined quantitatively and qualitatively. The architectures of the different production machines are studied. Typical usage protocols are considered, and energy and resource consumption units as well as emission-generating sub-processes are identified with their functionality and location.

See Figure 3 for data collection on a simple process (De Saxce, 2012).

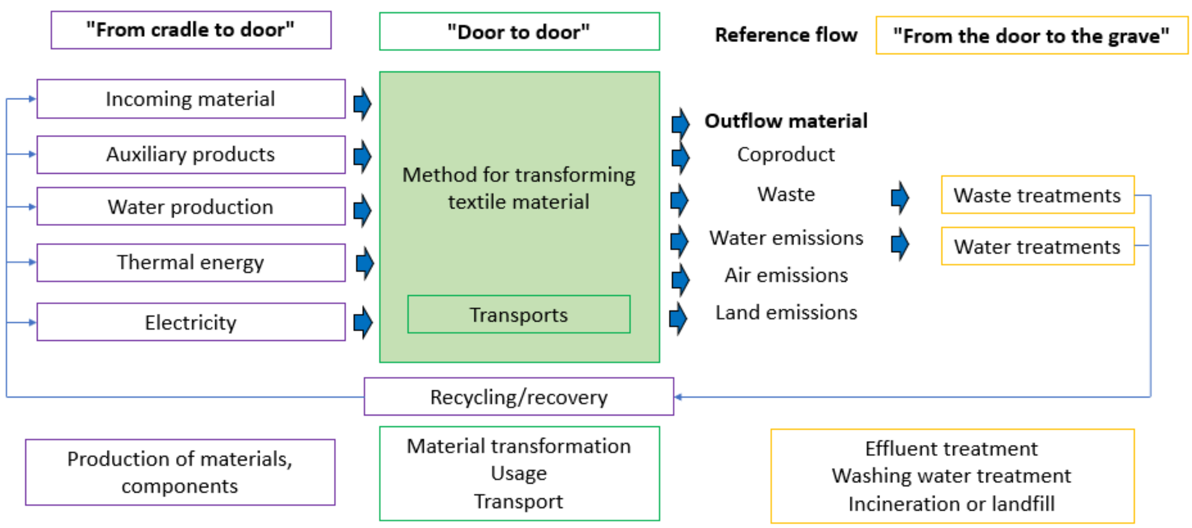

Figure 3 - Flowchart for data collection on a simple process

When a process is thus defined and structured, it makes it possible to identify the inventory data to be collected.

3.1.2. SCIENTIFIC JOURNALS AND ARTICLES

Some publications contain information that can be used to produce LCI data. Generally, this information only makes it possible to control and complete the data carried out elsewhere.

It is also possible that this data itself makes it possible to construct data. However, in this case, it is necessary to check that the methodology and completeness of the information are compatible with the expectations of the project, if necessary, by contacting the authors. Indeed, information is often missing on this subject.

3.1.3. PREVIOUS STUDIES CARRIED OUT

Some of the processes required for the project have previously been carried out by one or more consortium members as part of studies or for database development. These processes were reused after their update consisting of:

- Updating data in relation to the possible existence of more recent data
- Harmonization of the methodology with the methodology of the NégaOctet project
- A creation or update of the format of the documentation sheet in relation to the needs of the project.

3.2. LIFECYCLE INVENTORY DATABASE USED

In order to model the inventory data of the project life cycle, the modelling data (LCI database) used are as follows:

- ELCD 3.2 data: these data are used for transport and energy (intra-Europe only). Indeed, they are internationally recognized, and used in particular as part of the PEP ecopassport program
- Trade union data (Plasticseurope, Worldsteel, EAA): the main material data are developed by the industrial unions and made available to the LCA people. They are internationally recognized.
- EIME data: these data developed by the LCIE specifically concerning electrical and electronic components, as a result of the work carried out by the LCIE.
- Ecoinvent data: Occasionally, the ecoinvent database is used to fill data gaps.

All of its databases are integrated into the EIME software to ensure the methodological homogeneity of the data.

3.3. EXCLUSION RULES AND CUT-OFF RULE

The set of all elements that are not modeled must represent less than 5% of the mass and less than 5% of each impact category. These elements are said to fall under the cut-off rule to justify their exclusion from modeling.

For certain industrial sectors with high pollution potential in specific impact categories, it is necessary to measure the influence of the exclusion of the flow on the results of the associated indicators.

The following operations are usually excluded from the systems studied using the data development methodology:

- the manufacture and maintenance of infrastructure such as premises or roads. The associated impacts are generally amortized by their operating time. This does not apply to the buildings hosting the servers that are accounted for.
- water that circulates in a closed loop (cooling circuits). Water losses are well taken into account.
- the manufacture of machinery, vehicles providing transport operations and other production tools. The associated impacts are generally amortized by their operating time.
- employee travel.

3.4. ALLOCATIONS AND ALLOCATION RULES BETWEEN CO-PRODUCTS

Some processes generate multiple products. Impact allocation rules between different products are then applied. ISO 14040 defines assignment as "the imputation of incoming or outgoing flows of a process or product system between the studied product system and one or more other product systems". An important issue concerns the choice of a suitable allocation method.

ISO 14044 recommends, where possible, avoiding assignments by increasing the level of detail of the model or extending the boundaries of the system. Where this is not possible, the assignment should take into account physical properties such as masses or volumes. But the allocation will not necessarily be proportional to simple measurements such as molar masses. Where physical relationships cannot be established or used, the allocation should be based on other relationships between products such as the economic value of the products (ISO, 2006b).

The different allocation methods proposed by ILCD are as follows: economic value, higher calorific value, lower calorific value, energy content, element content, mass, volume, endurance, marginal causality, physical causality, 100% main function, other explicit function, equal distribution, area, best available technology, average – correction of economic value, average – correction on technical properties, recycled content, recyclability potential, average – no correction factor, specific, consequential effects – other (European Commission, 2010).

3.4.1. MANAGEMENT OF END-OF-LIFE ALLOCATIONS

In the context of the NegaOctet project, whether for production scraps or the consideration of end-of-life treatments, the method chosen is the inventory method.

This choice was made for several reasons: it is the method used in the building sectors (EN 15804+A1) as well as in the electrical and electronic sector (PEP ecopassport program). In addition, the database used to model end-of-life (ESR data) allows modeling using this method.

Various current pilots, programs and regulations recommend other methods (SBB, 50/50, 80/20 method). If it proves necessary to follow these methods, an update of the data will be carried out.

The inventory method consists of defining a boundary between two life cycles, using a stock (real or fictitious). The inventory method focuses on the product only. No data is required outside the evaluated product system. Everything that is before the stock is attributed to the cycle that generated the waste. Everything after stock is attributed to the cycle that uses the waste (see Figure 4). Energy and matter are counted as "recovered energy" or "recovered material". Thus, the secondary material does not replace virgin material, but it joins a "stock", so no consideration of the substitution of virgin material. It should be noted that the inventory method is a hybrid allocation approach since it attributes to the product benefits related to both the incorporation of recycled and the orientation towards recycling in different proportions (Shen, Worrell, & Patel, 2010).

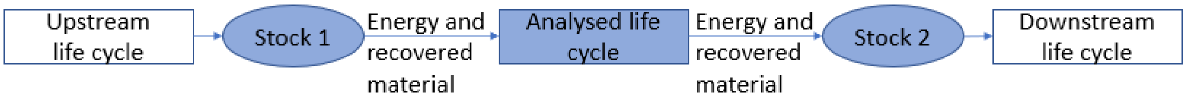

Figure 4 - Illustration de la méthode des stocks

Example 1: Application of the inventory method to an operation to produce a material consisting of recycled and virgin material

Impact of the material = Impacts of the production of the shares of "virgin + recycled" in the material + Impact of the elimination of the share of non-recovered material at the end of its life

The end of life of recycled/recovered materials is therefore not attributed to the material. With the so-called inventory method, the impacts decrease sharply when the recycled content compared to virgin increases. They also decrease when the recycling rate increases, but much less significantly.

Example 2: Application of the inventory method to recovery operations

The impacts caused by the production of materials from waste are not counted for those who use them. The impacts caused by the management of materials from a waste are not counted for those who produce this waste.

3.5. MANAGING THE REPRESENTATIVENESS OF MODULES

A module combines several specific data sets and/or average data to represent a combination of processes (e.g. different waste incineration technologies) or systems (e.g. a group of products). These data are aggregated in order to form a single data representing the system that one wishes to model, in relation to a technology, a place and a given period in particular. This is called the representativeness of a module. However, the different data used for the construction of the module do not necessarily have the same representativeness. These differences must therefore be managed in order to minimize uncertainties.

3.5.1. MANAGEMENT OF GEOGRAPHICAL REPRESENTATIVENESS

In many Life Cycle Assessments, LCI data valid for a specific geographical location is used to represent the same process in another location. Other times, to carry out a geographical transfer of the process, limited changes are made such as a change of electrical mix corresponding to the new location.

However, in order to carry out a geographical transfer, it must be taken into account that the waste and water treatment systems, the electrical and thermal mixes used, the water production systems and water resources, the distribution of emissions in fresh and salt water are not the same from one location to another (European Commission 2010).

The different sources for modelling a geographical location are: the aquastat database for water production (FAO, 2009), IEA for energy production and national studies and decrees for waste and water treatment systems (IEA & OECD, 2010).

3.5.1. MANAGEMENT OF TECHNOLOGICAL REPRESENTATIVENESS

When the data has been created from collection data, the validation of the technological representativeness is ensured by the company providing the data, or on the basis of the nature of the equipment that has been dismantled.

When the data comes from documentary sources, an analysis of the available sources is carried out to ensure technological consistency between these different sources and in relation to data from the industrial sector.

3.5.2. MANAGEMENT OF TEMPORAL REPRESENTATIVENESS

LCI are often made up of data from different sources published on different dates, resulting in a complexity of the evaluation process. However, the years of the different sources are entered in the documentation sheet, for information.

3.6. PROPOSED IMPACT CATEGORIES AND ASSESSMENT METHODS

The database makes it possible to calculate the results of impacts for a large number of categories, and according to a large number of methods.

Only the results on the "mid-point" impact categories were retained. Indeed, these indicators are currently the only ones used in the standards and regulations in force. Mid-point methods make it possible to assess environmental impacts at the problem level as opposed to the damage level. Emissions damage is not quantified, but emissions are reported at a common reference value. Features reflect first-rate effects; for example, global warming is characterized by the radiative forcing relative to each greenhouse gas, expressed in kg eq. CO_2.

For each LCI developed in the database, the ALCI results are presented in its documentation. This makes it possible to verify the results of a dozen impact indicators in the documentation. This analysis is also a validation of the environmental modelling carried out.

On the other hand, the material composition of the reference flow, for example, makes it possible to automatically check whether the law of conservation of mass for certain material flows has been respected.

Thus, the presentation of the ALCI results serves to validate and characterize the LCI obtained for a given elementary process.

Two sets of indicators have been selected for this project: the indicators selected in the framework of the European Environmental Score (PEF/OEF) recommended at levels I or II only initially (plus indicators of consumption of natural resources, essential for electronic products), and those used in the context of the building (EN 15804+A1 / CN)

3.6.1. PEF/OEF INDICATORS

The environmental indicators of the European Environmental Labelling (PEF/OEF) are:

Impact category	Méthode de caractérisation	Category indicator	Recommendation
Climate change	IPCC, 2013	kg CO_2 eq	I
Ozone depletion	World Metereological Organisation (WMO), 1999	kg CFC-11 eq	I

Impact category	Méthode de caractérisation	Category indicator	Recommendation
Human toxicity, cancer	USEtox (Rosenbaum et al., 2008)	CTUh	II/III
Human toxicity, non-cancer	USEtox (Rosenbaum et al., 2008)	CTUh	II/III
Particulate matter and respiratory inorganics	Fantke et al., 2016	death	I
Ionising radiation	Frischknecht et al., 2000	kBq U-235 eq.	II
Photochemical ozone formation	Van Zelm et al., 2008, as applied in ReCiPe, 2008	kg NMVOC eq.	II
Acidification	Posch et al., 2008	mol H+ eq	II
Terrestrial eutrophication	Posch et al., 2008	mol N eq	II
Freshwater eutrophication	Struijs et al., 2009	kg P eq	II
Marine eutrophication	Struijs et al., 2009	kg N eq	II
Land use	Bos et al., 2016 (based on)	pt	III
Ecotoxicity freshwater	USEtox (Rosenbaum et al., 2008)	CTUe	II/III
Water use	AWARE 100 (based on; UNEP, 2016)	m^3 water eq of deprived water	III
Resource use (fossils)	ADP fossils (van Oers et al., 2002)	MJ	III
Resource use (mineral and metals)	ADP ultimate reserve (van Oers et al., 2002)	kg Sb eq	III

Table 1 - PEF/OEF impact indicators

3.6.2. INDICATORS OF EN 15804+A1 / CN

The environmental indicators of EN 15804+A1/CN are:

Impact category	Characterization method	Category indicator
Global Warming	IPCC2007 via CML	kg CO_2 eq.
Eutrophication	CML - IA Version 4.1, October 2012, Baseline	kg $(PO_4)^{3-}$ eq.
Acidification of land and water	CML - IA Version 4.1, October 2012, Baseline	kg SO_2 eq.
Photochemical ozone creation	CML - IA Version 4.1, October 2012, Baseline	kg C_2H_4 eq.
Depletion of abiotic resources (elements)	CML - IA Version 4.1, October 2012, Baseline	kg Sb eq.
Depletion of abiotic resources (fossil)	CML - IA Version 4.1, October 2012, Baseline	MJ
Ozone depletion	CML - IA Version 4.1, October 2012, Baseline	kg CFC_{11} eq
Water pollution	DHUP, detailed with AIMCC recommendations	m^3
Air pollution	DHUP, detailed with AIMCC recommendations	m^3

Table 2 - Impact indicators EN15804+A1 / CN

The associated flow indicators are:

	Flow category	Category indicator
Describing resource: usage	Total primary energy	MJ
	Total use of non-renewable primary energy resources	MJ
	Use of non-renewable primary energy used as raw materials	MJ
	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials	MJ
	Total use of renewable primary energy resources	MJ
	Use of renewable primary energy used as raw materials	MJ
	Use of renewable primary energy excluding renewable primary energy resources used as raw materials	MJ
	Use of secondary material	kg
	Use of non-renewable secondary fuels	MJ
	Use of renewable secondary fuels	MJ
	Net use of fresh water	m^3
Describing categories waste :	Hazardous waste disposed	kg
	Non-hazardous waste disposed	kg
	Radioactive waste disposed	kg
Describing outflows:	Components for reuse	kg
	Materials for recycling	kg
	Materials for energy recovery	kg
	Exported Energy	MJ

Table 3 - Flow indicators EN15804+A1 / CN

3.7. VERIFICATION AND EVALUATION OF THE QUALITY OF MODULES

Verification of LCI data is carried out by an independent research laboratory. Detailed information on the verification shall be contained in the verification report.

This is a third-party verification, as the laboratory was not involved in the development of the LCI data

4. DOCUMENT MANAGEMENT

ISO 14048 provides a documentation format for all LCIs.

We have designed a new format to document LCI sets in EIME from the different Ecospold, ISO 14048 and ILCD documentation formats and from the pre-existing EIME documentation format (Domingo et Orgelet 2009). One of the objectives of this documentation format is to allow the conformity of data developed in compatibility with the nomenclature and the EF 3.0 format. The development of the data documentation is done in Excel format, before adaptation into an ILCD node format.

4.1. DOCUMENTATION SHEET

The documentation can be divided into 5 major parts corresponding to 5 tabs in an Excel spreadsheet.

The first tab gathers the fields required for compliance with the EF 3.0 nomenclature. Other fields have been added to integrate the specificities of the project. Macros have also been developed to facilitate and speed up the documentation work, mainly for the automatic intelligence of certain fields from other fields already filled in. The documentation format has also been designed to limit filling errors: automated nomenclature system in Excel, addition of a descriptive comment with example for each field to be filled in, automatic generation of the unique identifier of the LCI set on the software (UUID)...

The second tab includes a more complete table on the detail of the modeling. The intermediate flows or elementary processes that allowed the construction of the system are listed. For each intermediate flow value in this table, a field refers to the corresponding data source. This field is very useful since each intermediate flow data can come from a different source. For each intermediate flow value, a field is used to fill in the corresponding quality (DQR according to EF 3.0) on this value and numeric fields. The processes and flows excluded from the system are also listed with the corresponding exclusion justifications as in the ISO 14048 format. A field is available to present the flowchart of the system. Some fields such as those providing yield, loss processing or modeling constants help guide the LCI developer, ensure that the system is properly modeled and that there have been no omissions.

The list of input outputs is available in a specific tab. The life cycle inventory is presented first, then the output composition streams, then the waste stream inventory and the energy flow inventory.

Then, the results of the different design, flow and impact indicators of the system's LCI are documented. This tab also ensures the traceability of results between the different versions of the LCI of the system.

The last part of the documentation concerns the validation of all the data to obtain the LCI of the system. The documentation of the validation takes the form of a checklist, and the completion of this documentation is carried out in several stages, which requires exchanges between the author and the validator (see next chapter). For the last part, the author evaluates the overall quality of the LCI obtained.

4.2. CLASSIFICATION

Module and flow names must conform to ILCD nomenclature (see Figure 5).

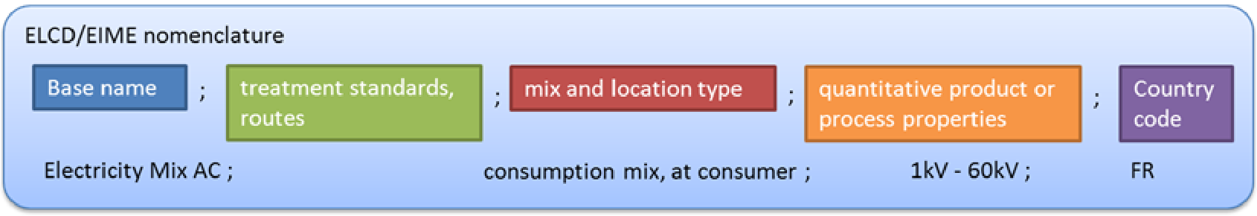

Figure 5 – Classification for module and flow names

4.3. REFERENCING

The UUID (Universally Unique IDentifier) is a combination of 32 numbers and/or letters automatically generated for each set of ICV. With the version number it makes it possible to uniquely identify the module and ensure its traceability in the database.

The ecobalance plays the same role as the UUID, only it is not assigned automatically but according to the content of the module, the date on which it was added and the database to which it belongs. Example: the ecobalance of a module belonging to the NégaOctet database will start with NEGA.

Access to previous versions of the modules ensures traceability of data and results obtained for studies carried out on previous databases.

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6. GLOSSAIRE

Base de données ACV / LCA database

Datasets of life cycle inventories supporting the realization of complete and simplified Life Cycle Assessments.

Cas d'étude / Case study

The data model associated with the analysis of a product.

Composition du produit sortant dans le système étudié / Bill of materials (BOM)

Compilation of the materials used in the composition of the modeled product.

Emissions

Emissions to air and release to water and soil (ISO 14040).

Extrant, Sortant / Output

Flow of product, material or energy out of a system.

Facteur de caractérisation / Characterisation factor

A factor based on a characterization model that is used to convert the results of the life cycle inventory into a common unit of category indicator (ISO 14040).

Flux de déchets / Waste flow

Flow to model the waste generated by the system studied.

Flux de produit / Product flow

Flow to model the materials or co-products generated by the system studied. Can be a reference flow.

Flux de rappel / Reminder flow

A type of flow that serves as a reminder of certain environmental data that was used to obtain the LCI. They are not included in the calculation of impact indicators. They can be included in the calculation of some flow indicators.

Flux de référence / Reference flow

Measurement of the outputs required from processes, in a given product system, to perform the function as expressed by the functional unit.

Flux élémentaire / Elementary flow

Material or energy entering the studied system, which has been drawn from the environment without prior human transformation, or matter or energy from the system studied, which has been released into the environment without subsequent human transformation (ISO 14040).

Example: CO_2 emissions to air

Flux intermédiaire / Intermediate flow

As opposed to elementary flows. Maybe a flow of product, waste, or energy.

Indicateur d'impact / Impact indicator

Translates the direct and indirect effects of an environmental phenomenon from the inventory data of the life cycle of the product system studied. The quantitative evaluation of the impact indicator is done via an evaluation method (called the flow characterization method).

Indicateur de design / Design indicator

Indicator relating to physical characteristics of the product that can allow the eco-design of the product. Example: Recycled content, number of distinct materials, number of parts...

Indicateur de flux / Flow indicator

Differs from an impact indicator because it does not have an evaluation method. A flow indicator is extracted directly from the life cycle inventory of the system under study (for example, the sum of water consumption flows over the entire life cycle of the system).

Intrant / input

Flow of product, material or energy entering an elementary process

Inventaire de Cycle de vie (ICV) / Life Cycle Inventory (LCI)

List of all elementary flows in and out of the system.

Métadonnées / Meta data

A set of information relating to a module, a flow or an indicator, and allowing to provide information on the nature of this data or on their traceability.

Modélisation / Modeling

Integration of collection data into the EIME software. This integration is done via trees produced and / or simplified windows.

Module / Donnée d'ICV / LCI data set

The module contains the environmental data associated with a material, process or component. This data includes the reference stream, metadata and the Inputs/Outputs list which includes: the list of elementary flows (LCI), the list of product flows presented in the BOM, the list of recall flows (energy and water flows) and the list of waste streams.

Processus / Process

A set of correlated or interactive activities that transform input elements into output elements.

Résultat d'impact / Impact result

Result of a life cycle analysis on a given impact category for a characterization method and model.

Example: 35 kg CO2 eq.

Set d'indicateurs / Indicator set

Compilation of several indicators to calculate the environmental footprint of a product. A set of indicators must be adapted to the specific issues of a sector of activity.

Set de modules / Module set

Compilation of a list of modules made available to one or more users.

Unité fonctionnelle / Functional unit

The reference from which the input and output data are (mathematically) normalized. Quantified performance of a product system to be used as a reference unit in a life cycle assessment

Validateur / Reviewer

Person responsible for verifying the compliance of the modules made available with the methodology and compliance with EIME requirements.

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