From a complex to a simpler building product
Life-Cycle Assessment (LCA)
Focus on simplification of LCA conduct for electronic and electrical equipment

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“The poetry of the earth is never dead.”
John Keats

“Earth provides enough to satisfy every man’s needs, but not every man’s greed.”
Mahatma Gandhi

“What’s the use of a fine house if you haven’t got a tolerable planet to put it on?”
Henry David Thoreau, Familiar Letters
Abstract

The EN 15804:2012 standard, focusing on building products, is implemented within a specific normative and industrial context. The large number of types of environmental declarations in Europe and their methodological differences constitutes an obstacle regarding its implementation. This standard gives a new framework regarding Environmental Product Declarations (EPDs) and corresponding Product Category Rules (PCRs) for building products. Its implementation aims at harmonizing the different methodologies developed in Europe to display their environmental performances. These requirements are relatively complex and difficult to apply for industrial practitioners, so that it is suitable to translate them in a simpler and more applicable way.

The methods presented in this Thesis are guided by an ambition to simplify the application of the Life-Cycle Assessment (LCA) methods for building products. The chosen solution to answer above-mentioned requirements has been to extend Bureau Veritas CODDE experience on simpler LCA of textiles to the building product sector. The final objective has been to suggest recommendations for simpler LCA of building products in compliance with EN 15804. Classification of LCI datasets, the introduction of “Flodule” and “Process Parts” modelling have appeared to be of importance in this regard. A particular focus has been put on Electronic and Electrical Equipment (EEE), i.e. at the core of the activities of the company. The calculation of indicators and the integration of process losses is thus made possible, in a simple and automated way. These methods have been assessed and are considered to be accurate and reliable even if some improvements are still to be performed.

Keywords: Life-Cycle Assessment, EN 15804 standard, building product, simplified LCA, EIME

Sammanfattning


Metoderna som presenteras i denna rapport, styrs av en vilja att förenkla tillämpningen av livscykelbedömningsmetoder för byggsprodukter. Den valda lösningen för att möta de nämnda kraven ovan, har varit att utvidga Bureau Veritas CODDE erfarenhet av förenklad LCA av textilier till byggsproduktsektorn. Tilldelning av en familj till databas modulerna och införandet av "Flodule" och "Process Part" modellering har visat sig vara betydelsefullt i detta sammanhang. Således är det möjligt att göra beräkningen av indikatorer och integreringen av processförluster på ett enkelt och automatiserat sätt. Dessa metoder har utvärderats och anses vara korrekta och tillförlitliga, även om vissa förbättringar fortfarande krävs.

Nyckelord: livscykelanalys, EN 15804 standarden, byggsprodukt, förenklad LCA, EIME
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<th>Description</th>
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<tbody>
<tr>
<td>AA</td>
<td>Air Acidification</td>
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<tr>
<td>AT</td>
<td>Air Toxicity</td>
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<tr>
<td>BOM</td>
<td>Bill Of Materials</td>
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<tr>
<td>CEN</td>
<td>European Committee for Standardization</td>
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<td>CNSPE</td>
<td>Commission Nationale de Suivi de la Politique de l’Emploi</td>
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<tr>
<td>CODDE</td>
<td>CONception Développement Durable</td>
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<tr>
<td>CPR</td>
<td>Construction Product Regulation</td>
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<tr>
<td>CSTB</td>
<td>Centre Scientifique et Technique du Bâtiment</td>
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<tr>
<td>DHUP</td>
<td>Direction de l’Habitat, de l’Urbanisme et des Paysages</td>
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<tr>
<td>ED</td>
<td>Energy Depletion</td>
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<td>EeB</td>
<td>Energy efficient Building</td>
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<td>EEE</td>
<td>Electronic and Electrical Equipment</td>
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<td>EIME</td>
<td>Environmental Improvement Made Easy</td>
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<td>ELCD</td>
<td>Environmental Life-Cycle Data system</td>
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<td>EN</td>
<td>European Norm</td>
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<td>EPD</td>
<td>Environmental Product Declaration</td>
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<td>FDES</td>
<td>Fiches de Déclarations Environnementales et Santé</td>
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<tr>
<td>GWP</td>
<td>Global Warming Potential</td>
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<td>HWP</td>
<td>Hazardous Waste Production</td>
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<tr>
<td>IBU</td>
<td>Institut Bauen und Umwelt</td>
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<tr>
<td>ILCID</td>
<td>International Life-Cycle Data system</td>
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<tr>
<td>ITMF</td>
<td>International Textile Manufacturers Federation</td>
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<td>ISO</td>
<td>International Organisation for Standardisation</td>
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<tr>
<td>LCA</td>
<td>Life-Cycle Analysis/ Assessment</td>
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<td>LCI</td>
<td>Life-Cycle Inventory</td>
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<td>LCT</td>
<td>Life-Cycle Thinking</td>
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<td>LHV</td>
<td>Lower Heating Value</td>
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<td>ODP</td>
<td>Ozone Depletion Potential</td>
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<td>POC</td>
<td>Photochemical Ozone Creation</td>
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<td>PCR</td>
<td>Product Category Rule</td>
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<td>PSR</td>
<td>Product Specific Rule</td>
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<td>PEP</td>
<td>Product Environmental Profile</td>
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<tr>
<td>REACH</td>
<td>Registration, Evaluation, Authorization and restriction of CHemicals</td>
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<td>RMD</td>
<td>Raw Material Depletion</td>
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<td>RSL</td>
<td>Reference Service Life</td>
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<td>SETAC</td>
<td>Society of Environmental Toxicology and Chemistry</td>
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<td>SME</td>
<td>Small and Medium Enterprises</td>
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<td>TC</td>
<td>Technical Committee</td>
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<td>TPE</td>
<td>Total Primary Energy</td>
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<td>UNEP</td>
<td>United Nations Environment Programme</td>
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<td>USEPA</td>
<td>United-States Environment Protection Agency</td>
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<td>VOC</td>
<td>Volatile Organic Compound</td>
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<td>WD</td>
<td>Water Depletion</td>
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<tr>
<td>WE</td>
<td>Water Eutrophication</td>
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<td>WEEE</td>
<td>Waste of Electronic and Electrical Equipment</td>
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<td>WT</td>
<td>Water Toxicity</td>
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**LIST OF STANDARDS**

**EN 15643:2010**: *Sustainability of construction works - Assessment of buildings*. European standard providing the methodological content for the environmental assessment of buildings.

**EN 15804:2012**: *Sustainability of construction works - Environmental Product Declarations - Core rules for the product category of construction products*. European standard giving a new framework for environmental declarations of building products.

**EN 15942:2011**: *Sustainability of construction works - Environmental Product Declarations - Communication format - Business to Business*. European standard giving a framework for environmental declarations of buildings.

**EN 15978:2012**: *Sustainability of construction works - Assessment of environmental performance of buildings - Calculations method*. European standard giving a framework for environmental assessment of building products, as well as ensuing calculation methods.

**ISO 14025:2006**: *Environmental labels and declarations - Type III environmental declarations - Principles and procedures*. International standard giving the framework for Type III environmental declarations.

**ISO 14040:2006**: *Environmental management - Life cycle assessment - Principles and framework*. International standard giving general background and definitions for conducting an LCA.


**NF P01-010:2004**: *Qualité environnementale des produits de construction - Déclaration environnementale et sanitaire des produits de construction*. French standard giving rules and methodologies to assess environmental performances of building materials.
GLOSSARY

**Assignment criterion**: factor weighting two units together (Joint Research Centre, 2010)

**Bill of Materials**: comprehensive list of raw materials, components and assemblies required to build or manufacture a product. (ISO14025:2006, 2006)

**Building Materials**: natural and artificial materials and products used for the construction and repair of buildings and structures. (EN 15804:2012, 2012)

**Building/ construction Products**: item manufactured or processed for incorporation in construction works. (EN 15804:2012, 2012) Building products encompass building materials, Electronic and Electrical Equipment, textiles among others.

**By-product/ Co-product**: any of two or more marketable materials, products or fuels from the same unit process, but which is not the object of the assessment. (EN 15804:2012, 2012)

**Database**: collection of data and information organized for storage, search and retrieval with a computing system. (Joint Research Centre, 2010)

**Data set**: data file or collection of interrelated data. (Joint Research Centre, 2010)

**Declared Unit**: quantity of a construction product for use as a reference unit in an EPD for an environmental declaration based on one or more information modules. (EN 15804:2012, 2012)

**Electronic and Electrical Equipment**: equipment which is dependent on electric currents or electromagnetic fields in order to work properly and equipment for the generation, transfer and measurement of such currents and fields. The ten categories of concern are: large household appliances; small household appliances; IT and telecommunications equipment; consumer equipment; lighting equipment; electrical and electronic tools; toys, leisure and sport equipment; medical devices; monitoring and control instruments; automatic dispensers. Their end-of-life scenario is defined by a WEEE directive. (PEP ecopassport®, 2011)

**Elementary Flow**: materials or energy entering the system, which was drawn from the environment without any human intervention; materials or energy leaving the system, which is rejected into the environment without any human intervention. (Joint Research Centre, 2010)

**Environmental Product Declaration**: standardized and LCA based tool to communicate the environmental performance of a product or system, and is applicable worldwide for all interested companies and organizations. (ISO14025:2006, 2006)

**European Life Cycle Database**: publicly available database available on the European platform of Life-cycle Assessment; it mainly concerns raw materials and energy mixes. (Joint Research Centre, 2010)

“**Fiches de Déclarations Environnementales et Santé**”: Type III environmental declarations as described by the ISO 14025 standard and framed by the PEP ecopassport® program for building materials. It should among other things inform the bill of materials, recyclability rates and environmental impacts on four life-cycle phases. (F.D.E.S., 2012)

**Flow indicator**: indicator concerning a physical flow (energy consumption, water consumption, waste production). (Joint Research Centre, 2010)

**Functional Unit**: quantified performance of a product system to use as a reference unit. (ISO14040:2006, 2006)
**Impact indicator:** indicators calculated through elementary flows defining the Life-Cycle Inventory. Contributing elementary flows are classified. All data from elementary flows is multiplied by a characterization factor depending on the environment of emission. (Joint Research Centre, 2010)

**Intermediate Flow:** flow taking place between two entities. It can be a product or waste flow. (Joint Research Centre, 2010)

**International Life Cycle Data systems:** International platform giving a framework and guidelines aiming at harmonizing LCA practice. (Joint Research Centre, 2010)

**Life-Cycle Analysis/Assessment:** compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life-cycle. (ISO14040:2006, 2006)

**Life-Cycle Inventory:** phase of life-cycle assessment involving the compilation and quantification of inputs and outputs for a product throughout its life-cycle. It is the base from which LCA is built. (ISO14040:2006, 2006)

**Life-Cycle Inventory data set/Module:** customizable dataset including an exhaustive list of inputs and outputs. It can be seen as a compilation of flows. (Joint Research Centre, 2010)

**Lower Heating Value (MJ/kg):** Amount of heat released during the combustion of a quantity of materials. The latent heat of vaporization is not taken into account. (US Department of Energy, 2012) This value of energy is thus representative of the intrinsic heating potential of a material. For information, wood has a LHV about 17MJ/kg depending on the species (Matbase, 2009) and polystyrene about 42MJ/kg. (Walters, et al., 2000)

**Metadata:** data providing information about one or more aspects of the data (de Saxcé, 2012)

**Module (ElME):** LCI corresponding to a set of flows (Bureau Veritas CODDE, 2012b)

**Module (EN 15804):** specific unit process in the product’s life-cycle taking into account raw materials extraction, transport, manufacturing, maintenance, etc. (EN 15804:2012, 2012)

**Non-Renewable Energy:** energy from non-renewable sources: brown coal, crude oil, hard coal, naphtha, natural gas, peat, uranium. (EN 15804:2012, 2012)

**Non-renewable resource:** resource that exists in a finite amount that cannot be replenished on a human time scale. (EN 15804:2012, 2012)

**Primary data:** data issued from direct measurements or calculations issued from measurements. (Joint Research Centre, 2010)

**Product Category Rule:** set of specific rules, requirements and guidelines to develop Type III environmental declarations for one or more product categories. (Desmaris, et al., 2012)

**Product Environmental Profile:** type III environmental declarations as described by the ISO 14025 standard and framed by the PEP ecopassport® program for electronic and electrical equipment. It should among other things inform the bill of materials, recyclability rates and environmental impacts on four life-cycle phases. (PEP ecopassport®, 2011)

**PEP ecopassport® program:** program giving a framework regarding Product Environmental Profile environmental declarations. In conformity with ISO 14025, it assesses environmental performances of electronic, electrical and environmental engineering equipment. (PEP ecopassport®, 2011)

**Product Flow:** Flow allowing the modelling of materials and co-products generated by the product system. (Joint Research Centre, 2010)

**Reference Flow:** outputs from processes for a product system relevant to fulfil the function expressed by the reference unit. (Joint Research Centre, 2010)

**Reference Service Life:** Service life of a construction product which is known to be expected under a particular set, i.e. a reference set, of in-use conditioned and which may form the basis of estimating the service life under other in-use conditions. (ISO15686:2012, 2012)
**Renewable Energy:** energy from renewable non-fossil sources: wind, solar, aerothermal, geothermal, hydrothermal and ocean energy, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases. (EN 15804:2012, 2012)

**Renewable resource:** resource that is grown, naturally replenished, or naturally cleansed, on a human time scale. (EN 15804:2012, 2012)

**Secondary data:** data issued from the transformation of primary data. (de Saxcé, 2012)

**Secondary Material:** material recovered from previous use or from waste which substitutes primary materials. (EN 15804:2012, 2012)

**Simplified LCA:** application of the LCA methodology for a comprehensive screening assessment i.e. covering the whole life cycle but superficial, followed by a simplified assessment. (EeB Guide, 2011)

**Total Primary Energy (MJ):** sum of total renewable and non-renewable primary energies

**Upstream/ Downstream process:** process that either precedes (upstream) or follows downstream a given life-cycle stage. (EN 15804:2012, 2012)

**Waste:** substance or object which the holder discards or intends to discard or is required to discard. (EN 15804:2012, 2012)
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PREFACE – PRESENTATION OF BUREAU VERITAS CODDE AND EIME AS LCA SOFTWARE

This Master Thesis is carried out in conjunction with Bureau Veritas CODDE, an LCA and eco-design consulting office based in Fontenay-aux-Roses (close to Paris) and Grenoble, and undertaken to fulfil the requirements for the degree of Master of Science (double degree in conjunction with the University of Montpellier, France) at the Royal Institute of Technology (KTH, Stockholm, Sweden). As the tackled project is at the core of the company’s activities, this preface is aiming at describing the activities of both Bureau Veritas and its subsidiary Bureau Veritas CODDE. It highlights the importance of environment in nowadays activities. A short presentation of the LCA software in use at Bureau Veritas CODDE, EIME, is given as well.

Bureau Veritas group

Bureau Veritas was founded in 1828 in Antwerp (currently Belgium) and had only one goal: provide insurers with information on the state of ship and ship equipment. (Bureau Veritas, 2012) The company became stronger and stronger as it got involved into new sectors so that it is now considered to be the second largest group of evaluation of conformity and certifications in terms of quality, safety, human health and the environment. In 2011, the revenue reached more than €3.4 billion. (Bureau Veritas, 2012)

The Group main activity consists in analysing, inspecting and certifying both products (buildings, equipment, ships etc) and Management Systems. As a consequence, 8 major business units are developed, such as Marine, Building and Infrastructure or Consumer Product and Services. (Bureau Veritas, 2012)

As the emblem of Bureau Veritas is “Move forward with confidence”, it is nowadays present in 140 countries worldwide through more than 900 laboratories and offices. It has been extending year after year so that it now reaches 52,000 employees, taking care of 400,000 customers throughout the globe. For information, 7,600 employees in 170 offices and 10 laboratories are currently working in France. (Bureau Veritas, 2012)

Bureau Veritas CODDE

Founded in 2003, Bureau Veritas CODDE (“COnception Développement Durable et Environnement”, standing for Design, Sustainable Development and Environment) is the fruit of the work of industrials of the French Federation for the Electrical and Electronic Industries and Communication (FIEEC) and 7 years of experimentation of EIME software (Environmental Improvement Made Easy). It joined Bureau Veritas Group in 2008 in order to meet the demand of customers concerning new regulatory requirements. It is now considered to be Bureau Veritas group pole of expertise related to product environmental concerns. In 2009, the annual revenue reached 800,000 Euros. (Bureau Veritas CODDE, 2012)
Bureau Veritas CODDE mainly deals with 4 types of advising activities. The most characteristic one is Life-Cycle Assessment (LCA). Thanks to the expertise of Bureau Veritas CODDE, it is possible to go further and use an LCA as the starting point to perform eco-design. Bureau Veritas CODDE expertise also consists in conducting LCAs’ critical reviews and environmental declaration verification to ensure that they comply with standards and program requirements. The mission of Bureau Veritas CODDE is finally to empower its customers by training them on different aspects such as eco-design initiation, environmental diagnostics, etc and to provide them with licenses of the LCA and eco-design software they develop, EIME. (Bureau Veritas CODDE, 2012)

Bureau Veritas CODDE is divided in two agencies in two different places. About twelve employees are working permanently in both sites. The first one is located in Moirans in the French Alps. It gathers the textile, electrical and electronic equipment, building, transport expertise poles. Maud Jacquot, Agnès Quesne and Julie Orgelet, in charge of this Master Thesis, are working in Moirans. The Parisian agency, located in Fontenay-aux-Roses, is specialized in the food-processing, hard-line and cosmetics industries. The overall manager of Bureau Veritas CODDE, Marie-Elisabeth d’Ornano is present as well in the Parisian site. Other sales and marketing people are related to Bureau Veritas CODDE and can participate to its revenue. As for me, I have been working in this office. (Bureau Veritas CODDE, 2012)

EIME as an LCA software

Bureau Veritas CODDE has been developing its own Life-Cycle Assessment software: Environmental Improvement Made Easy (EIME). It is originally the fruit of a consortium of six industrials from the electrical and electronic industry, such as Legrand, Schneider Electric, IBM, Alcatel and Technicolor. It has been since then developing sector-based databases following the trend to find new customers in other sectors: textile, building, marine, aeronautics, food-processing industries. Different updates have been carried out and different versions of this software have been created, so that it now reaches the fifth version. (Bureau Veritas CODDE, 2012)

Stringer and stringer regulations and constraints enforced the birth of new needs regarding the quantification of environmental impacts. As a consequence, the development of a new interface such as EIME has been developed. The main values associated with EIME are its user-friendly aspect, an Electrical and Electronic Equipment adapted database (meaning LCI datasets) and a collaborative-based tool. (Orgelet, et al., 2012) As it has been argued before, its purpose is to provide a strong tool of support for eco-design and environmental labelling in small, medium and global enterprises. It is now able to support LCA at a larger scale thanks in particular to a wider database. LCA software very widely relies on the available databases, the main in use being the Ecoinvent one. (Swiss Centre for Life Cycle Inventories, 2012) EIME’s specificity is to integrate its own database and in particular, to get a strong differentiation on Electronic and Electrical Equipment (EEE) and textile industries. To remain competitive and the most accurate possible, EIME has now integrated the new requirements of the international platform International Life-Cycle Data system (ILCD) as well as the European Life-Cycle Data system (ELCD). (Bureau Veritas CODDE, 2012)

As it can be used by both consultants and customers, Bureau Veritas CODDE proposes trainings and licenses for customers. (Bureau Veritas CODDE, 2012)
Outlook

The purpose of the mission at Bureau Veritas CODDE perfectly takes place in the stakes of the company. The question of simplification for LCA, and the adaptation of the EN 15804 standard are issues for Bureau Veritas CODDE that must be faced and solved in a short period of time. The mission of this Master Thesis is thus particularly interesting, as it allows working with most of the consultants of Bureau Veritas CODDE and gain from their experience. The topic of this Thesis is also multidisciplinary, going from the electrical and electronic world to the textile sector to building products. It consequently gives a good overview of what the main activities of Bureau Veritas CODDE are. Last but not least, this Master Thesis is at the border between two worlds. The assigned task is first and foremost academic and is enrolled in the Research & Development activities. However, as my final objective is to become an LCA and eco-design consultant, the opportunity has been given to me to realize concrete LCA thanks to the help of confirmed LCA experts.
INTRODUCTION

Background

Life-Cycle Assessment (LCA) is a strategic environmental method used to assess the impacts of a product or a service resulting from its life-cycle. It has been evolving since its first use so that it is nowadays internationally acknowledged by the International Standardization Organization (ISO). It is framed by a systematic methodology, reinforced by the ILCD Handbook (European Commission, 2012).

However there is an increasing demand for simplicity and transparency regarding the use of LCA. There are nowadays plenty of means of conducting and communicating about LCA, so that the results can differ depending on the database and impact assessment methods. The large number of environmental declaration programs worldwide spreads more complexity in this particular context. They differ from the way they are conducted, their scope, their sets of indicators, etc. It appears a need to strengthen the framework for conducting LCA. But introducing more restrictive frames and complexity is generating additional effort and cost for the practitioner.

The publication of the EN 15804:2012 standard gives a new framework regarding Environmental Product Declarations (EPDs) and corresponding Product Category Rules (PCRs) related to building products. Its implementation aims at harmonizing the different methodologies developed in Europe to communicate the environmental performances of building products. The implementation of this standard creates new difficulties that must be faced by Bureau Veritas CODDE. Namely, existing tools must be adapted to EN 15804 requirements and concepts in the standard need to be simplified.

Problem area and methodology

Given this particular background, EN 15804 problematic engenders mainly two questions:

- Regarding harmonisation of existing tools so that they can function within this framework.
- Regarding simplifications of LCA conduct so that this standard can be applied in practice.

The main hypothesis on which this Thesis is based on says: “it is possible to extend Bureau Veritas CODDE experience on textiles to implement simplifications on building product sector afterwards”.

It is important to grasp the methodology adopted to answer these two problems. It is divided in three parts. It starts from the description of the normative and industrial context for the implementation of EN 15804: existing environmental declaration programs (PEP ecopassport® and FDES); comparison of PEP ecopassport® and EN 15804 approaches. In a second time, simplification approaches based on the experience of textiles are extended for building products. The final problem consists in suggesting a simplified approach to fit onto EN 15804 requirements.

Aim and objectives

The aim of this Thesis is then to adapt the tools used at Bureau Veritas CODDE to EN 15804 requirements as well as to simplify intrinsic concepts in the standard. It should in the end be easy
for LCA practitioners (consultants and customers) to apply LCA software and conduct LCA within the framework of EN 15804 for building products.

The word *simplification* and relatives are widely used in this report. *Simplification* is not used as it is normally intended in LCA community. It refers to the way LCA conduct is simplified, suggesting modelling rules, considering industrial constraints while meeting the standard requirements. A particular focus is made for Electronic and Electrical Equipment (EEE) as it is at the core of Bureau Veritas CODDE’s activities. It is then relevant to assess the impacts on the LCA software, EIME (Environmental Improvement Made Easy), and database structure to be compliant with EN 15804 standard requirements. EIME is the LCA software used at Bureau Veritas CODDE. A more detailed description is available in Preface.

This Thesis aims at being publically available. Though, LCA knowledge is required. It focuses on a specific topic related to LCA and environmental declarations. Explanations and popularizations are thus largely developed all along the report so that it can be easily understandable and easy to follow.

**Delimitations**

Even though the nature of LCA gives the study a holistic and exhaustive approach, it is in reality hard to take all aspects into account – especially given the time limitation of 20 weeks. In addition, a particular focus is done on EEE as it is at the core of Bureau Veritas CODDE’s activities. Besides, the present report does not encompass all the aspects that have been tackled during this Thesis. Only those aiming at answering the research question are highlighted in the present report.

It can be hard to catch why this main hypothesis has been chosen. The validity of this methodological approach will be assessed in the chapter “Discussion”.

This project is a first attempt regarding Bureau Veritas CODDE adaptation to EN 15804 requirements. The final deadline of the application of EN 15804 for EEE is 2017. It gives thus the time perspective from which this Thesis should be considered.

There is unfortunately no similar example of such work in the literature. As this project is mainly intended for an application for EIME LCA software, it is hard to compare the work performed in this report.
In order to have a clear overview of the stakes implied by this Master Thesis, the structure of the following report is shown in Figure 1. The present introduction is preceded by a Preface presenting Bureau Veritas CODDE, subsidiary of the Bureau Veritas group. Different methodological aspects related to LCA are depicted in Chapter 2. Chapter 3 gives thereafter a description of the existing frameworks related to environmental declarations and the influence of the implementation of the EN 15804 standard regarding their structure and nature. Then, an overall review of the possible LCA simplification is drawn in Chapter 4, with a particular focus on textiles. It is time in Chapter 5 to establish a methodology for the simplification of LCA conduct in compliance with the EN 15804 standard. Afterwards, a discussion deals with the scientific relevance of such results and the limitations they imply. Last but not least, a conclusion brings some closure to this report.
LCA METHODOLOGY OVERVIEW

When dealing with Life-Cycle Assessment, it is necessary to have a full comprehension of the different notions hidden behind these words. There are plenty of subtleties that must be understood before dealing with the subject as it gives the frame from which subsequent simplifications are based on. It introduces LCA for building products, keeping in mind LCA simplification connecting thread. It also gives a non-expert reader a general background on LCA.

Methodological approach

To reach the aim of the Thesis, such project needs to be defined thanks to a solid methodological framework.

The first task to carry out has been to study available literature (ISO 14025, ISO 14040 and EN 15804 standards) giving the general background of the Thesis, as well as handling EIME LCA software. Besides, some work had already been performed to rough out the tasks to be carried out to implement EN 15804. In particular, a painstaking reading of EN 15804 standard had been undertaken. Internal references in the end of this report highlight the fact that some work had been performed before the beginning of this Thesis. As the different pinpointed notions were complex, it has been clear from then that simplification of these concepts was necessary.

Secondly, EN 15804’s scope encompasses building products, including building materials and EEE. Now, PEP ecopassport and FDES are respectively two French programs for environmental declarations for these EEE and building materials. These two programs are widely applied within the company. Their translation to EN 15804 approach is thus of importance. In addition, as PEP ecopassport® approach is simple and well-automated; its study is relevant in a simplifying perspective.

During the literature study, it has been made clear that textiles are nowadays integral part of building products. As simplification methods had been developed for LCA of textiles, it has been thought fit to extend Bureau Veritas CODDE experience from textiles to building products.

It has finally been time to suggest a simpler approach to fit onto EN 15804 requirements. This has been done thanks to numerous internal meetings with other members of Bureau Veritas CODDE. Methods have been developed following the results of a gap analysis between the existing solutions and the requirements set by EN 15804. Non-relevant methods have been disregarded thanks to the use of if/if not flowcharts. Possible problems have appeared clearly and could have been corrected or new solutions could have been developed.

Literature review

This Thesis is mainly based on three documents: EN 15804 standard and EeB (Energy efficient Buildings) guides. Published in 2012, EN15804 is rather complicated as it defines different notions that are not common in usual LCA conduct. These notions will be defined in next chapters. To provide more transparency and simplicity, two EeB guides - one for products and one for buildings - have
been developed. Both documents are organised by life cycle stages of a building. Important aspects for products and buildings are defined to provide information on how to conduct LCA for environmental declarations of buildings and related products. (EeB Guide, 2011) (EeB Guide, 2011)

The reading of these guides has been helpful to get the knowledge required to bridge the principles of EN 15804 to EIME methodology. Internal presentations and documents have also been helpful in this regard.

A full study of LCA of textiles has been conducted for three years at Bureau Veritas CODDE thanks to the work of Marie de Saxcé. The report and subsequent methods are confidential and thus not available to general public.

It is important to mention that no similar example of such work has been found in the literature review. There is thus no example from which comparing these methods is relevant.

Data was collected thanks to different interviews within the company but also with customers. A small group of people has continuously assessed and reviewed the on-going work.

**Principle of LCA**

The ISO 14040 standard series gives specific requirements and guidelines for LCA. (ISO14025:2006, 2006) LCA is an analytical method, whose purpose is to evaluate the environmental impacts - natural environment, natural resources - for products or industrial processes. It takes into account the whole life-cycle of the product (i.e. a good or a service). The expression “from cradle to grave” refers to accounting of all impacts from raw material acquisition, through production, setting and use phases to disposal are assessed. (Klöpffer, 2003) (Finnveden G., 2009) (Grant, 2009) In this model, raw materials are extracted from nature and go through the whole process by eventually ending as waste or emissions back to nature.

A typical life-cycle assessment should encompass all these different steps, as described in Figure 2:
As a consequence, LCA provides the decision-maker with a comprehensive overview of possible environmental impacts on the up- and downstream flows of a product. (Jeswani, et al., 2010)

The different LCA steps

This paragraph describes the different steps related to the realization of LCA. The ISO guidelines give a description of the four steps of a common LCA (Figure 3).

Figure 2: Life cycle of products or services

Figure 3: The different LCA steps (Adapted from ISO14040:2006, 2006)
Definition of goal and scope

Like many exercises, it is important when performing an LCA to get a clear definition of what the goals and scopes are. This part is the most critical as it influences the entire process. The different methodologies and the necessary data are identified in this step. The goal should include a definition of the experimented product or process and the stakes it raises.

The scope of the study is helping to define the characteristics of the LCA – functional unit, system boundaries, and allocations for instance. It gives the frame of LCA, by specifying what is included or not in the study, as well as the level of details. The limitations have to be specified, by regarding the validity of data or the relevancy of the system boundaries. (Guinée et al, 2004) (Rebitzer, et al., 2004) Since LCA is an iterative process, the goal and the scope may need to be revised as the study goes along.

Life-Cycle Inventory

The goal and scope phase is followed by Life-Cycle Inventory (LCI), also called data collection. The United-States Environmental Protection Agency (USEPA) defines this step as the “process of quantifying energy and raw material requirements, atmospheric emissions, waterborne emissions, solid waste and other releases for the entire life-cycle of a product, process or activity”. (ISO14040:2006, 2006)

Required data is informed; it may be time-consuming, depending on the level of complexity of the product. It can also be very hard to get access to some data, especially if the study is not carried out in the country of production. The more intermediaries, the tougher is the data collection. All assumptions and allocations should be expressed specifically so that it is possible to date back the source of data. (Baumann H., 2004) The data must be validated before going further and translated in terms of functional unit. The results are often presented in an inventory table, summing up the whole information. (Guinee, et al., 2011) (Rebitzer, et al., 2004)

Life-Cycle Impact Assessment

Life-Cycle Impact Assessment (LCIA) is commonly the third phase of an LCA. It consists in the translation of the previously-set inventory into environmental impacts. The ISO standards (ISO14040:2006, 2006) give a general framework for the LCIA phase. The main four elements that should be present are:

- Category definition: selection of interesting environmental impacts
- Classification: assignment of the LCI flows to the correct impact categories
- Characterization: quantitative step aiming at translating LCI results into relevant indicators for each category
- Weighting: assignment of a value to the impact depending on their estimated weight so that different impact categories can be equally compared. For instance, methane has a GWP 25 times higher than CO₂; 1kg of methane will be considered as 25kg CO₂ eq (according to IPCC 2007 method, 100 years). (Guinée et al, 2004) (Lanfranconi, 2011)
Interpretation of results

The different results of the LCI analysis and the impact assessments are interpreted, while keeping in mind the goal and scope of the study. In other words, interpretation is performed all along the life-cycle of the product to ensure that the primary objectives are fulfilled. In this way, Significant Environmental Aspects (SEAs) are pinpointed and can be apprehended in more details.

The strength of the model is assessed: relevance of data, hypotheses, etc. This can be done by performing sensitivity analyses for instance, that is to say by varying one parameter and seeing how the others are influenced. A critical review can also be written detailing the different results and conclusions, and justifying the choices undertaken for the study. Assumptions and limitations are thus clearly stated, and it ensures the good transparency of the study. (European Environment Agency, 1997) (US Environmental Protection Agency, 2006)

Notions of importance

Functional Unit

In order to give the same basis for the whole scientific community, the ISO 14040 standard defines the functional unit as a “quantified performance of a product system for use as a reference unit”. (ISO14040:2006, 2006)

As a consequence, the functional unit specifies the functions of a system and must be consistent with the objectives of the study. (Joint Research Centre, 2010) The functional unit gives thus a reference from which input and output can be quantified and standardized. There are mainly three aspects associated with the notion of functional unit: the function of the product, the durability as well as the performance quality standard. It should:

- Allow the comparison of goods or services based on the service they provide to the user.
- Allow the identification of significant environmental aspects of the product.
- Be based on a simple, representative and reliable unit so that it can be available for most people. (Agence de l'Environnement et de la Maîtrise de l'Energie, 2012) (Rebitzer, et al., 2004)

Impact and flow indicators

Once the system is modelled, it is necessary to determine the relevant environmental impacts for the product category. There are mainly two- types of indicators: impact and flow indicators. An impact indicator aims at describing a particular phenomenon and quantifies it. The International Life-Cycle Data (ILCD) system recommends characterisation methodologies to calculate impact indicators. On the contrary, a flow indicator aims at quantifying a physical flow (energy, water, waste or material).

A sub-classification for impact indicators exists depending on the level of impacts: mid-point and end-point indicators. The first ones aim at assessing environmental impacts as problems. The purpose is to give a reference value from which two products can be easily compared. For instance, climate change as radiative forcing for greenhouse gases is a mid-point indicator. These indicators are fairly reliable and understandable by LCA-acquainted people. On the contrary, end-point indicators aim at assessing impacts in terms of damages and consequences. Namely, the
consequence of climate change by the resulting damage on human health is an end-point indicator. These indicators are easier to understand but also more difficult to implement as they engender a lower accuracy. (Joint Research Centre, 2010) The choice between mid-point and end-point indicators is driven by the goal of LCA and the intended audience. Figure 4 takes up the idea presented above:

![Figure 4: Classification of indicators (Adapted from (Peuportier, et al., 2011))](image)

Nevertheless, it is more relevant to use a selection of indicators for a particular product or service. It is for instance less relevant to assess the eutrophication of seawater for EEE while it is highly advised for food-processing products as their life cycle requires a lot of phosphates and nitrates. The user has to consider which indicators fit the situation the best. By way of example, 11 indicators are used by the PEP ecopassport® program, namely eight impact indicators and three flow indicators.

### LCA perspectives

The following chapter lists assets and drawbacks related to LCA, as well as possible applications subsequent to its conduct. It shows the limitations of LCA and highlights the importance of simplifications.

#### LCA advantages and drawbacks

The first advantage of LCA is that it gives a comprehensive overview and an exhaustive approach on the up- and downstream flows of the product. In addition, it is a very useful comparative tool that allows the comparison of different products on the environmental perspective, as long as the functional unit allows it and system scope is equal. This tool is well implemented in the market strategy and can even be an asset for a company as it can cultivate its image. (Klöpffer, 2003) (Finnveden G., 2009) (Grant, 2009)

Nevertheless, there are several shortcomings associated with the use of LCA. It can be time-consuming and even tedious as it requires the collection of data that then has to be analysed. As LCA
is quite complex and detailed, there can be differences derived from the improper definition of functional unit, for instance. There can also be some problems related to the use of data: low representativeness (technology, geography, etc) and reliability of the database, obsolescence, etc. Finally, this method does not introduce the notion of criticality of emissions depending on the sensitivity of the environment. For instance, NO\textsubscript{x} emissions are more critical within an urban area during an anticyclone period. (Rebitzer, et al., 2004) An important weakness concerning LCA is the lack of regulations. As there are no directives or commonly accepted drivers related to its conduct but only standards, there is no real market push for its development. As a consequence, stakeholders are not enforced to perform LCA and this creates a huge gap in the opportunities. Social and economic criteria are not taken into account by this single LCA. Let’s mention that Life-Cycle Sustainability Assessment and social LCA have been explored to answer this problem. (UNEP, et al., 2009) These are not considered as mature tools yet.

As a consequence, there are some limitations related to the use of LCA. Most of them are related to its complex and difficult to apply behaviour.

**Specific LCA of building products**

The building product industry involves many stakeholders to be defined. All of them are closely or remotely related to LCA of building products:

- Manufacturers of building products use LCA as a tool to assess the environmental performance of their products. They can display it through EPDs afterwards.
- Law-makers have the same interest as their aim is to develop regulations to globally improve environmental performances of buildings.
- LCA practitioners would like LCA to be a strong tool from which environmental assessment of building products is reliable.
- LCA and building design software developers would like to stabilize a reliable LCA method for building products.
- Decision-makers would like environmental performances of buildings to be trustable to choose the best supplier.

LCA is thus important within the building industry. Given the number of involved stakeholders, it is likely to assume the manufacturing chain of building products is complicated. Moreover, a building is made of hundreds of interlinked building products, with great quantities and high energy consumptions, which complicates the overall environmental assessment. Simplifications for LCA of building products in this particular context are thus relevant.
FRAMEWORKS FOR LCAs OF BUILDING PRODUCTS

This chapter describes the frameworks in regard to simplified LCAs of building products and technical equipment. First, different environmental declaration systems are described: PEP ecopassport® and FDES. Then, the EN 15804 standard is introduced and the stakes regarding its implementation are pointed out. A comparison between these approaches is performed in order to analyse the gap of the simplifications to be established.

Fundamentals

Environmental Product Declarations (EPDs) are environmental declarations which gather information concerning environmental impacts of a product or a system. Environmental declaration is always resulting from the realization of a Life-Cycle Assessment. They belong to type III environmental declarations as described by the ISO 14025 standard. (Desmaris, et al., 2012) To be able to fulfil high market expectations for a number of practical applications, EPDs have to meet and comply with specific and strict methodological prerequisites. To achieve this goal, EPD programs establish common and harmonized rules to ensure that similar procedures are used when creating type III declarations. (Desmaris, et al., 2012)

Besides, there are many categories of products that obviously differ from the way they are manufactured, their use modes, etc. The necessity appears to establish rules – or Product Category Rules (PCR) – that can give a framework to this type of documentation. They specify the method for LCA to be applied, as well as the elements to be declared within the EPD: functional unit, relevant indicators and information, allocation rules, etc. (Desmaris, et al., 2012) As a consequence, PCRs should be regarded as complements to EPD program rules. Nevertheless, the development and implementation of PCRs are very slow (Desmaris, et al., 2012) (Environdec, 2012)

More specifically, following standards set PCRs for building products at three different levels. The international ISO 21930 standard gives general rules to elaborate PCRs for building products. The European EN 15804 standard gives core rules applicable for building products. The French NF P 01-010 standard gives PCRs applicable for all building materials (Figure 5). (Desmaris, et al., 2012) An example of PCR for building products in compliance with EN 15804 has been conducted by IBU. (Institut Bauen und Umwelt, 2012)
The PEP ecopassport® program: EEE

The purpose of this section is to describe the PEP ecopassport® program and highlight its simplified approach.

Scope

The Product Environmental Profile (PEP) Association is a non-profit association aiming at developing its own type III declaration program-organisation and PCR: the PEP ecopassport® program.

The objective of the program is primarily to give a common framework for EEE industry with an organisational structure (PEP Association) that manages the Type III program according to ISO 14025 requirements. The members of the association are industrials, users and different institutions. The products of concern are EEE such as cables, lighting, Heating, Ventilation, Air-Conditioning, Refrigeration (HVACR). PCRs are completed by Product Specific Rules (PSRs) for certain types of products, aiming at giving a specified framework for environmental declarations of products (for wires, cables, accessories, etc).

Methods for the PEP ecopassport® program

In this context, it has been given to me the opportunity to perform six updates of PEP ecopassport®. The matter is to get a clear understanding of this program and the simplifications concerning environmental declaration it implies. As those six are not published yet, an already published PEP of DB90 circuit breaker is presented in Appendix 1. Helpful examples of simplifications have been experimented through the realization of those six updates:

- Automation of data collection and documentation formats
- Use of a simplified database
- Development of secondary data: local, continental and international transport hypotheses
- Exclusion of non-relevant aspects: primary packaging
- Establishment of systematic hypotheses: transport steps

On the one hand, this approach raises questions regarding the comprehensiveness of studies and the representativeness of the PEP format. As some aspects are disregarded, it can jeopardize accuracy and validity of results. On the other hand, the method recommended by PEP ecopassport® for environmental declarations of EEE is rather easy to apply. The purpose is to maintain this apparent simplicity for environmental declarations of EEE in compliance with EN 15804 requirements.

The PEP ecopassport® program uses its own set of indicators as described in Appendix 2. It is interesting to highlight as the difficulty to compare environmental performances of products is partly due to the difference of indicators between programs.

Fiche de Déclaration Environnementale et Sanitaire (FDES) : building materials

**Scope**

“Fiche de Déclaration Environnementale et Sanitaire” (FDES) stands for Environmental and Health Declaration Forms. It permits, thanks to an LCA, the realization of environmental declarations for building materials. The format of FDES is standardized and homogenized for all products and the set of impact indicators is also chosen so that two products can be easily compared.

The NF P01-010 standard concerns the writing of FDES rules. It specifies the system boundaries, the hypotheses in use and sets calculation methodologies for environmental impacts. This is coupled with trials to assess the contribution of the product to the air quality inside buildings. As a consequence, its aim is to present in a whole the environmental and health effects of a building material. (Bureau Veritas CODDE, 2012) (F.D.E.S., 2012)

**Methods in use by the FDES program**

Unlike PEP ecopassport®, FDES approach considers a gate-to-gate assessment: from gate-to-gate of material A, from gate-to-gate of material B, etc. These materials are then linked to one another to get full cradle-to-grave LCA. In this way, each step should encompass all the environmental aspects related to the life-cycle of the material, until the final one. Figure 6 gives a hint regarding the FDES approach:
Figure 6: Environmental assessment of building materials according to FDES program

The set of indicators used by the FDES program is presented in Appendix 3. These indicators are different from the one used by the PEP ecopassport® program. It thus complicates the comparison of these two approaches.

Perspectives

Comparison of the two approaches

Figure 7 below sums up these differences.
For building materials, there are usually less materials, processes and sub-contractors involved for manufacturing the product; there is thus a better knowledge of life cycle parameters that influence the product environmental impact. That is unfortunately not the case for EEE, as there is a multimaterial approach and a widely extended use of subcontracting manufacturing phases of components or sub-assemblies to international providers. This fact is emphasized by the difficulty for manufacturers to get access to information with plenty of suppliers and intermediaries in such an international context.

As a consequence, FDES and PEP ecopassport® do not present the same approach, targets and set of indicators. For instance, accounting of inert waste for FDES does not find its equivalent in the PEP ecopassport® program. In addition, some indicators are not expressed in the same unit: Raw Material Depletion in y⁻¹ for PEP and in kg-Sb eq for FDES. PEP ecopassport is intended for EEE while FDES is intended for building materials. However, EN 15804’s scope encompasses all building products, including EEE and building materials. As discrepancies between the two previous programs already exist, it will be an additional obstacle to apply EN 15804 for environmental declarations of building products.

Previous assessment only deals with the situation in France. Indeed, each EU country develops several environmental declaration programs (Swedish EPDs for instance) with their own set of indicators and characteristics. The implementation of a new framework in this particular context is thus hardened by previous conclusions.

The following paragraphs are focussing on the gap that has to be filled for a comprehensive EEE LCA in compliance with EN 15804 requirements and limiting LCA practitioner workload.

**EN 15804:2012 standard as a new framework**

This part is aiming at describing the EN 15804 standard content.

**Regulatory framework**

The implementation of the EN 15804 standard comes within the scope of several requirements. They are represented in Figure 8 below:
There are several levels concerning the regulatory frame of building products. First, at the framework level, EN 15643 gives general remarks for environmental assessment of buildings. Secondly, at the building level, EN 15978 sets the different calculation methods regarding environmental assessment of buildings. Last, at the building product level, there are two standards of interest. The purpose of EN 15804 is to provide this frame for building products’ EPDs. It should harmonize methods so that environmental information can be more easily compared, irrespectively of the countries, or the industrial who edited the declaration. Nonetheless, EN 15804 does not provide a specific layout of documentation. (PE International, 2012) That’s the reason why a complementary standard, EN 15942, has been created to try to harmonize environmental product declaration formats. (EN 15942:2009, 2009) (EN 15804:2012, 2012)

Besides, publication of one decree and two technical orders of application are aiming at imposing the communication format of EPDs. It should be applicable from July 2013 for building and decoration material EPDs and from July 2017 for EEE EPDs.

**EN 15804 standard: notions of importance**

**Generalities**

In more details, EN 15804 gives a common framework, or Product Category Rules (PCR), for type III declarations (according to ISO 14025) for all building products. It specifies the system boundaries, calculation methods of environmental and flow indicators. EN 15804 set of indicators has now evolved to be based on CML 2001 methods. (Bureau Veritas, 2012) (Bureau Veritas CODDE, 2012)
Besides, EN 15804 introduces different notions. It is for instance possible to choose between the traditional Functional Unit and the Declared Unit, defined as follows: "quantity of a construction for use as a reference unit in an EPD for an environmental declaration based on one or more information modules". As a consequence, there is no longer a performance dimension which can be a drawback regarding the comparison of several products.

Then, this standard introduces the notion of Reference Service Life, i.e. an estimated lifespan for a product: "Service life of a construction product which is known to be expected under a particular set, i.e. a reference set, of in-use conditioned and which may form the basis of estimating the service life under other in-use conditions". (ISO15686:2012, 2012) However, EEE, integral part of building products, do not enter into the scope of this standard. The fact RSL is not suitable for EEE highlights the difficulty of application of EN 15804 for all building products. (ISO15686:2012, 2012)

**Content of the EPD**

There are several items that need to be declared in an EPD in compliance with EN 15804. The purpose of this section is not to be exhaustive but to give a hint in regard to the requirements set by this standard (Figure 9).

![Figure 9: Content of the EPD set by EN 15804 (Adapted from (EN 15804:2012, 2012))](image)

As a consequence, there is plenty of information to be declared in an EPD (much more than in a PEP). By way of example, the German Institut Bauen und Umwelt (IBU) has already developed EPDs in compliance with the EN 15804 standard for luminaires. (Institut Bauen und Umwelt, 2012) (Institut Bauen und Umwelt, 2012) It highlights the fundamental difference between these two approaches as the required level of detail is not the same.
Modularity principle and choice of covered stages

EN 15804 introduces the principle of modularity. A module\(^1\) is a specific unit process in the product’s life-cycle. Modules take into account raw materials extraction, transport, manufacturing, maintenance, etc. They are then independent entities that can be combined.

EN 15804 gives LCA practitioner the choice of covered stages he/she wants to deal with. There are commonly three types of life-cycle stages covered; the first one is the only one mandatory. Then, practitioner can pick up some modules to his/her willingness. (EN 15804:2012, 2012) (Bureau Veritas CODDE, 2012) These different stages are:

- From cradle to gate (from step A1 to A3): this is the production stage with considering raw material extraction, upstream transport, manufacturing of sub-systems and their transport.
- From cradle to gate with options (from step A1 to A3 mandatory + other modules to D optional): can be added any other stage of the product life cycle – the transport to the construction site and the installation, use of the product (such as servicing and maintenance), end-of-life (demolition, treatment of waste) and eventually the benefits and loads beyond the system boundaries (recycling).
- From cradle to grave (from step A1 to C4 to D optional): all the life cycle steps of the products have been included in the environmental declaration.
- This standard introduces among others the D module aiming at quantifying and assessing benefits and loads due to reuse or recovery.

The different modules are presented in Figure 10 below.

---

\(^1\) Module as defined by EN 15804
Towards a harmonized system?

The following paragraphs focus on the matching between PEP ecopassport® and EN 15804. What is necessary to implement in order to transcribe the PEP ecopassport® approach into EN 15804 terms?

Gap analysis between PEP ecopassport® and EN 15804 methods

Comparison of PEP ecopassport® and EN 15804

Table 1 compares PEP ecopassport® and EN 15804:

Table 1: Comparison of the difference of the lifecycle steps in PEP ecopassport® program and EN 15804 standard

<table>
<thead>
<tr>
<th>Life cycle stages: mandatory</th>
<th>PEP ecopassport® program</th>
<th>EN 15804 standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 mandatory phases: manufacturing, distribution, installation, use and end of life</td>
<td>1 mandatory phase (Product stage) corresponding to 3 modules (A1 to A3): raw material, supply transport, manufacturing</td>
<td></td>
</tr>
<tr>
<td>Life cycle stages: optional</td>
<td>Not applicable</td>
<td>Choice of optional modules apart from A1-A3 mandatory ones</td>
</tr>
<tr>
<td>Benefits and loads of the recycling</td>
<td>Not applicable</td>
<td>Declared in Modele D (optional)</td>
</tr>
<tr>
<td>Life cycle total</td>
<td>Mandatory</td>
<td>Not applicable</td>
</tr>
<tr>
<td>Reference unit</td>
<td>Functional unit</td>
<td>Declared unit or Functional Unit</td>
</tr>
<tr>
<td>Temporal description</td>
<td>Expected lifetime</td>
<td>Reference service life</td>
</tr>
<tr>
<td>Indicators</td>
<td>8 Impact indicators 3 flow indicators</td>
<td>7 Impact indicators 17 flow indicators divided in 3 categories</td>
</tr>
</tbody>
</table>

As mentioned in Table 1 above, three types of covered stages are conceivable in EN 15804: from cradle to gate, from cradle to gate with options and from cradle to grave. As a consequence, the principle of modularity described by EN 15804 is not familiar to usual life cycle delimitation used by PEP ecopassport®. (Bureau Veritas CODDE, 2012) Moreover, there is a fundamental difference between the functional and the declared unit, but also between the lifetime and the reference service life. It implies a reunderstanding of the methods in use by EEE LCA practitioners.

As a consequence, the PEP ecopassport® program appears to be more restricting than the EN 15804 requirements as all life-cycle phases are mandatory. Nonetheless, the D module must be introduced and a new delimitation of life-cycle is necessary.

Comparison of environmental impact indicators

Table 2 below gives the comparison between environmental impact indicators recommended by PEP ecopassport® and EN 15804.
As it can be seen from above, there are only a few indicators that match between these two approaches, such as Air Acidification. Nevertheless, even they do not present the same characterization method. Consequently, they cannot be directly used as such. Consequently, all environmental impact indicators have to be adapted or created from scratch in order to be compliant. In addition, some of them are not used to being employed by EEE LCA practitioners. (EeB Guide, 2011)

The environmental impact indicators recommended by EN 15804 are different from the ones used by the PEP ecopassport® program. The methods of characterization are also different which induce the creation of new indicators or an adaptation of previous ones.

**Comparison of energy and water flow indicators**

As Table 3 below compares energy and water flow indicators for both methods:

**Table 3: Comparison of energy and water flow indicators between PEP ecopassport® and EN 15804**

First, this table rises there is currently no difference between primary and secondary energy flows for the PEP ecopassport® program. But EN 15804 does propose to differentiate these two.
In addition, no difference is made between internal and external sources of energy. In this way, no difference is made between wood burned to produce heat for the considered manufacturing process whether issued from waste collection, or wood shavings issued from the internal sawmilling.

Secondly, no distinction is made between the use of renewable and non-renewable energy in the PEP ecopassport® program. Keeping the example of wood, if it is originated from a sustainably managed forest, then, the source of energy is considered as renewable, otherwise not.

Finally, EN 15804 foresees to implement a special indicator dedicated to the net use of fresh water, while it was not the case for the PEP ecopassport® program. It will in this way provide reliable and publically available information in regard to the use of net fresh water.

These indicators are indeed hard to implement for EEE. First, they are based on metals and fossil-based materials. Besides, as components are made of several materials, it is difficult to differentiate and assess these indicators for each material. In addition, supply chain is very complex; so data concerning amount of waste and origin of consumed energy is collected with difficulty.

While comparing energy and water flow indicators for these two approaches, it clearly shows EN 15804 is not intended for EEE. There is indeed some work to perform to implement new indicators. A strong revision of how to feed these indicators must be carried out.

Comparison of waste flow indicators

Table 4 below compares waste flow indicators for both methods:

### Table 4: Comparison of waste flow indicators between PEP ecopassport® and EN 15804

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow indicators EN 15804 (method name)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Then, EN 15804 addresses waste quantities generated during product life cycle. The PEP ecopassport® approach does already take into account the production of hazardous waste. Nevertheless, waste has to now and then be quantified and classified in a certain category depending on its nature: hazardous, non-hazardous or radioactive. This will provide more transparency to the overall results of the study regarding quantities and types of waste disposed. It also establishes a category scaling from which waste is assessed according to its dangerousness.

The implementation of produced waste categories engenders a complexity regarding the collection. These indicators provide essential information regarding the dangerousness of waste and thus of very high concern to EEE.

Comparison of additional recovery information

Table 5 below gives the comparison of additional energy flow indicators between PEP ecopassport® and EN 15804.
Table 5: Comparison of additional recovery information between PEP ecopassport® and EN 15804

<table>
<thead>
<tr>
<th>Flow indicators PEP ecopassport® (method name)</th>
<th>% of reuse</th>
<th>% of specific end-of-life treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow indicators EN 15804 (method name)</td>
<td>Components for reuse</td>
<td>Materials for recycling</td>
</tr>
</tbody>
</table>

Green: same indicator and method; Orange: same indicator, different method; Red: different indicator

An entire set of indicators is dedicated to the recovery of energy and materials that are derived from the product system. Both materials and energy can be recovered. In this way, it will be easier to prove the environmental-friendly behaviour of certain systems. (EN 15804:2012, 2012) These notions were barely dealt with by the PEP ecopassport® program, as only the percentage of reused materials had to be informed. This is particularly important in an eco-design context as it highlights the different solutions to improve environmental performances of a system.

The implementation of this standard will provide more transparency to the results and value eco-friendly systems.

Implementation of the EN 15804 standard within EIME software

There are two aspects that need to be tackled in order to develop and extend a simpler LCA approach in the framework of EN 15804 implementation. It consists in suggesting modelling rules which will consider industrial constraints in terms of data supply, in particular concerning EEE manufacturing. It involves changes in EIME that Bureau Veritas CODDE must pilot. The tasks to be performed in order to be compliant with this standard are as following:

- Results: this task is aiming at integrating the different calculations and results into EIME. It requires some time as the purpose is to transform the interface and associated database into a more adapted one.
- Modelling: New topics have to be tackled such as the possibility to inform process losses, to quantify and differentiate the nature of waste, to differentiate energies and integrate the benefit and cost of recycling.

A need for both harmonization and simplification

EN 15804 has been developed within CEN TC 350 (European Committee for Standardization – Technical Committee on Sustainability of construction works) group, that is to say for and by people from building materials while environmental standards of EEE have been developed within TC 111 (Technical Committee on Environmental standardization for electrical and electronic products and systems). It implies discrepancies of the vision of a product lifecycle between a building material and EEE. For building materials, there are usually less materials, processes and sub-contractors involved for manufacturing the product; there is thus a better knowledge of life cycle parameters that influence the product environmental impact. The harmonization of environmental declarations is essential to allow European decision-makers and stakeholders working with the same reference tables. In this way, these declarations will present the same assessment procedure, level of details and verification accuracy from one to another country.
Last but not least, it can be extracted from this chapter that the implementation of EN 15804 will bring some complexity regarding the readability of the declarations, especially for EEE. Besides, there is no common impact or flow indicator (same indicator and same method) between the PEP ecopassport® and EN 15804 approaches. As a consequence, the new requirements that EN 15804 is spreading to the EEE industry are generating additional efforts for informing data. Admittedly EN 15804 is necessary but engenders new difficulties that must be faced.
POSSIBLE LCA SIMPLIFICATIONS

In the continuity of previous chapters, it is now time to present possible LCA simplifications. Tackled simplifications may be applied for LCA in general but are presented in this chapter with examples and experiences from textiles.

The development of the textile database is a real bet for Bureau Veritas CODDE whose specialty is EEE. However, it represented a real gap in the market and Bureau Veritas CODDE has invested for three years to develop a solid and reliable database on textiles. The objective of this paragraph is not to be exhaustive but to get a clear overview of the simplifications principles for LCA in the textile sector in order to adapt them for building products afterwards. Besides, textiles are integral part of building products. For instance, they can be used for furniture or for isolation. (Pohl, 2012)

Overview of the life-cycle of textiles

There are two types of raw materials available in the textile sector: natural (wool, silk, cotton, flax, hemp) and artificial (viscose, polyamide, polyester). (Oerlikon, 2010) Cotton is for instance produced in more than 100 countries; it thus hardens the way data collection is performed and its representativeness assessed. (Dahlöff, 2004) This large diversity of raw materials available undergoes afterwards several interlinked steps to eventually produce fabrics and clothes. For information, the nature of the fibres influences the nature and number of processes afterwards. (ITMF, 2011)

Then, it is very unlikely that all the pieces making clothes come from the same factory. Accounting for the distribution phase is important with this in prospect. Besides, states of the roads and impacts incumbent upon vehicles are well-known in Europe but it is doubtful that this is the case for all countries. (PE International, 2010) It consequently hardens the way transport steps are taken into account. (de Saxcé, 2012) (Perrin, 2005)

Thereafter, most of textile experts state that the use phase is the most impacting but also the most uncertain, depending on textiles and chosen hypotheses: washing, drying and ironing. (Levis Strauss, et al., 2006) There are besides countless ways to wash clothes, depending on the use of a machine, the choice of a temperature, etc. Some studies aim at harmonizing this type of data collection. (Saouter, et al., 2002)

Lastly, there are different end-of-life scenarios for such products: reuse, recycling, incineration and landfilling. About half of the textile waste is assumed to be reused. (Giusiano, et al., 2010)

These different steps are summed up in Figure 11 below:
Summary and future stakes

Previous paragraph highlights the fact each element will play on a particular environmental issue. Namely, synthetic fibres have an undeniable impact on raw material depletion while cotton production has a great impact on water consumption.

In addition, most of the studies show that there is a lack of data, making the truthfulness of data opaque. (Laursen, et al., 2007) The globalization allows a worldwide production of textiles, but hardens considerably the job of data collectors. Given the infinity of available materials, it remains difficult to assess the impacts for a fibre in a specific country. In addition, it can often be hard to have access to some data for remote places all over the world. In a nutshell, the geographical spreading of the industry, difficulties concerning the modelling of technologies and the overall decrease of the quality are as many factors that complicate the conduct of LCA of textiles. (de Saxcé, 2012)

Different ideas can stand out. Generic data are already adopted concerning the habits of customers thanks to the help of different surveys and studies, like the one carried out by Procter & Gamble. (Saouter, et al., 2002) Some of these methods are described in the following paragraphs.
The geographically-adapted method

As it can be seen from a textile product life-cycle, the main problem concerns its geographical scattering. The user is thus invited to implement a new method to simplify this step: the geographically-adapted module method.

Principle and hypotheses

Originally, a module is representative of a specific country. This method consists in adapting a module for different geographical regions. In this way, it is not necessary to build up the whole module from scratch, but instead adapt what has already been performed to the new module. In this way, by only changing a little data, a module can be declined in most of the countries. Types of data concerned by this method are:

- Water and resource supplying
- Energy and thermic mixes
- Waste and water treatment
- Scattering of emissions into the air, the water and the soil

Scientific relevance

First of all, a global module for the production of a textile is not enough to represent accurately technical and industrial reality. For instance, waste treatment plants exist for the end-of-life of textiles in Europe whereas it is often not the case in Southern Asia. (de Saxcé, 2012) (Ossés de Eicker, 2010)

Though, it is realistic to assume a module can be declined the same way for different countries. The countries of adaptation are chosen thanks to statistics published by the International Textile Manufacturer Federation (ITMF) recommendations. The purpose is then to represent 90% of the global production. I got the opportunity to develop 104 declined modules and validate 94 others. As a consequence, I appreciated the accuracy of this method and its great simplification regarding data searching and sourcing.

The geographically-adapted method is linked to the energy set by EN 15804. Indeed, with these methods, not only the environmental impact indicators are influenced but also water and energy indicators. The percentage of renewable and non-renewable materials is dependent on the country for which it is assessed. Having a better understanding of this method allows a better comprehension of EN 15804 indicators.

Process loss consideration

As it can be understood from 0, the textile industry involves a succession of manufacturing steps. The resulting calculation mistake is in this way proportional to the number of steps involved. The higher the number of steps, the higher the resulting mistake will be.
Principle and hypotheses

Indeed, each process engenders losses that need to be accounted in order to stick to reality. Nevertheless, sectorial constraints do not impose a way to calculate these process losses. Either they are calculated from the ingoing mass or the outgoing mass. (de Saxcé, 2012) Figure 12 below gives the description of a linear chain of production:

A table sheet for an automatic calculation of process losses has been developed. Its aim is to apprehend as good as possible the complexity of the textile chains of production. A fabric is indeed often issued from different types of clothes, fact that must be taken into account in the calculations. (de Saxcé, 2012)

Scientific relevance

The textile chain of production is complex, interlinked and worldwide-spread so that this simplification turns out to be necessary. Taking into account process losses sticks more to reality than considering that they always reach 100%. In addition, the calculation method fits reality requirements as it is possible to perform the calculations from the beginning or the end of the supply chain. Manufacturers often have access to one of this data.

Nonetheless, the industrial complexity is often higher than studied before. In reality, a linear chain of production (vertical aggregation) is very unlikely to be implemented. A branched chain of production (both horizontal and vertical aggregations) fits more reality, and especially in a textile context. Figure 13 below gives the description of a branched chain of production:
Having an accurate calculation of process losses is thus essential for mainly two reasons. On the one hand, it allows an improvement of environmental performances of machines and techniques. On the other hand, the question regarding process loss consideration is directly related to the approach set by EN 15804 as it proposes a process-oriented approach.

Allocation methods for waste

EU regulations have ruled on a revision of the status of waste, so that they can be valuable for energy and material recovery. Reusing of waste breeds then different questions: where should the process impact be allocated? Should it penalize the process engendering the waste or the one using the recycled material?

The different methods

First, “stock method” only focuses on recycled products and materials. A material can be used in other processes afterwards. With a simplification perspective, no data out of the system is required to assess a product. (de Saxcé, 2012) By using the stock method, the total impact imputed to the product which has incorporated recycled material is the sum of:

- The impacts due to virgin material production and transformation, as well as recycled material transformation.
- The impacts due to the non-recycled part of the material in the end-of-life.

In this way, impacts for textiles decrease when the recycled content and recycling rate increases. It can be considered as a hybrid mass allocation method as benefits can be gained from both the incorporation of recycled materials and the willingness to recycle materials. (de Saxcé, 2012) (Le Guern, et al., 2011)

The second method is the “system expansion”. It allocates the different impacts on the materials depending on their monetary values. Nonetheless, it requires out-of-the-system data which increases the complexity of application of the method. (de Saxcé, 2012) (Chen, 2011) By using the stock
method, the total impact imputed to the product which has incorporated recycled material is the sum of:

- The impacts due to the recycled part of the material in the end-of-life.
- The impacts due to the non-recycled part of the material in the end-of-life.

Figure 14 sums up the main characteristics of the two previous methods:

Figure 14: Allocation methods for waste

Scientific relevance

First of all, in a simplification perspective, the system expansion method is more likely to be evicted. It has indeed the drawback to undergo the different market price fluctuations. It implies a heavy workload in terms of data research and updates. This phenomenon is emphasized by the geographical spreading of textile production, complicating the process of economic attribution. It can be tricky to drift in an economic perspective while environmental matter has to be addressed. (Chen, 2011)

A mass allocation seems to be a good alternative. The main asset is that it is constant in time and rather easy to implement. Nonetheless, this method might allocate a large part of the impacts to by-products which could be a shame in some cases. The environmental impact of waste should not have the same burden as the main product. (Chen, 2011)

As a consequence, it appears there is no perfect solution regarding allocation methods for waste. It is incumbent upon the LCA practitioner willingness and experience. Economic allocation seems to be more precise but also harder to implement. A mass allocation as described by the stock method is a good compromise between all possible solutions. EN 15804 has developed different indicators
related to the classification of waste. Allocation methods for waste are then essential to respond to these indicators.

A simpler system for LCA conduct of textiles

A specific EIME database has been developed for textiles, in compliance with ILCD requirements. As a consequence, the data collection file has been revised to fit it. The number of primary data to be collected decreases as the development of the database goes along. (de Saxcé, 2012)

Developments of EIME LCA software have also been carried out. Distribution, use and end-of-life phases have been particularly simplified through the implementation of templates. For instance, the distribution template integrates distance, type of transports, mass, etc. It should be extended to all life-cycle phases to be applicable for each transport step. (de Saxcé, 2012)

The most important problem consists in integrating process losses for textiles. An Excel file has already been developed but its direct integration in EIME software would highly simplify the calculation. The purpose is then to create a link between successive modules so that losses get accounted into the calculations. Intermediary flows could be created in order to bind two modules together. In this way, it would automatically imply that the reference flow of the previous module constitutes the input of the following process. Figure 15 gives a representation of the method proposed above for two processes:

![Figure 15: Perspectives of evolution for LCA of textiles](image)

To put it in a nutshell, several simplification methods have been and are to be performed on LCA of textiles. This chapter is crucial for several reasons:
- Textiles are nowadays more and more used within buildings as isolation or furniture materials.
- Simplifications on textiles pave the way for future simplifications on building products. The geographical adaptation of modules is interesting for the calculations of indicators set by EN 15804. Process loss consideration and allocation methods for waste are important regarding the process-oriented approach adopted by EN 15804.
- The notion of link between modules in regard to the integration of process losses has been tackled. This topic and other simplification considerations will be reused and developed in the following chapter for building products.

This approach for assessing environmental performances of textiles is relevant as it takes into account, in an automated way, the reality of the supply chain with plenty of intermediaries and treatments to be performed. The ideal solution would be to introduce a new type of tool which gathers all the simplification aspects that have been tackled in this section and more. This tool is implemented in the following chapter.
LCA SIMPLIFICATION METHODOLOGY FOR BUILDING PRODUCTS

The objective of this fifth chapter is to present a methodology to get a simpler building product LCA in compliance with EN15804 for EIME LCA software. The overall scientific relevance of this method is described in the following chapter.

Stakes of the implementation

The parallel drawn with the textile industry is crucial for several reasons. The geographically-adapted method, process loss consideration and allocation methods for waste are important notions that introduce further simplifications developed in this chapter. The notion of link between modules in regard to the integration of process losses has been tackled. A solution is to introduce a tool which gathers all these simplifications.

The purpose is then multi-pronged:

- Automate some calculations. LCA practitioner handling must be reduced to avoid mistakes and simplify LCA conduct.
- Complete the product-oriented with a process-oriented approach. EN 15804 does propose to take into account the presence of by-products, the integration of process losses, the becoming of waste, etc.
- Introduce classification of elements: renewable/non-renewable; materials/processes; primary/secondary.

Presentation of energy flow indicators

This section describes the different elements implemented in order to consider the indicators required by EN 15804, as introduced in 0. Environmental impact indicators must be adapted or created. Nonetheless, this work has been carried out by another person and that’s the reason why these results are not presented in this section. Though, the compliance with EN 15804 induces the development of flow indicators. They are related to accounting of physical flows (materials, energy, water and waste). The calculation of these indicators is described in the following section.

Use of primary energy resource indicators

The different indicators related to this category are listed in Table 6 below:
Table 6: Use of primary energy resource indicators

<table>
<thead>
<tr>
<th>Example</th>
<th>Use of renewable primary energy excluding renewable primary energy used as raw materials</th>
<th>Use of renewable primary energy resources used as raw materials</th>
<th>Total use of renewable primary energy resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP</td>
<td>M\textsubscript{L}, LHV</td>
<td>M\textsubscript{L}, LHV</td>
<td>M\textsubscript{L}, LHV</td>
</tr>
<tr>
<td>ERM</td>
<td>M\textsubscript{L}, LHV</td>
<td></td>
<td>M\textsubscript{L}, LHV</td>
</tr>
<tr>
<td>ER= ERP+ERM</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Example:** Energy from wood incineration, Bio-sourced polymers, Solar energy

**Covered stages:**
- Cradle to gate
- Cradle to gate with options
- Cradle to grave

**Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials**

<table>
<thead>
<tr>
<th>Example</th>
<th>Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials</th>
<th>Use of non renewable primary energy resources used as raw materials</th>
<th>Total use of non renewable primary energy resources</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENRP</td>
<td>M\textsubscript{L}, LHV</td>
<td>M\textsubscript{L}, LHV</td>
<td>M\textsubscript{L}, LHV</td>
</tr>
<tr>
<td>ENRM</td>
<td>M\textsubscript{L}, LHV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENR=ENRM+ENRP</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Example:** Energy from oil incineration, Fossil-based polymers, Energy from crude oil

**Covered stages:**
- Cradle to gate
- Cradle to gate with options
- Cradle to grave

---

Figure 16 pinpoints the links between above-mentioned indicators:

![Diagram of energy flow](image_url)

**Figure 16: Use of primary energy flow indicators**
Net use of fresh water

The different indicators related to this category are listed in Table 7 below.

<table>
<thead>
<tr>
<th>Covered stages</th>
<th>Net use of fresh water</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NUFW</td>
</tr>
<tr>
<td>Cradle to gate</td>
<td>m³</td>
</tr>
<tr>
<td>Cradle to gate with options</td>
<td></td>
</tr>
<tr>
<td>Cradle to grave</td>
<td></td>
</tr>
</tbody>
</table>

Freshwater is defined as water containing less than one milligram per liter of dissolved solids, most often salt. (USGS, 2012) With today’s demand for freshwater outrunning the supply, the planet is facing serious water shortages with some areas being more directly threatened than others. The depletion and pollution of water resources is mainly caused by water usage throughout the various steps in industrial production (Susskind, 2008)

Use of secondary resource indicators

The different indicators related to this category are listed in Table 8 below.

<table>
<thead>
<tr>
<th>Covered stages</th>
<th>Use of secondary material</th>
<th>Use of renewable secondary fuels</th>
<th>Use of non-renewable secondary fuels</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>USM (kg)</td>
<td>URSF (MJ, LHV)</td>
<td>UNRSF (MJ, LHV)</td>
</tr>
<tr>
<td>Example</td>
<td>Use of recycled polypropylene</td>
<td>Incineration of wood issued from sawmilling</td>
<td>Incineration of waste tyres</td>
</tr>
<tr>
<td>Cradle to gate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cradle to gate with options</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cradle to grave</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Use of secondary material (USM in kg): use of materials from recycling.
- Use of renewable secondary fuels (URSF in MJ): use of a renewable energetic material issued from recovery
- Use of non-renewable secondary fuels (UNRSF in MJ): use of a non-renewable energetic material issued from recovery

Additional information on output flow indicators

The different indicators related to this category are listed in Table 9 below.
Table 9: Additional information on output flow indicators

<table>
<thead>
<tr>
<th>Components for reuse</th>
<th>Materials for recycling</th>
<th>Materials for energy recovery</th>
<th>Exported energy</th>
</tr>
</thead>
<tbody>
<tr>
<td>CRU kg</td>
<td>MRE kg</td>
<td>MER kg</td>
<td>EE MJ</td>
</tr>
</tbody>
</table>

**Example**
- Semiconductors leaving the system destined to reuse
- Polypropylene scraps leaving the system to recycling
- Incineration of polypropylene scraps leaving the system

<table>
<thead>
<tr>
<th>Total</th>
</tr>
</thead>
</table>

- Components for reuse (CRU in kg): Account of components that are destined to reuse in another system.
- Materials for recycling (MRE in kg): Account of materials that are destined to recycling.
- Materials for energy recovery (MER in kg): Account of materials that are destined to incineration with energy recovery.
- Exported energy (EE in MJ): Account of energy from waste incineration and emitted from landfilling sites. Example: energy lost from the incineration of not energy-recovered waste.

**Waste flow indicators**

The different indicators related to this category are listed in Table 10 below.

Table 10: Waste flow indicators

<table>
<thead>
<tr>
<th>Hazardous waste disposed</th>
<th>Non hazardous waste disposed</th>
<th>Radioactive waste disposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>HW kg</td>
<td>NHW kg</td>
<td>RW kg</td>
</tr>
</tbody>
</table>

**Example**
- Disposal of paints, solvents, etc in class 1 landfilling activity
- Disposal of biodegradable polymers in class 2 landfilling facility
- Disposal of uranium

**Covered stages**
- Cradle to gate
- Cradle to gate with options
- Cradle to grave

Waste has now and then to be classified in different categories as recommended by the European directive 2008/98/EC according to its dangerousness.

**Initial situation in EIME**

**Presentation of EIME modelling**

Figure 17 gives a comprehensive overview of current modelling within EIME. It shows which elements can be inserted in which container. Mastering the design of the architecture tree allows understanding further simplifications:

- “Folders” make the modelling of a process step possible.
- “Sub-Assemblies” make the modelling of complex systems possible, including sub-set parts and components
- “Parts” make the modelling of consistent parts that cannot be dismantled possible.
Besides, EIME database is implemented so that two categories of elements are used:

- Modules\(^2\): LCI corresponding to a set of flows. They are in broad outline divided in three categories: components, processes, materials/substances.
- Flows: basic elements for modelling life-cycle of a product. They are in broad outline divided in three categories: elementary flows, product flows, waste flows. (Bureau Veritas CODDE, 2012b)

![EIME Primary Modelling Situation](image)

**Figure 17**: EIME primary modelling situation (Adapted from (Bureau Veritas CODDE, 2012b))

Within EIME, energy flow indicators are currently calculated through the compilation of primary energy flows (feedstock/fuel energy and renewable/non-renewable energy) for each module. The approach proposed by EN 15804 is different from the primary situation in EIME. That’s why new flows must be created to feed new flow indicators. It could also be interesting to rely more on metadata\(^3\) in order to simplify LCA conduct.

**Gap analysis**

To be in compliance with EN 15804 requirements, everything must not be created from scratch. EIME’s primary situation does provide a solid background from which it is possible to work on. It is for instance possible to use already existing LCI energy flows. For instance, Total use of renewable primary energy resource (ER) is equivalent to the compilation of “Renewable energy” flows for all modules. In parallel, Total use of non-renewable primary energy resource (ENR) is equivalent to the compilation of “Non-renewable energy” flows for all modules. Besides, the problem of classification of resources depending on their nature or use (materials/process – renewable/non-renewable –

\(^2\) Modules as used within EIME

\(^3\) Metadata: data providing information about one or more aspects of the data (de Saxcé, 2012)
primary/secondary) must be addressed. There is currently no differentiation between so-called energy “used a process” or “used as materials” and primary or secondary energy.

Moreover, recycled content is already calculated by EIME. This data is helpful as it allows calculations of indicators based on secondary data: “Use of secondary materials”, “Use of renewable fuels”, “Use of non-renewable fuels”.

Besides, LCA practitioner can already tick a checkbox within EIME to inform when an element is destined to reuse. This allows the implementation of the indicator “Components for reuse”.

Lastly, the indicators developed by EN 15804 are based on the Lower Heating Value (LHV) of contributing elements. Some modules already have an accurate LHV within EIME. This data is not to be developed but requires some literature review.

As a consequence, further simplifications should lie on already existing elements. It avoids the development of new solutions from scratch.

Developed solutions

Classification of modules

Three types of categories, or Families, are conceivable:

- Materials and components: plastics, chemicals, semiconductors, etc
- Process: moulding by injection, cutting, etc
- Process with Materials: painting, welding, etc

However, a material (resource) can be used as material or as energy. For instance, wood can be either used as building materials (Materials Family) or used as a burner in a furnace to produce heat (Process Family). The idea is thus to give LCA practitioner the possibility to change the module’s Family when using it. As a consequence, a revision of EIME database structure is necessary.

Introduction of the “Flodule”

EIME LCA software has been adapted to answer previous requirements. It is nevertheless necessary to go further. For instance, previous considerations did not differentiate primary and secondary energy flow indicators. Besides, modelling of waste as input of a process is still blurry in EIME.

The idea is then to create a hybrid flow between a Flow and a Module: the Flodule. It shall be considered as a material flow for which metadata\(^4\) is informed (Figure 18).

\(^4\) Metadata: data providing information about one or more aspects of the data (de Saxcé, 2012)
The introduction of Flodule allows solving two problems:

- Giving a physical dimension to Flodules allows keeping a physical balance between all inputs and outputs. It indeed adds a material-value to a flow as characterized by its reference weight, LHV, etc. LCI databases were first and foremost developed to get elementary flows but not energy or waste flows. Flodule is thus especially interesting when dealing with recycled materials.

- Informing metadata for an element considered as a flow is relevant regarding the calculation of indicators set by EN 15804.

Calculation of the net use of fresh water

The implementation of this indicator is rather easy to implement within EIME as it is close to currently-used Water Depletion indicator.

Some water flows already exist allowing the calculation of the net use of fresh water so that no additional data needs to be developed. This indicator is thus the sum for all flows of concern of groundwater flows, lake water flows and river water flows.

Creation of recycling process modules

“Materials for recycling”, “Materials for energy recovery” and “Exported Energy” indicators are calculated through the creation of recycling process modules. For each module, two flows are created:

- Materials for recycling. The resulting mass increments “Materials for recycling” indicator.
- Materials for energy recovery

Nevertheless, EN 15804 introduces two different ways to account for materials destined to energy recovery from waste:

- From its weight: The resulting mass increments “Materials for energy recovery” indicator.
- From its LHV: The resulting LHV increments “Exported energy” indicator.

Besides, as “Exported Energy” also ensues from energy from landfilling, it is necessary to implement a flow “exported energy” for all landfilling modules. Figure 19 sums up above information:
Creation of waste flows

The integration of waste treatment relies on the fact a waste is accompanied by the suitable end-of-life treatment module. Besides, waste is categorized according to its dangerousness, according to the European Directive on waste (Directive 2008/98/EC, 2008). Consequently, one out of three waste flows is created for each end-of-life treatment module:

- Hazardous waste
- Non-hazardous waste
- Radioactive waste

Calculation of flow indicators

Previous solutions allow the calculation of flow indicators. All the calculations are confidential. Information is defined only in EIME development specifications and cannot be partially or entirely communicated outside Bureau Veritas CODDE’s organisation. This section gives the reasoning which led to the calculation of indicators.

Use of primary energy resource indicators

According to 0, a Family for each module can now be informed by LCA practitioner. It allows the calculation of indicators related to the use of primary energy resource (Figure 20).
As an example, if the module “wood” is classified as “Materials and components” Family, then LHV value is feeding the “Use of renewable primary energy materials” indicator. In parallel, if “wood” is considered to belong to “Process” family, its LHV is feeding the “Use of renewable primary energy process” indicator. Same reasoning can be applied for non-renewable resources.

The introduction of the Family notion allows automation and simplification regarding the calculation of use of primary energy resource indicators. A minor change in term of database is essential to get access to such major results.

**Use of secondary resource indicators**

As a reminder, these indicators are shown in Figure 21:

The update of modules and the implementation of the Flodule and associated metadata allow the calculation of use of secondary resource indicators. Informed metadata (reference weight, recycled content, LHV, etc) of Flodules are feeding “Use of secondary resource” indicators. For instance, the weight of a Flodule representing renewable secondary materials feeds “Use of secondary materials” indicator.

**Integration of waste treatment**

As a reminder, these indicators are shown in Figure 22:
The flows created in 0 increment corresponding waste flow indicators. Figure 23 sums up this information:

![Diagram of waste indicators]

**Figure 23: Calculation of waste indicators**

The categorization of waste is the logical result of the simplification methods for allocation of waste presented in 0. Allocation method for waste is essential to be able to categorize them afterwards. As a consequence, upstream simplifications on waste management allow an easy implementation of the indicators set by the EN 15804 standard.

To conclude, this section proposes different notions of importance regarding the calculation of indicators set by EN 15804:

- Choice of a Family for modules allows valuing a material in energy; it simplifies the calculation of most indicators.
- The creation of the notion of Flodule allows completing missing information for usual modules and flows; it also simplifies the calculation of most indicators.
- Creation of new flows should be integrated in LCI developments.
- Creation of new modules is helpful for the simplifications of most indicators.

Calculation of indicators is automated and simplified as LCA practitioner handling is limited. Though, at this stage, there is no consideration of process losses. Next paragraph aims at answering this question.

**Integration of process losses**

EN 15804 proposes a process-oriented approach, which means it stresses more on a succession of manufacturing steps than in an end-product approach. In the building industry, a process is usually part of a linear or branched succession of processes. The relationships between these processes and their influence on each other have been studied in 0 for the textile industry. The same reasoning is applicable for more general building products.
Problems to overcome

There are several problems that need to be overcome to integrate process losses into the calculations:

- Within a process, there must be a consistency in terms of units, materials and energy. For instance, reference flows and by-product flows must be expressed in the same physical quantity. This issue is inherent in LCA practitioner decisions and solutions are not tackled in the following paragraph.

- Integration of process losses is a brake in regard to modelling in EIME because it represents a practical difficulty of implementation in terms of database. Additional information of process losses must indeed be found to fit at best reality. Linear and branched chains of production harden their integration.

- A link between processes must be established to build the manufacturing chain step by step. Besides, a material A going out a process 1 does not necessarily enter the process 2 with the same quantity. That's why assignment criteria must be developed.

- EIME’s internal characteristics make the integration of process losses difficult.

Figure 24 takes up this information:

![PROBLEMS FOR THE INTEGRATION OF PROCESS LOSSES](Image)

- **Modelling problems**
  - Consistency within a process (unit, balances)
  - Integration of process losses, presence of by-products, waste
  - Link between different processes, integration of linear and ramified chains of production

- **EIME’s internal problems**
  - Intrinsic characteristics of the Part

SOLUTIONS TO BE DEVELOPED

Figure 24: Problems for the integration of process losses

A new level of modelling on EIME: the Process Part

The introduction of a new tool or container, the **Process Part** ensues from this particular context. A Process Part can be considered as a Part with an extra-layer of calculations allowing taking into account process losses, the production of by-products and waste. Its aim is to create links between processes and have a holistic, multimaterial and multiprocess approach.
In broad outline, the Process Part is made of three tabs:

- Tab 1 “Overview”: general information
- Tab 2 “Modelling”: choice of contributing elements (inputs and outputs)
- Tab 3 “Calculation”: link between previous elements, allocation of quantities, etc.

Materials (reference flows, additives, etc) and energy (electricity, water, etc) are required in input.

Materials and energy can also be informed in output. The reference flow provides the link between different processes. By-products and waste can also be defined as outputs.

Nonetheless, a practical problem raises regarding modelling of the Process Part. Editing a new container brings some complexity that needs to be faced. The purpose is then to have access to a convenient interface with only a few calculation steps for LCA practitioner. Previous information induces a cascade modelling: different containers can be interlinked within each other. EIME interface will have to move towards this new approach (Figure 25):

![EIME Adaptation for EN 15804](image)

**Figure 25: EIME adaptation for EN 15804**

When an output is informed as a Reference flow, then another Process Part must be dedicated to this output. An assignment criterion is then associated to this new Process Part (Figure 26).
For instance, if A=100kg and B=90kg, then the process loss for the Process Part 2 is 10%. If material B enters Process Part 1 with a quantity $B' = 45kg$, then the corresponding assignment criterion is $90/45 = 2$.

The description above is made for two processes. It can be extended to both linear and branched chains of productions following the same approach. For N processes, N+1 assignment criteria are to be calculated. It is incumbent upon LCA practitioner to inform the reference flow of each process.

To conclude, this method allows accounting for several processes, the possible production of by-products or waste and the consideration of process losses.

**Adjustments of the database**

The compliance with EN 15804 induces changes in terms of database. This chapter aims at listing these different developments.

*Development of new modules*

Previous requirements induce an update of EIME database. Above all, the process of development and documentation of modules should be updated as well.

The first assignment is to develop from scratch new process modules that are very useful in the building industry. One example of developed modules is the extrusion of a polycarbonate sheet. (Plastics Europe, 2010) Moreover, as EN 15804 requirements take an interest in waste and its becoming, 10 modules of recycled plastics have been developed with this in prospect.
Update of existing modules

As it has been introduced in the previous paragraphs, LHV data is crucial in order to calculate energy indicators. Having a reliable access to this data is essential. I had the opportunity to update LHV for 120 different modules, from plastics, to wood products to paper and cardboards. Updates for other modules have to be performed later.

As studied in 0, LCA practitioner should be able to modify the Family of a module. All modules must include information by default. Then EIME interface must let the user choose a Family and change the default value. Consequently, the introduction of Family for modules requires a consequent workload in terms of resource and time.

Next development concerns the categorisation and quantification of waste. In this way, one out of three waste flows must be created for each end-of-life treatment module; hazardous waste flow, non-hazardous waste flow, radioactive waste flow. It implies in particular a revision of end-of-life modules to be sure they rest on a categorisation of waste depending on its dangerousness.

Definition of default values

Such a constraining normative context induces the development of secondary data. There are indeed two major problems for data and LCA method developers:

- It remains difficult to get on-site data reflecting technological and industrial reality, and thus jeopardizing representativeness of the LCA.
- The appearance of new reference tables for EPDs implies informing additional data allowing the calculation of flow and waste indicators. LCI databases were first and foremost developed to get elementary flows but not energy or waste flows.

In order to simplify both data collection and modeling within EIME, the idea is then to launch a data collection campaign for secondary data with users of Bureau Veritas CODDE. The objective is first and foremost to be in compliance with cut-off rules for building products by proposing default values. The purpose is also to fit at best industrial activities. The data to be collected concerns mainly:

- Average process losses for profiling, cutting and machining of materials (metals and plastics) and their becoming (recycling, incineration, landfilling, etc)
- Environmental impacts incumbent upon processes (material, energy and water consumptions, operating temperature, etc)

EIME users have been appealed to support this data collection (example in Appendix 4). Collected data is then studied, assessed and aggregated. These data could afterwards be taken up as reference values, representative of on-site values (and not from literature) to complete the flows of LCIs.

To go further: creation of a PCR for EEE

Problems regarding the implementation of the EN 15804 for EEE

The only mandatory covered stage imposed by EN 15804 is from cradle to gate (from step A1 to A3), corresponding in broad outline to the current manufacturing phase. However, the use phase is likely to be the most impacting for EEE as EEE are very often power-consuming. For instance, for the DB90 circuit breaker in Appendix 1, the use phase has the greatest impact on most indicators. (Schneider
Electric, 2011) This approach is not compliant with ISO 14040 requirements and can induce mistakes during LCA conduct.

Next, EN 15804 gives the ability to choose between a functional and a declared unit. There is no longer a performance dimension which is used to allowing the comparison of products. Hence, how to assess the environmental performances of two products set by a declared unit while they do not work the same amount of hours? For instance, two different types of EPDs in compliance with EN15804 have been conducted for two luminaires (IBU). (Institut Bauen und Umwelt, 2012) (Institut Bauen und Umwelt, 2012) As the first EPD does not inform the same number of operational hours as the second does, it remains impossible to find a common basis from which comparing these luminaires.

This standard also introduces the notion of Reference Service Life (RSL), i.e. an estimated lifespan for a product. This notion has been defined by ISO 15686 standard. However, EEE, integral part of building products, do not enter the scope of this standard. (ISO15686:2012, 2012) It highlights the fact EN 15804 is not intended for EEE in the first place.

A complementary PCR for EEE

Some of the intrinsic problems of the application of EN 15804 to EEE can be overcome thanks to the creation of a complementary documentation to support EEE environmental declarations. This documentation could be considered as complementary Product Category Rules (PCR), aiming at providing the rules for a simpler conduct of EEE LCA in compliance with EN 15804. A complementary “PCR” for building materials is already under development and could inspire the development of an EEE “PCR”.

To start with, as it is not relevant for EEE to only adopt A1-A3 perimeter, this “PCR” should clearly set that complete life cycle approach is mandatory to avoid incomplete and incompatible declarations. (EN 15804:2012, 2012) In addition, the EEE “PCR” shall allow the declaration of complementary information such as the presence of substances of very high concern in the product (REACH and RoHS compliancy).

Concerning the introduction of the declared unit and the choice between functional and declared units, a frame regarding their implementation should be settled. The energy consumption of a product is very dependent on its use scenario. It could be interesting to implement consumption declarations by using mode, aiming at giving necessary information for the exploitation of results. In this way, two previous luminaires can be part of a luminaire system that is configured by the light designer who is assessing the Luminaire system LCA. Such an EEE “PCR” should thus provide mandatory information to be declared no matter the choice of Declared Unit or Functional Unit.

Then this “PCR” should settle general scenario concerning lifespan of EEE. For all categories of products, RSL is to be homogenized in a realistic way. It should indeed take into consideration technical properties of EEE, information on their manufacturing, etc. For example, the previous luminaires could have a RSL of 20 years. In broad outline, the implementation of this type of template would harmonize and simplify practice of LCA for EEE.

Last but not least, in order to meet the requirements for EN 15804 flow indicators, the “PCR” shall impose upstream simplifications for the use of generic data. By setting general hypotheses and
taking an interest from the very beginning of the supply chain, it is possible to simplify the data collection process. By way of example, especially in such an international context for EEE, transport steps can be simplified for all products by setting distances and means of transport. So it can facilitate the modelling for the person using fed and upgraded databases.

The implementation of an EEE PCR could in this way bring two aspects at the same time:

- A harmonization of LCA methods for all EEE as part of building products
- A simplification for LCA practitioner concerning the realization of EEE as an integral part of building products.

Figure 27 sums up the information presented in this paragraph:

![Diagram of obstacles regarding the implementation of the EN 15804 for EEE and creation of a complementary PCR for EEE]

**Figure 27: Creation of a complementary PCR for EEE**

In a nutshell, several aspects have been tackled in this chapter regarding LCA simplification methodology for building products in compliance with EN 15804. Methods and tools in regard to the simplification of calculation of indicators have been proposed to allow at the same time the calculation of flow indicators and the integration of process losses. Possible approximations have been presented.
DISCUSSION

This last chapter but one is assessing the findings from previous theoretical analyses and empirical materials. Previous simplifications and harmonisations have created discrepancies and questions. Some limitations about the results are also discussed, as well as the possibility of improvements that could be carried out in a short-, middle- and long-term period.

Assessment of the relevance, the validity and the objectivity of results

Summary of accomplished work

On the one hand, the harmonization of environmental declarations is essential to allow European decision-makers and stakeholders working with the same background and allow the environmental assessment of building products, which includes EEE. Besides, the new requirements that EN 15804 is spreading to the EEE industry are generating additional efforts for informing data.

On the other hand, several methods and methodologies have been explored in relation with LCA of textiles. Besides, the notion of link between modules in regard to the integration of process losses has been tackled. Let’s keep in mind that textiles are nowadays part and parcel of building products.

Several aspects have lastly been tackled regarding LCA simplification methodologies for building products in compliance with EN 15804. Content of the corresponding EPD and the difficulties to be overcome have been presented. Then, different methods and tools in regard to the simplification of calculation of flow indicators have been presented. Family notion, flodules and Process Part tool have appeared to be crucial for this matter.

About the methodology

The establishment of simplifying rules mainly relies on the following hypothesis: it is possible to gain from textile LCA simplifying experience to set a know-how transmission from textile to building product industry. Now, the approach for assessing environmental performances of textiles is relevant as it takes into account, in an automated way, the reality of the supply chain: large variety of products and scenarios, geographical spreading, accounting of process losses, becoming of waste. Besides, as textiles are integral part of building products, these two manufacturing chains are interrelated. Working on environmental assessment of textiles contributes to some extent to the assessment of environmental performances of building products. In addition, the methods presented for textiles are an introduction to the methods and tools developed for building products. For instance, the integration of process losses in a systematic way has first been introduced for textiles and developed afterwards for building products.

The model represents the simplification methods established in previous chapters. The target is thus the resulting simpler LCA of building products still in compliance with EN 15804. This model does not isolate one factor but tries at the opposite to encompass several considerations at the same time.
It is important to mention that no practical application of the methods described in this report has been experimented to this day. It thus remains very difficult to discuss empirical results. That’s why the robustness of the model cannot have been assessed. These implications are also very dependent on the studied type of building products.

In no way a simplified LCA can be as accurate as a detailed one. As LCA is very often a matter of available data, the more data is subsumed, the more accurate the resulting LCA will be. It provides nonetheless a good approximation of results to be obtained. Starting with a simple but realistic model allows reaching an accurate representation of the target. Besides, practitioners are given the choice to use or not implemented simplifications tools. As a consequence, the model is suitable for industrial applications as LCA practitioners can sketch at best the reality of the supply chain for building products. Building a model means finding the best trade-off for the purpose of the research. This requirement is fulfilled by the model presented in here.

**About the methods**

The notion of classification of modules is scientifically relevant as it does not jeopardize the accuracy of LCA results. At the opposite, it provides additional and valuable information for all modules. It represents a low investment in terms of resource but provides several benefits, namely the calculation of most indicators.

The introduction of modules as hybrid flows with metadata can raise questions regarding its relevancy. It allows solving important problems without jeopardizing EIME’s primary philosophy. Calculation of corresponding indicators is then rather easy.

The integration of the Process Part is interesting as it gathers several aspects in one and only tool. Integration of process losses is likely to fit reality since all types of manufacturing chains are taken into account. The Process Part tool is also coherent with a technical and industrial reality in terms of data collection. It is sufficient to have access to information for each process, without any link between them and the calculation method binds them. Lastly, industrials often get quantities for either inputs or outputs, putting a brake on the integration of process losses in the calculations. The method is thus independent of these considerations.

These methods take into account waste modelling as an important parameter, through attributional modelling. Another approach is called consequential modelling. Some credit is thus given to the potential of recycled material waste can give. It assesses the avoided impacts of virgin material by the use of recycled materials. (Peuportier, et al., 2011) This last method involves a certain degree of subjectivity that can jeopardize the accuracy of LCA. At a micro-level such as the one considered for building products, attributional LCA is more applicable.

In regard to the level of uncertainty these methods engender, no empirical measurements can be performed. Nevertheless, a quantitative assessment is given. Apart from data accuracy and LCA software functioning considerations, uncertainties are incumbent upon LCA practitioner decisions. LCA practitioner has the responsibility to define a Family for modules. Besides, LCA practitioner is guided as the filling of the “Calculation” tab goes along. Drop-down menus and checkboxes are present so that LCA practitioner handling is eventually rather small. It can thus be assumed the level of uncertainties incumbent upon modeling of LCA for building products is rather small.
Validity and objectivity of the methods

It is rather hard to assess the validity of results as LCA software developer is to ensure quality of results and an easy access and implementation. FDES and PEP ecopassport® approaches have been widely experienced for years within Bureau Veritas CODDE. As EN 15804 is a hybrid between the method of FDES for building materials and the simpler approach set by PEP ecopassport®, it gives credit to the method.

In addition, the methods presented in this report are based on strict reasoning, methods and calculations. It does not rely on any invention or the negligence of any aspects.

Besides, the company has decided to create a partnership with CSTB (Centre Scientifique et Technique du Bâtiment). The purpose is to have a third-party reviewer to validate the methods and the calculations presented in this report.

Concerning the objectivity of results, it is acknowledged that this work is company-oriented and is intended for EIME LCA software. Nevertheless, this work is still an autonomous academic research and should be considered as such.

Contribution to the LCA community

Developed solutions are intended for an application by Bureau Veritas CODDE for EIME LCA software. The purpose of this paragraph is to deal with the adaptation of these solutions for other LCA software.

There is no particular LCA software recommended by EN 15804 or EeB guides. (EeB Guide, 2011) It should at the opposite be applicable for all companies using some LCA software. All LCA software adopts a process-oriented approach: a succession of LCI datasets which all combined represent a succession of processes. Most of it is ready for the implementation of EN 15804. The main challenge concerns the presentation of results.

Most of LCA software is based on Ecoinvent database. The philosophy of Ecoinvent is to model the different processes in “boxes” for which all information is required. But there is currently no link between the different “boxes” or systems. LCA practitioner is not guided and calculations are not automated.

GaBi LCA software is often mentioned when dealing with LCA of buildings. It is even recommended by PE International, a company offering sustainability consulting services. (PE International, 2012) Its objectivity is nonetheless doubtful as it is the organisation in charge of its development.

According to Evea LCA consulting office website, SimaPro LCA software is ready for the compliance with EN 15804. Trainings on customers are already on their way. There is nevertheless no assistance concerning LCA conduct. Additional calculations are often incumbent upon LCA practitioner handling. That’s why it is necessary to develop an extra-software to deal with these additional calculations. For instance, Evea has developed a new tool called Ev-dec, aiming at assessing environmental performances of building products in compliance with EN 15804. (Evea, 2012)

Team LCA software has decided to play on a process-oriented approach. Processes are represented by “boxes” for which all necessary modules are informed (electricity, transport). The reference flow
makes then the link between the different processes. But there is no transparency in the calculations and no assistance for LCA practitioner. It might then engender a lot of mistakes that jeopardize the accuracy of the method. The approach set by Team is visually interesting, but not so easy to implement. (Joint Research Centre, 2012)

The developments proposed in this report are close to the previous approach. The purpose was to have a process-oriented approach while keeping in mind EIME philosophy. Namely, as EIME is mostly intended for non LCA experts, LCA practitioner must be guided all along LCA conduct. That’s why transparency of the calculations has been a decisive criterion in the research process. The methods proposed in this report are thus of general value for other LCA software.

Limitations

The purpose of this section is to identify the limitations incumbent upon both characteristics of EN 15804 and model and methods proposed above.

General assessment

To start with, this Thesis is mainly based on three documents: EN 15804 standard and two EeB guides. It is also based on confidential documents such as Bureau Veritas CODDE internal reports and presentations. This is a brake regarding the overall assessment of this report by an external reviewer. Current literature has been used as often as possible.

EN 15804 is a complex standard introducing plenty of subtleties; it can lead to uncertainties and discrepancies in this regard. The fact that no mandatory covered stages is imposed can lead to misuse and sometimes contribute to hide environmental impacts. It remains also difficult to compare two building products from this reference if the same aspects are not dealt with. Then, it has been highlighted EN 15804 is primarily made in Business to Business (B2B), i.e. for and by people from the building industry. It can be hard for the general public to understand both the subtleties of this standard, as well as the interpretation of results. In addition, the content of the EPD is not harmonized - as highlighted by the example of environmental declarations of luminaires – which creates a striking discrepancy in this regard. The question regarding the applicability of the methods for all building products is raised. The example of EEE and the necessity to create an “EEE” PCR has showed that some uncertainties prevent a good conduct of LCA for these products. This is strengthened by the fact EN 15804 is not perfectly settled and can still be subject to modifications. Lastly, only environmental assessment is performed and no social and economic aspects are tackled.

There are thereafter different limitations concerning the calculation of energy flow indicators. The requirements set by EN 15804 propose to conduct the calculation of most energy flow indicators based on LHV of fuels. Nevertheless, the building industry often calls upon the use of condensing boilers. (Peuportier, et al., 2011) In this way, the condensation of water must be accounted in energy calculations. Considering Upper Heating Values seems to be more suitable with this in prospect.

Apart from these issues, some indicators are not taken into account by the requirements while they could be interesting for this purpose. Namely, “Land use occupation and transformation” could be important in a building perspective, as it gathers space occupied and land use needed for resource
(wood for instance). Integrating such a dimension for EPDs of buildings would have provided an important added-value.

Besides, flow indicators are divided in renewable and non-renewable categories which is relevant for the environmental assessment of building products. Namely, solar energy is part of renewable energies. Nevertheless, consuming solar energy from internal photovoltaic panel will not have the same impact as consuming solar energy from the grid. This difference is not made by the energy flow indicators. It seems fair to reason in terms of exhaustible resource. As such, solar energy would be inexhaustible while energy from biomass would be. (Peuportier, et al., 2011)

About the methods

It is important to mention this Thesis is a first attempt concerning the compliance with EN 15804 for Bureau Veritas CODDE. The purpose was to be able to conduct LCA for building products in the next year. There is still some work to carry out and improvements to make after the outcome of this Thesis.

The main problem related to the use of these methods concerns its specificity. It may indeed be oriented as it is dedicated to EIME for an application by Bureau Veritas CODDE. It consequently hardens the work of external audience to apply it to other LCA software. The present report gives nevertheless a method that can be generally undertaken and should be considered as such.

One important limitation concerns allocation methods. Process Part tool and the related methods only take into account physical allocations, both for products and waste. Thanks to physical allocations (on masses, volumes, etc), it is possible to go back and forth through easy calculations. However, economical and energy allocations are not so easy to tackle and have been dismissed by the methods. Though, it is important to both avoid double-counting and assess all relevant impacts, no matter the way calculations are performed. This matter must be considered and discussed in the future. Let’s just mention these types of allocations are less likely for building products.

Last but not least, the calculations of energy flow indicators depend on classifications of modules: renewable/non-renewable, materials/processes, and primary/secondary. Some of these conditions are incumbent upon LCA practitioner’s willingness. It can engender mistakes for a non-expert practitioner. Further improvements should take this in consideration by anticipating possible mistakes.

Outlook: perspectives of evolution in the future

The purpose of this section is to address what the next tasks to carry out are. It also takes an interest in the possibilities of improvements. There are two dates important in regard to the implementation of the standard: 2013 corresponds to the elevation to the level of regulation of the Construction Product Directive for a first wave of building products and in July 2017 for the rest of them. These two reference dates are chosen to define short-, middle- and long-term periods.

In the short term (by the end of 2013), development of the interface is the main task to carry out. Algorithms must be indeed implemented to concretely conduct an LCA for building products. It concerns IT developments; that’s why they do not enter in the scope of the Thesis. Once, this has
been performed, it would be reasonable and fair to practice and see if the proposed model is applicable in reality. At the same time, the different adjustments and updates relative to the database should be carried out.

In the middle term (from July 2013 to July 2017), the results from the data collection campaign on process losses should be integrated. The results must first and foremost be assessed and aggregated to rely on as accurate as possible data, from different manufacturers and industries. The absolute solution would then be able to choose a process and have automatically access to the corresponding value of process loss. This value would then be integrated into the calculations in a systematic and automated way. It would also be time to conduct a know-how transmission of the accumulated knowledge and train LCA practitioners within Bureau Veritas CODDE. It implies the redaction of an internal modelling guide and practical exercises.

In the long term (after July 2017), it would be relevant to train Bureau Veritas CODDE’s customers on this topic. As they are mostly industries from EEE sector, external trainings on the adaptation of LCA conduct for EEE in compliance with EN 15804 requirements is highly relevant. It implies the redaction of an external modelling guide and practical exercises. Last but not least, verification of EPDs is mandatory from July 2017 for EEE. It would be interesting to anticipate and get the accreditation to verify EPDs of building products in compliance with EN 15804.
CONCLUSION

This Master Thesis has been undertaken in order to fill a gap in knowledge in regard to the implementation of a standard concerning environmental declarations of building products: EN15804:2012. The aim of this Thesis is considered to be met. This last chapter takes up main conclusions and brings some closure to this report.

Summary

The large number of types of environmental declarations in Europe and their methodological differences puts an obstacle on the publication of EN 15804. It gives then a new framework regarding Environmental Product Declarations (EPD) and corresponding PCRs for building products. Its implementation aims at harmonizing the different methodologies developed in Europe for communicating on their environmental performances. It specifies among others declared or functional units, cut-off rules, calculation methodologies of environmental and flow indicators. These requirements are thus relatively complex and hardly applicable for industrial practitioners, so that it is suitable to translate them in a simpler and more applicable way.

Table 11 below summarises the recommendations directly intended for Bureau Veritas CODDE, as well as recommendations that may be of general interest:

Table 11: Recommendations for simplifications of LCA of building products

<table>
<thead>
<tr>
<th>Bureau Veritas CODDE</th>
<th>LCA community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extension of simplifications on textiles to building products</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Classification of modules into different categories</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Creation of modules</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Creation of recycling process modules</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Introduction of the Process Part representative of a process</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Establishment of links between Process Parts through the reference flow</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Development of tools for automation and transparency of calculations</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Adjustments of databases</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
<tr>
<td>Creation of a PCR for EEE</td>
<td>Classification of LCI datasets into different categories</td>
</tr>
</tbody>
</table>

Implications of this research

The problem research carried out by this Master Thesis is double-pronged:
Theoretically: Since the concept of simplifications of environmental assessment of building products in compliance with EN 15804 is quite new and unexplored in academic circles, it was hard to find reliable sources from which comparing the results was relevant. Nonetheless, this work paves the way for future research on environmental declarations for building products, even if there is still some work to be carried out. This work is company-oriented as the findings are aiming at being used by Bureau Veritas CODDE. It gives nevertheless methods and methodologies from which it is possible to get inspired.

Empirically: The implementation of EN 15804 within Bureau Veritas CODDE and ensuing simplifications is a long-term job. This is especially true for EEE as the ultimate deadline is 2017. However, in early January, Bureau Veritas CODDE has got its first case study on LCA of building products. It highlights the fact this study arrives in time and is integral part of the activities of the company.

Outlook: settlement of EN 15804 in the long term

Given the large number of available environmental product declarations, the spreading and large diversity of building products and the complexity of the supply chain, does EN 15804 have a chance to settle in the long term?

There used to be no common framework regarding environmental assessment of building products. LCA appears to be a first choice method with this in prospect, as databases are nowadays well-implemented and is a tried-and-tested solution through eco-labelling for instance. The EN 15804 standard provides a necessary framework and recommendations for LCA practitioners and developers. Environmental assessment of building products can eventually lead to the assessment of building performances, and can even contribute to an assessment at an urban scale. The implementation of this standard has allowed filling a gap in knowledge.

Nonetheless, this standard does not provide the degree of harmonization it should reach. Discrepancies in PCRs of building products and a great variation for content and format of declarations are difficulties to be overcome to be applicable at a European level. Some companies and organizations could set their own rules without further delay. That would be a shame as it distorts the very own harmonising ambition of EN 15804.

Fortunately, different commissions and committees have organized two workshops to determine the gaps to be filled in for companies to be compliant with EN 15804. Training courses and case studies have also been carried out to provide an actual conduct of LCA for building products. EeB guides (A for products and B for buildings) constitute a practical guidance for conducting LCA running on from EN 15804 requirements. It gives credit to the method as well as it eases the reading and understanding of the standard. In this case, EN 15804 is more likely to settle on a long-time period and be the first choice framework and reference regarding the conduct of LCA for building products.
PUBLIC REFERENCES


**Schneider Electric. 2011.** *Product Environmental Profile - DB90 circuit breaker.* Rueil Malmaison : s.n., 2011.


BUREAU VERITAS CODDE INTERNAL REFERENCES


APPENDICES

Appendix 1: Product Environmental Profile of DB 90 circuit breaker

Appendix 2: Set of indicators of PEP ecopassport® program

Appendix 3: Set of indicators of FDES program

Appendix 4: Data collection of process losses – Example of profiling of plastics processes
Appendix 1: Product Environmental Profile of DB 90 circuit breaker (Schneider Electric, 2011)
Product Environmental Profile - PEP

Product Overview
The main function of the DB90 circuit breaker product range is to protect low voltage electrical installations and to provide protection against indirect contacts. This range consists of 2-poles and 4-poles circuits breakers, with rated current from 5 A to 90 A with residual current protection. The representative product used for the analysis is DB 15-45 A bipolar, with sensitivity 500 mA type S referenced 13120.

The environmental impacts of this referenced product are representative of the impacts of the other products of the range which are developed with the similar technology. The extrapolation rules are described in the following chapters. The environmental analysis was performed in conformity with ISO 14040.

This analysis takes the stages of the life cycle of the product into account.

Constituent materials

The mass of the product range is from 512 g and 910 g no including packaging. It is 521 g for the DB 15-45 A 500 mA type S.

Products of this range are designed in conformity with the requirements of the RoHS directive (European Directive 2002/95/EC of 27 January 2003) and do not contain, or in the authorised proportions, lead, mercury, cadmium, chromium hexavalent, flame retardant (polybrominated biphenyls PBB, polybromodiphenylthers PBDE) as mentioned in the Directive.

Manufacturing
The DB90 circuit breaker product range is manufactured at a Schneider Electric production site on which an ISO 14001 certified environmental management system has been established.

Distribution
The weight and volume of the packaging have been reduced, in compliance with the European Union's packaging directive. The DB 15-45 A 500 mA type S packaging weight is 63 g. It consists of 100 % cardboard and paper. The product distribution flows have been optimised by setting up local distribution centres close to the market areas.
Product Environmental Profile - PEP

Use

The products of the DB90 circuit breaker range do not generate environmental pollution requiring special precautionary measures (noise, emissions, and so on) in using phase. The dissipated power depends on the conditions under which the product is implemented and used.

This dissipated power spreads out between 4.5 W and 36 W for the DB90 circuit breaker product range. It is 13.5 watts for DB 15-45 A 500 mA type S.

This thermal dissipation represents less than 0.1% of the power which passes through the product.

End of life

At end of life, the products in the DB90 circuit breaker have been optimized to decrease the amount of waste and valorise the components and materials of the product in the usual end of life treatment process.

The design has been achieved so as components are able to enter the usual end of life treatment. The product doesn’t need any specific depollution process.

The potential of recyclability of the products has been evaluated using the Codde “recyclability and recoverability calculation method” (version V1, 20 Sep. 2005) and published by ADEME (French Agency for Environment and Energy Management). According to this method, the potential recyclability ratio is: 46%.

Environmental impacts

The environmental impacts were analysed for the Manufacturing (M) and Utilisation (U) phases.

This product range is included in the category of Energy Passing Product (assumed lifetime service is 20 years and using scenario: Loading rate is 30% and uptime percentage is 30%).

The EIME (Environmental Impact and Management Explorer) software, version 4.0 and its database, version 11 were used for the life cycle assessment (LCA).

The calculation has been done on DB 15-45 A 500 mA type S. The electrical power model used is European.

Presentation of the environmental impacts

<table>
<thead>
<tr>
<th>Environmental indicator</th>
<th>Unit</th>
<th>DB90</th>
<th>M</th>
<th>D</th>
<th>U</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Material Depletion</td>
<td>Y-1</td>
<td>3.66 $10^{-4}$</td>
<td>3.57 $10^{-4}$</td>
<td>6.57 $10^{-4}$</td>
<td>8.30 $10^{-4}$</td>
</tr>
<tr>
<td>Energy Depletion</td>
<td>MJ</td>
<td>8.68 $10^1$</td>
<td>1.26 $10^2$</td>
<td>6.29 $10^1$</td>
<td>7.31 $10^2$</td>
</tr>
<tr>
<td>Water depletion</td>
<td>dm$^3$</td>
<td>1.44 $10^2$</td>
<td>38.65</td>
<td>5.97 $10^1$</td>
<td>1.06 $10^2$</td>
</tr>
<tr>
<td>Global Warming</td>
<td>g$\text{CO}_2$</td>
<td>4.21 $10^4$</td>
<td>5.12 $10^3$</td>
<td>1.03 $10^3$</td>
<td>3.69 $10^4$</td>
</tr>
<tr>
<td>Ozone Depletion</td>
<td>g$\text{CO}_2\text{CFG}-11$</td>
<td>2.88 $10^2$</td>
<td>8.41 $10^4$</td>
<td>3.51 $10^4$</td>
<td>2.00 $10^4$</td>
</tr>
<tr>
<td>Air Toxicity</td>
<td>m$^3$</td>
<td>9.07 $10^5$</td>
<td>2.88 $10^5$</td>
<td>6.79 $10^4$</td>
<td>6.12 $10^5$</td>
</tr>
<tr>
<td>Photochemical Ozone Creation</td>
<td>g$\text{NO}_x$</td>
<td>16.74</td>
<td>3.21</td>
<td>4.29 $10^5$</td>
<td>12.49</td>
</tr>
<tr>
<td>Air acidification</td>
<td>g$\text{SO}_4$</td>
<td>6.71</td>
<td>1.68</td>
<td>5.30 $10^4$</td>
<td>4.98</td>
</tr>
<tr>
<td>Water Toxicity</td>
<td>dm$^3$</td>
<td>1.21 $10^4$</td>
<td>1.53 $10^4$</td>
<td>6.21</td>
<td>1.05 $10^4$</td>
</tr>
<tr>
<td>Water Eutrophiliation</td>
<td>g$\text{PO}_4$</td>
<td>4.48 $10^4$</td>
<td>3.60 $10^4$</td>
<td>8.19 $10^4$</td>
<td>8.67 $10^4$</td>
</tr>
<tr>
<td>Hazardous waste production</td>
<td>kg</td>
<td>7.84 $10^4$</td>
<td>1.72 $10^4$</td>
<td>1.93 $10^4$</td>
<td>6.12 $10^4$</td>
</tr>
</tbody>
</table>

The life cycle analysis shows that the Utilization phase (U phase) is the life cycle phase which has the greatest impact on the majority of environmental indicators. The environmental parameters of this phase have been optimized at the design stage.

Extrapolation rules for product range:

Depending on the impact analysis, the environmental indicators (except RMD) of other products in this family may be proportional extrapolated by power dissipation of the product.

The RMD impact of the other products of the family may be proportional extrapolated by product mass.

Schnedler
Product Environmental Profile - PEP

System approach
As the product of the range are designed in accordance with the RoHS Directive (European Directive 2002/95/EC of 27 January 2003), they can be incorporated without any restriction within an assembly or an installation submitted to this Directive.

N.B.: please note that the environmental impacts of the product depend on the use and installation conditions of the product. Impacts values given above are only valid within the context specified and cannot be directly used to draw up the environmental assessment of the installation.

Glossary

Raw Material Depletion (RMD) This indicator quantifies the consumption of raw materials during the life cycle of the product. It is expressed as the fraction of natural resources that disappear each year, with respect to all the annual reserves of the material.

Energy Depletion (ED) This indicator gives the quantity of energy consumed, whether it be from fossil, hydroelectric, nuclear or other sources. This indicator takes into account the energy from the material produced during combustion. It is expressed in MJ.

Water Depletion (WD) This indicator calculates the volume of water consumed, including drinking water and water from industrial sources. It is expressed in dm³.

Global Warming (GW) The global warming of the planet is the result of the increase in the greenhouse effect due to the sunlight reflected by the earth's surface being absorbed by certain gases known as "greenhouse-effect" gases. The effect is quantified in gram equivalent of CO₂.

Ozone Depletion (OD) This indicator defines the contribution to the phenomenon of the disappearance of the stratospheric ozone layer due to the emission of certain specific gases. The effect is expressed in gram equivalent of CFC-11.

Photochemical Ozone Creation (POC) This indicator quantifies the contribution to the "smog" phenomenon (the photochemical oxidation of certain gases which generates ozone) and is expressed in gram equivalent of ethylene (C₂H₄).

Air Acidification (AA) The acid substances present in the atmosphere are carried by rain. A high level of acidity in the rain can cause damage to forests. The contribution of acidification is calculated using the acidification potentials of the substances concerned and is expressed in mode equivalent of H⁺.

Hazardous Waste Production (HWP) This indicator calculates the quantity of specially treated waste created during all the life cycle phases (manufacturing, distribution and utilization). For example, special industrial waste in the manufacturing phase, waste associated with the production of electrical power, etc. It is expressed in kg.

Registration No.: SCHN-2011-001-V0
Programme information: www.pep-ecopassport.org
PEP in compliance with PEPecopassport according to PEP-AP0011 rules
ACV rules are available from PEP editor on request

We are committed to safeguarding our planet by "Combining innovation and continuous improvement to meet the new environmental challenges".
Appendix 2: Set of indicators of PEP ecopassport® program

These indicators are:

- **Air Acidification (AA):** This impact indicator deals with the phenomenon of acidification by gases, that is to say the deposition of acidifying pollutants – SO\(_x\), NO\(_x\), NH\(_3\) – which will react with water in the atmosphere and lead to acid rains. Unit: kg H\(^+\) eq

- **Air Toxicity (AT):** This impact indicator deals with the release of toxic substances into the atmosphere. Tolerated sets of concentrations are commonly known for most of substances. Unit: m\(^3\)

- **Energy Depletion (ED):** This flow indicator represents the quantity of total primary energy (non- and renewable energies) used during all the life-cycle phases of a product. Different sources of energy (nuclear, fossil fuel, solar for instance) will have a different impact on the environment and this should be quantified. Unit: MJ

- **Global Warming Potential (GWP):** This impact indicator deals with the release of greenhouse gases into the atmosphere and their potential to emphasize greenhouse effects. All gas impacts are translated in terms of CO\(_2\) impacts. This indicator is one of those whose general public is aware of. Unit: kg CO\(_2\) eq

- **Hazardous Waste Production (HWP):** This flow indicator deals with the production of hazardous waste, such as Uranium. The related products will need a specific end-of-life treatment. Unit: kg

- **Ozone Depletion Potential (ODP):** This impact indicator quantifies the potential of gases to emphasize the depletion of ozone in the stratosphere resulting in the shrinking of the ozone layer. Unit: kg CFC-11 eq

- **Photochemical Ozone Creation (POC):** This impact indicator deals with the release of gases – carbon monoxide, VOC – that are likely to emphasize the production of ozone in the troposphere. All gas impacts are translated in terms of C\(_2\)H\(_4\) impacts. Unit: kg C\(_2\)H\(_4\) eq

- **Raw Material Depletion (RMD):** This impact indicator is related to the time a raw material is available on the surface of the Earth, and thus taking into account the size of the reserve. It is expressed as the fraction of the reserve disappearing each year Unit: y\(^{-1}\)

- **Water Depletion (WD):** This flow indicator is related to the scarcity of freshwater on the surface of the Earth. The public awareness is high concerning this issue and is now a common impact indicator. Unit: dm\(^3\)

- **Water Eutrophication (WE):** This impact indicator deals with the phenomenon of eutrophication emphasized by the presence of nitrates and phosphates in water. In high quantities, the presence of these nutrients leads to an unnatural development of algae and aquatic plants, resulting in the depletion of oxygen and thus jeopardizing the aquatic environment. It is often divided in seawater and freshwater eutrophication. Unit: kg PO\(_4\) eq

- **Water Toxicity (WT):** This impact indicator deals with the release of hazardous substances into the water and that are thus affecting the ecosystems. Tolerated sets of concentrations are commonly known for most of substances. Unit: m\(^3\) (Bureau Veritas CODDE, 2012)
Appendix 3: Set of indicators of FDES program

These indicators are:

- **Energy consumption**: This impact lists the needed energy consumption during the life-cycle of building materials. It is divided in three categories: Total Primary Energy, Renewable Energy and Non-Renewable Energy. Unit: MJ

- **Resource Depletion**: This impact indicator is related to the time a raw material is available on the surface of the Earth, and thus taking into account the size of the reserve. It is expressed as the fraction of the reserve disappearing each year. Unit kg-Sb eq

- **Water consumption**: As water scarcity is one of today’s and tomorrow’s most important issues, this indicator relates to the consumption of water (fresh and sea water) for the whole life-cycle of building materials. Unit: L

- **Solid waste**: As waste is more and more produced and discarded nowadays, this indicator accounts for the total production of solid waste. It is divided in several categories: Total recovered waste, Eliminated waste (hazardous, non-hazardous, inert, and radioactive). Unit: kg

- **Climate Change**: This impact indicator deals with the release of greenhouse gases into the atmosphere and their potential to emphasize greenhouse effects. All gas contribution is referring to its radiation potential and translated in terms of CO₂. This indicator is one of those whose general public is aware of. Unit: kg CO₂ eq

- **Air Acidification**: This impact indicator deals with the phenomenon of acidification by gases, that is to say the deposition of acidifying pollutants – SOₓ, NOₓ, NH₃ – which will react with water in the atmosphere and lead to acid rains. Unit: kg SO₂ eq

- **Air pollution**: This impact indicator deals with the pollution of air through the release of hazardous substances in the atmosphere. It is expressed as the quantity of air needed to dilute released pollutants to an accepted level. Unit: m³

- **Water pollution**: This impact indicator deals with the pollution of water through the release of hazardous substances in fresh and sea water. It is expressed as the quantity of water needed to dilute released pollutants (heavy metals, etc) to an accepted level. Unit: m³

- **Ozone Depletion Potential**: This impact indicator quantifies the potential of gases to emphasize the depletion of ozone in the stratosphere resulting in the shrinking of the ozone layer. Unit: kg CFC-11 eq

- **Photochemical Ozone Creation Potential**: This impact indicator deals with the release of gases – carbon monoxide, VOC – that are likely to emphasize the production of ozone in the troposphere. All gas contribution is translated in terms of C₂H₆. Unit: kg C₂H₆ eq

These environmental impact indicators are complemented with health impact indicators such as indoor air quality. There are seven more in addition to those listed, so that all important health aspects are tackled.
### Data collection: profiling of plastics

<table>
<thead>
<tr>
<th>Colour code</th>
<th>Examples of plastic profiling processes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Moulding by compression</td>
</tr>
<tr>
<td></td>
<td>Extrusion of elastomers</td>
</tr>
<tr>
<td></td>
<td>Extrusion of thermoplastics</td>
</tr>
<tr>
<td></td>
<td>Moulding by injection</td>
</tr>
<tr>
<td></td>
<td>Thermoforming</td>
</tr>
</tbody>
</table>

Add lines if necessary. For each column, an informative commentary help you filling in this data collection file.

**General information**

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<thead>
<tr>
<th>Process</th>
<th>Production site</th>
<th>Implemented technology</th>
<th>Process description</th>
<th>Machine in use</th>
<th>Age of the machine</th>
<th>Type of materials</th>
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<td>Moulding by injection</td>
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<td>Between 5 and 10 years</td>
<td>Polycarbonate</td>
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## Data collection: profiling of plastics

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<th>Thermoforming</th>
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<tr>
<td>Optional data</td>
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<td>Example</td>
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### PROCESS

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<th>Energy consumption</th>
<th>Water consumption</th>
<th>Losses</th>
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<td>Unit</td>
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<td>kg</td>
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<td>°C</td>
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88
## Data collection: profiling of plastics

<table>
<thead>
<tr>
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</thead>
<tbody>
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<td></td>
<td>Thermoforming</td>
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### COMPLEMENTARY INFORMATION

<table>
<thead>
<tr>
<th>Scraps and auxiliary materials</th>
<th>Waste management</th>
<th>Additional information</th>
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<tbody>
<tr>
<td>Scrap rate (%)</td>
<td>Type of waste</td>
<td>Nature of waste</td>
</tr>
<tr>
<td>1%</td>
<td>Lubricants</td>
<td>0.05</td>
</tr>
</tbody>
</table>

- **Waste management**
  - Waste water treatment
  - Complementary information