CONSTRUCTION CHOICES IN THE LIGHT OF LIFE CYCLE ASSESSMENT

A PRACTICAL REPORT ON ENVIRONMENTAL PRODUCT DECLARATION

WHICH METHODS FOR WHICH DECISIONS?

1 INTRODUCTION

Our aim is to finance or design buildings and urban development with a lower impact on the environment. In the framework of our national and European undertakings[1] to substantially reduce the energy consumption of buildings, we are set to construct low-consumption, then "energy positive", buildings. This means that the environmental impact of the building's life will be lower than the impact of its manufacture.[2] Our guide is about ecodesign linked to the environmental impact of construction materials and products. This impact is caused by their manufacture, transport, use and end of life.

What tools are currently available for us to choose our materials within an ecodesign rationale?

The Life Cycle Assessment (LCA) is one answer. Thanks to the emergence of instruments such as the EPD[3] and the progress made in terms of standards, we are witnessing the beginnings of genuinely operational ecodesign methods.

However, these procedures are still quite recent and many questions remain about the use of this new data. What is the scope and what are the limits of these approaches? How reliable are they and how should they be used in practical terms for the ecodesign of projects?

This guide answers questions from actors in the field who are not specialised in the standardisation issues often associated with these new tools.

Our goal is to describe them simply and to give information about their potential as well as the future developments in terms of LCA-based "environmental accounting".

[1] Law of 3 August 2009 related to the Environment GRENELLE (N°1), Law of12 July 2010 for national environmental undertakings (GRENELLE N°2), Energy – Climate of the EU section (December 2009).
[2] See Appendix I
[3] Environmental Product Declaration, and the French version *Fiches de Déclaration Environnementales et Sanitaires* (FDES).

2 CONTENTS

3 GENERAL PRINCIPLES OF THE LIFE CYCLE ASSESSMENT (LCA)

Faced with the issues of global warming, dwindling natural resources and various types of pollution locally, regionally and worldwide, we need to understand the mechanisms that are producing these negative effects, note their impacts and simulate the changes required for us to act.

There are numerous methods for the environmental assessment of human activities and these methods are often given labels (ecological footprint, carbon balance, etc.). We explain how these environmental labels are constructed below.

First developed in the 1970s in the industrial sector, LCA is a standardised environmental accounting system now governed by the ISO 14040 and ISO 14044 standards. It is a global method that addresses every level of impact, from local (e.g. waste) to global (climate change); this method is multi-criteria (looking at all forms of pollutions via the calculation of environmental indicators) and quantitative (quantifying emissions or consumption of natural resources).

A Life Cycle Assessment is the "grammar" of environmental assessments. Those of you who are already familiar with the principles of these assessments should go straight to page 13.

LCA is used to inventory the materials and processes employed in order to measure the impacts of a system, a product or a service, from the extraction of the materials used through to the end of their life, and taking in all the phases of distribution and use.

LCA results in the systematic quantification of environmental impacts throughout the product's life cycle: energy consumption, uses of raw materials, discharges into the environment, etc.

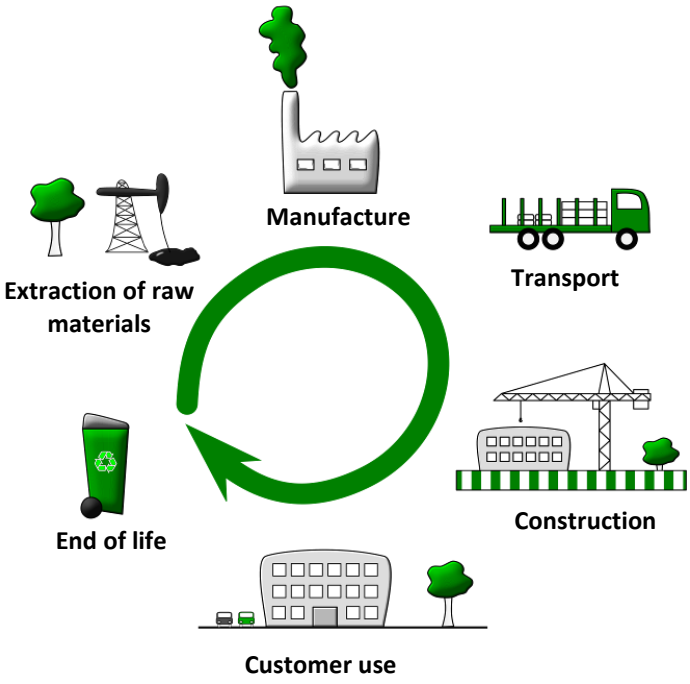


Figure 1 – Simplified LCA cycle for the construction industry

LCA is a decision-making tool intended to ensure better:

- **DESIGN**: it aids in the ecodesign of buildings.
- **COMPARISON**: Comparison leads to choice. LCA studies allow comparisons between several scenarios (energy, materials).
- **ACTION** on the product, i.e. for industrial firms producing materials, targeting the main impacts (hot spots) and prioritising the areas in which the product can improve by identifying the main sources of environmental impact. LCA is also used to identify key components and to arbitrate (or avoid) displacements of pollution from one stage in the cycle to another or from one impact to another.
- **INFORMATION**: the key to communication, both internal and external, about ecodesign and its results, on an established basis.
- **FOLLOW UP**: after a first diagnostic, the instrument can be used to ensure that the decisions and actions engaged genuinely have the expected effect.

3.1 ESTIMATED IMPACTS

Here we list the main environmental impacts, their definition and measurement method as adopted by French and European construction standardisation organisations.

- **Local pollution (<100 km)**

- Photochemical ozone formation: the sum of the gas emissions likely to produce ozone (irritant) at low altitude; an indicator expressed in Kg C_2H_2 (ethylene) equivalent.

- Water consumption: total consumption across all sources.

- **Regional pollution (100 to several thousand km)**

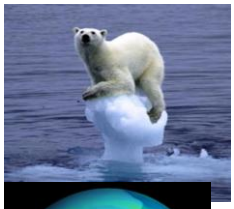
- Atmospheric acidification: caused by emissions of SO_2 and NOx leading to the formation of sulphuric acid and nitric acid likely to pollute natural waters; indicator expressed in kg SO_2 equivalent.

- Eutrophication: Imbalance of the aquatic system caused by an increase in nutriments in water (impact on ecosystems).

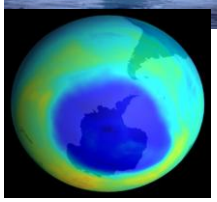
- Solid waste: hazardous, non hazardous, inert, radioactive, recovered (reused, recycled, used for energy purposes).

• Planetary pollution

- Consumption of energy resources (total primary energy, non renewable, renewable).
- Resource depletion: includes the consumption of energy or non-energy resources (excluding water), weighting each resource with a depletion factor indexed to antimony (index 1). A value higher than 1 indicates that the resource is rarer than antimony. The higher the indicator, the more the product depletes resources.



- Air pollution: mainly concerns metals and volatile organic compounds; indicator expressed in m^3 of air required to dilute emissions of the product in order to respect the concentration limits given by the ICPE regulations.



- Climate change: the sum of GHG emissions expressed in CO_2 equivalent.
- Destruction of the stratospheric ozone layer: the sum of gas emissions likely to alter the ozone layer; indicator expressed in KgCFC11 equivalent.

3.2 LCA : GENERAL METHODOLOGY

An LCA of a product is an iterative, normalised process which is valid for all products and services. It is iterative because each stage can lead to a review of the previous ones: for example, difficulties obtaining data for the inventory may result in a review of the study objectives and scope. Full LCAs are broken down into four parts as shown in the diagram below.

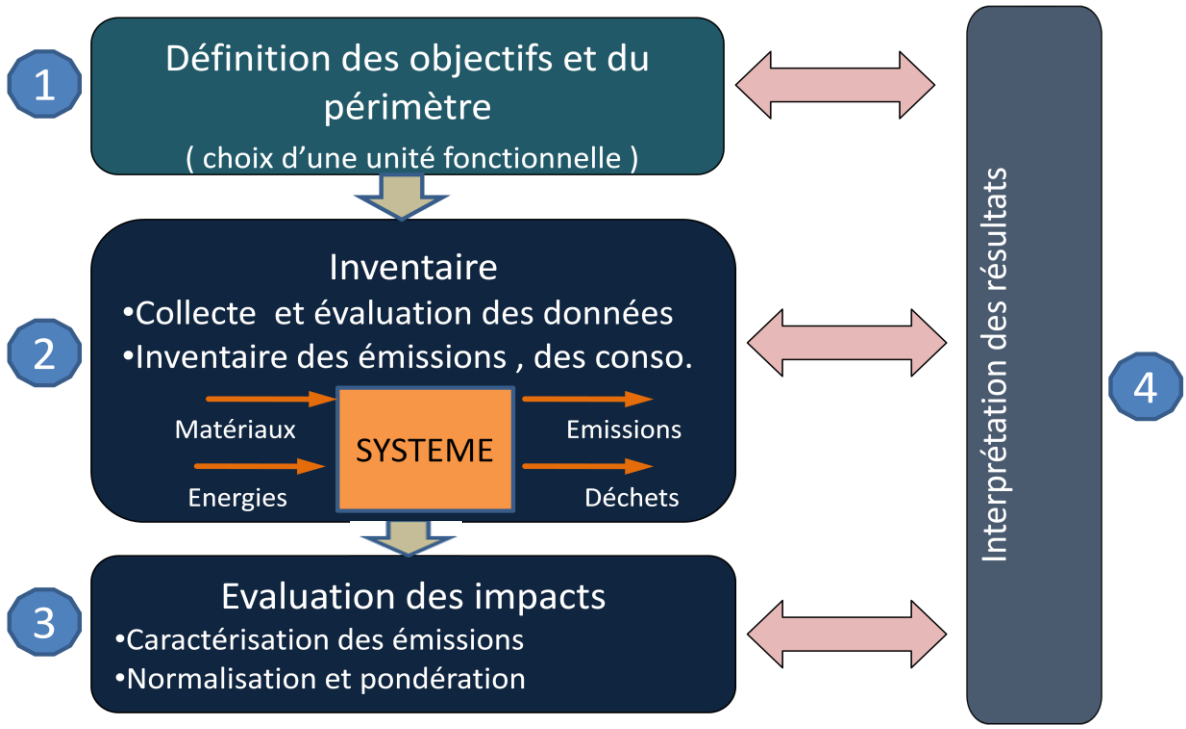


Figure 2 – the four stages of LCA

The weighting of results (e.g. taking the various environmental impacts to give a global score to a product) is not recommended by the standard.

3.2.1 STAGE ONE: DEFINITION OF OBJECTIVES

This first stage is crucial. It aims to determine the exact, delimited purpose of the study as well as your expectations. If the scope of the study is too restricted (for example manufacture only, or customer use only), important impacts may be neglected and the results may be incomplete, leading to decisions based on inaccurate information.

If a broad perimeter is selected, the impacts should be detailed phase by phase. If the aim is to reduce the global impact, the ecodesign levers will emerge from knowledge of the contribution of each phase. The sum of all phases gives much less information.

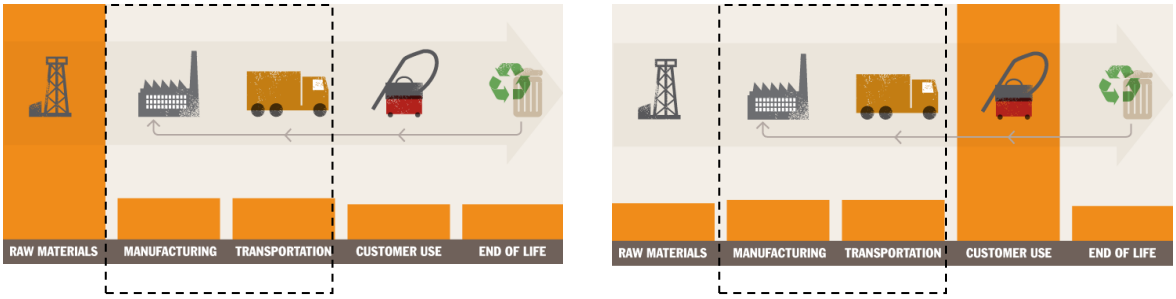


Figure 3 – If the scope is too restricted, for example manufacture and transport, the majority of impacts will be ignored (an example for flooring).

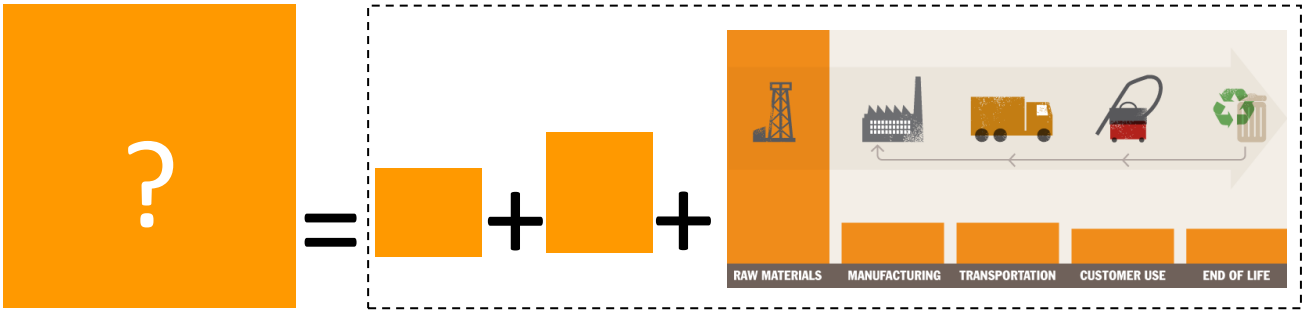


Figure 4 - The results must be supplied phase by phase rather than as a lump total, for example with inclusion of the upstream impacts (energy and raw materials used to build the machines which manufacture the product).

This definition will lead to the definition of the **functional unit** selected, as well as the initial assumptions and the target readership of the study results, in order to guarantee that the scale, depth and level of detail are compatible with your objectives. Examples of functional units:

- For insulating material: *"provide a heat insulation function on 1 M² of wall with a thickness of 100 mm for a typical lifetime of 50 years with thermal conductivity λ = 0.039 W/M.K whilst assuring the product's prescribed performances."*[4]

- 100% softwood 'traditional wood' frame: *"The function of a frame as defined in this study is to assure the transfer of loads from the roof supporting structure to the carcass of the building under the best conditions of stability. The traditional frame is made to measure for each construction site, most often by digital cutting. The volume of wood required and the takeoff of the frame are calculated by the factory's design office. The reference flow associated with this functional unit is 1 M³."*

The impacts to be measured will also be defined at this stage.

[4] Source: EPD for the METISSE M 'recycled textile fibers' 100mm-thick insulating material

3.2.2 STAGE TWO: DATA COLLECTION

The data should be collected for the perimeter under consideration. These data may concern a material, a process, buildings of all types, transport, services, infrastructures, etc. If there is no scale restriction, complexity obviously increases with scope.

What are the data sources?

- Operational field data, which are a highly valuable source (actual consumption by the manufacturing process, known flows, precise knowledge of the materials used and their origin)

- The translation of these field data into an inventory via LCA or product databases, i.e. into hundreds of resource consumption flows (ore, etc.), pollutant emission into the water, air and soil.

3.2.3 STAGE THREE: ASSESSMENT AND CALCULATION OF ENVIRONMENTAL IMPACTS

The data collected in the previous stage are synthesised into environmental impacts (as listed in 3.1)

The standard does not recommend aggregating the impacts into a single score (BREEAM[5] certification). This comes down to weighting the environmental impacts and deciding on their relative importance, a point on which there is no consensus. Furthermore, the scale of the impacts may vary according to the project priorities, for example water and energy on isolated sites or in deserted regions, pollutant and waste impacts on urban sites, etc.

3.2.4 STAGE FOUR: INTERPRETATION OF RESULTS

LCA is a decision-making tool to evaluate the impact on the environment of various solutions, but under no circumstances may it replace the user's final decision on the use of materials. The user can arbitrate in full knowledge of the facts and integrating his economic and social criteria.

The results can be reported in the form of a comparison of N scenarios per type of environmental impact (greenhouse gas emissions, water consumption, extraction of raw materials, etc.) and, for buildings, in the form of a breakdown by lot (carcass work, technical finishing work, etc.)

A comparison of life cycle assessments requires these assessments to be conducted in accordance with the same criteria and the same scope (cradle to grave, cradle to factory gate, etc.), otherwise there is a risk of inaccurate comparisons.

[5] 'Green Guide to Specifications', BREEAM. The BRE ecology guide ecopoints, widely used in the United Kingdom and to a lesser extent in other countries, are based on the weighting of impacts, but there is no international standard or method, as the weighting is arbitrary and may vary according to local issues.

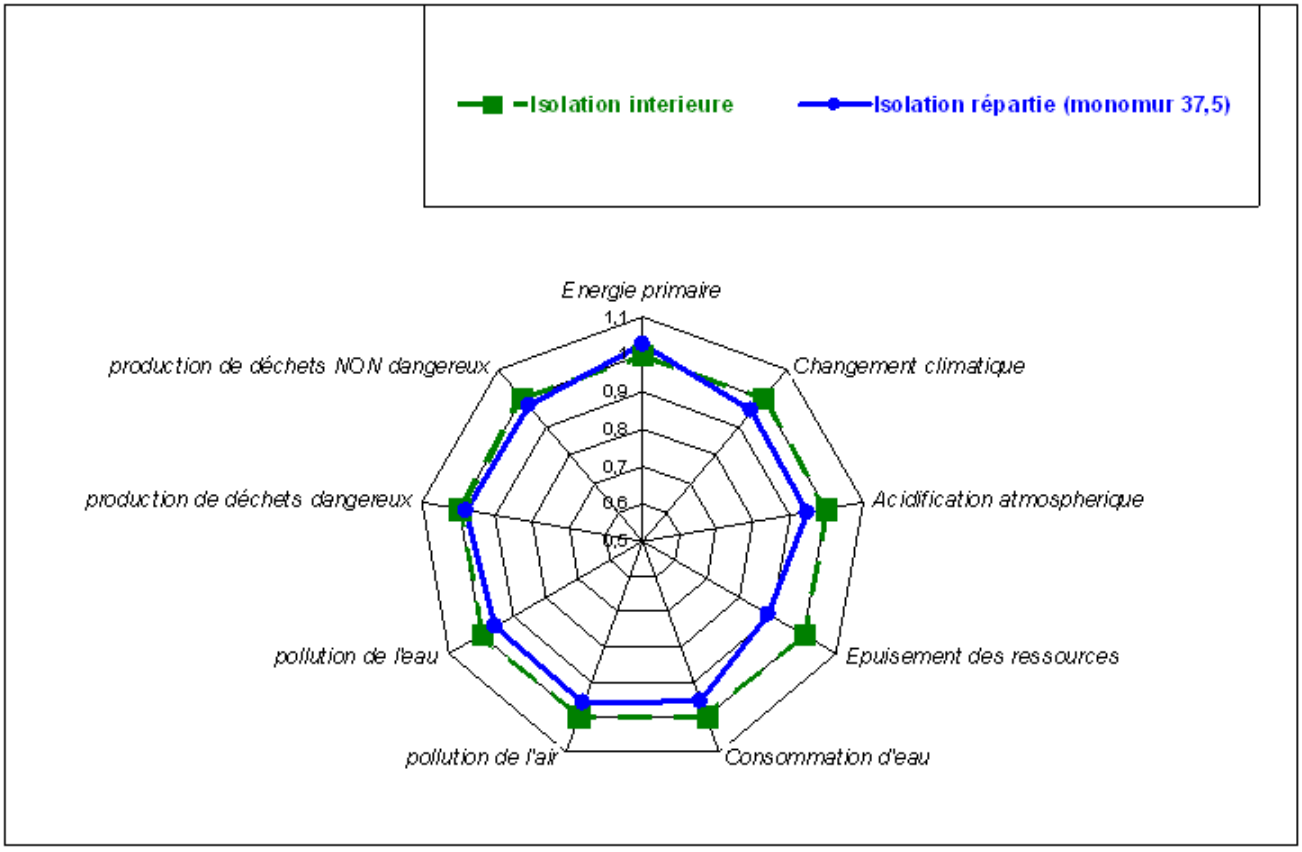


Figure 5 – Comparison of two solutions

Example: Comparison of the impacts of product variants on a complete building for the same function, based on EPD indicators. The first solution (green) is the basic solution; it serves as a benchmark and is given a value of 1 (100%) for each of its indicators in order to facilitate comparisons with the other solution (blue).

3.3 INTERNATIONAL LCA STANDARDS

The International Standardisation Organisation, or ISO, is a world-renowned NGO whose purpose is to promote the creation of voluntary common standards that can be applied all over the world. ISO is composed of national bodies specialised in standardisation. These bodies are public, semi-public or State-supervised, or are national organisations set up by professions (such as AFNOR in France). The authority with the same role at European level is the European Standardisation Committee (CEN).

ISO standards are international standards with voluntary application; their aim is to define and share good practice in a sector (test protocols, vocabulary, management or quality assurance methods, format...) in order to harmonise the activity of that sector. This avoids the profusion of standards specific to each country complicating the development of products, process or services in an increasingly global economy. These standards are developed and updated by various technical committees composed of experts in each field.

Some of these ISO standards may give rise to certification, that is, verification by a competent external third-party organisation that the standards are complied with and applied. ISO 14001[6] is an example of a standard that can lead to certification.

The ISO 14 040 and ISO 14 044 standards provide the principle, the framework, the requirements and the guidelines for LCA. These documents are relatively open in that they do not recommend any particular environmental assessment methodology for each impact, do not set a perimeter, etc. According to the ISO 14 044 standard, if the LCA results are intended to be communicated to a third party, i.e. to an interested party other than the sponsor or the entity conducting the study for their own benefit, a report should be drawn up by a third party in order to ensure the quality and impartiality of the information sent.

LCAs concern all products and services in the economy. This generic analysis should be narrowed down to the construction sector, and the same impacts by product family should be measured in order to make the data usable.

[6] ISO 14001: Environmental Management Standard

4 THREE IMPORTANT CONSIDERATIONS ABOUT PRODUCT LABELLING

Unless the calculations are standardised and the results are presentable, LCAs are unusable. How do we switch from a completely general method designed to study the multiple impacts of all the products and services in the economy using highly diverse verification modes to a method shared by the construction sector as a whole? Or failing this, shared by a product family? With a standard type of result which is comparable from one product to the next?

Labelling is the simple and quick way of assigning a sign of environmental quality or improvement to a product. For example, FSC[7]-labelled wood certifies that the forest it comes from is sustainably managed. In most cases the label only covers a limited number of impacts, sometimes only one.

We return briefly to the main general considerations concerning **the construction of labels and environmental certifications.**

4.1 WHO DEVELOPS THE CERTIFICATION?

The first consideration for a label or environmental certification is its instigator, that is, who (institution, body) is behind the development of the certification/accreditation programme. One or more bodies have consulted the industry's stakeholders in a more-or-less wide-ranging approach in order to create specifications that define the label.

We find several **levels of consensus**:

Origin	Leader	Key points
Private	A commercial entity that sells its analysis	- Quick to develop - Sale of consultancy services for obtaining accreditation - No opening to competition (trademarks)
Semi-private	An industry or a grouping of industrialists with a common interest	- Natural defence of industry interests (no major constraints on themselves, possibilities of methodological bias)
National standardisation	Independent entity falling within the national public sphere.	- Complexity of national consensus (place for debate) - Necessary liaison with the European and International level
International standardisation	International entity led by national entities	- Complexity of European and International consensus - Difficult to harmonise methods

Particular attention should be brought to the labels instigated by private or semi-private actors - their level of rigorousness and seriousness should be checked, as well as the genuineness of the interest group's independence.

[7] FSC: Forest Stewardship Council

National and international programmes are often steered by public bodies and/or NGOs[8] recognised for their expertise and their independence, thus guaranteeing the neutrality and quality of the programme. Below we will only focus on **national and international programmes** capable of generating generalised and shared tools.

4.2 WHO CERTIFIES? (AUDIT, LABORATORY TESTS)

A second consideration is who will accredit or certify the products. The independence of the certifying body is a crucial issue for the transparency and accuracy of the data provided by the label.

There are three degrees of **independence:**

Type	Who certifies	Comments
Self-declaration	The producer declares his own product.	- Untested, unverified declarations
Non-independent third party	The entity depends on the sector of the industrial firm that labels its product. A certificating council of a trade association	- Dependency on the industry
Independent third party	An accredited independent third party	- Independence and accreditation

A self-declared label (for example, “100% recycled”) does not require the declaration to be independently verified.

When a third party certifies the programme, the total independence of the verifier/certifier is the key to avoiding conflicts of interest of the “judge and jury” type. The same is true when the certifying body also provides advice on application and management of the programme.

4.3 CRITERIA AND SCOPE

During an LCA, we may wish to address just **one fundamental environmental impact**: global warming, deforestation, water pollution, drinking water consumption, etc. This is often the case of certain industries with a history of such subjects (heavy industry with pollution, cement works with energy consumption), or when the aim is to address worldwide issues identified as requiring our fullest attention: global warming as already mentioned, destruction of the ozone layer, etc.

The number of criteria determines whether a particular problem is addressed or whether we need a more comprehensive analysis which would also seek possible interactions between impacts.

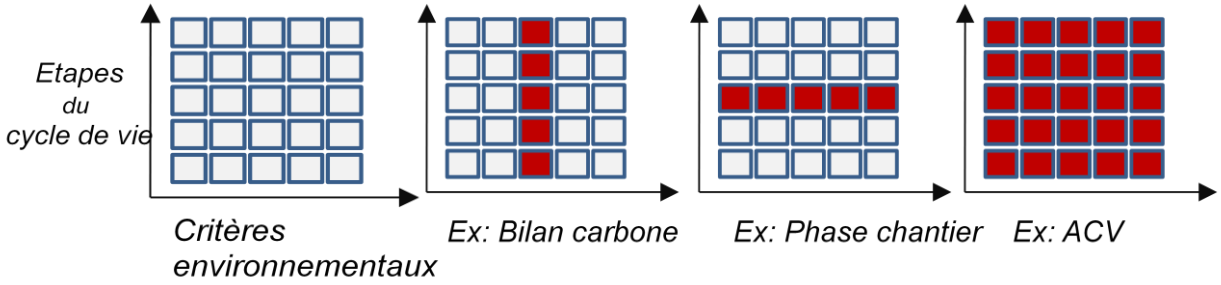
[8] Non-Governmental Organizations

In summary:

Type	What is certified	Comments
Single criterion	Greenhouse gas emissions, water, waste production, human toxicity, volatile organic compounds, deforestation, etc.	- The interest lies in the link between an indicator and a global problem (global warning, deforestation, etc.)
Multi criteria	A count of one o more impacts partial or complete life cycle assessment.	- Comprehensiveness - Cost is sometimes high

A single-criterion label may be simpler to implement, less costly, and focused on the major impact of the product or service.

LCA is a multi-criteria, multi-phase approach which allows global comparisons and avoids – to the extent possible – pollution displacements (aggravating an impact by attempting to reduce another).



A concrete example of pollution displacement: in France a 100% electric commercial vehicle produces less than 25 gCO_2 / Km of carbon along with nuclear waste, due to France's decarbonised/nuclear energy mix. The same van driving in India produces almost 250 gCO_2 / Km, but very little other residue.

4.4 THE "TYPES" OF LABELS AND ENVIRONMENT DECLARATIONS

The ISO 14020 series gives the general principles on labels and environmental declarations:

Type	ISO standard	Mandatory LCA	Third party required?	What the label means	Examples	Good basis for B2B[9]
Type I **Certified Ecolabels**	14024	Sometimes	Yes	The product meets the conditions set by the label – traditionally just one criterion	European Ecolabels Nordic *Swan*, *Blue Angel*, *Etc.*	No
Type II **Self -declarations**	14021	No	No	Usually, improvement in just one environmental aspect	Recyclable symbol, « no parabens » marking	No
Type III **Environmental declarations**	14025	Yes	Yes	LCA information	*Environmental Product Declarations* (EPD)	Yes




The ISO 14024 standard covers Type I environmental declarations, i.e. **environmental labels** indicating the general environmental superiority of a product within a product category, and requires verification by a third party (e.g.: European Ecolabel, French *NF Environnement* standard). For this kind of declaration, an LCA is not necessary but the lifecycle approach is nonetheless recommended, as is the multi-impact approach. This type of programme certifies the conformity of a product or service to the requisites of the programme's specifications. These programmes mainly focus on impact domains such as interior air quality (*Blue Angel, GUT*...), energy consumption (*Energie Star*, NF), or the absence of hazardous chemicals (*ÖKO-TEST*), among others. **Very high-quality and generally intended for mass consumer markets, these labels have become essential and allow people to make a quick selection of products that conform to strict programmes**.


The ISO 14021 standard covers Type II environmental declarations, that is, environmental self-declarations generally based on a single criterion and not requiring third-party verification; this is the case with "recyclable" labelling because although the product or its main components are theoretically recyclable (sufficiently to be indicated), there has been no independent check that the product is actually recyclable at the end of its life. Wording such as "100% natural" and "PVC Free" are also self-declarations. **They should be treated with precaution.**

[9] B2B stands for 'business to business' and is not to be confused with B2C, 'business to client', where the transaction is between a company and a private individual.

The ISO 14025 standard specifies the principles and operating modes for Type III **environmental declarations**, which are based on an LCA (e.g. EPD, ECO-LEAF) and are checked by a third party. The standard stipulates how the **Product Category Rules** (PCR) are to be established for each product type:

- The standards that the LCA must comply with for products in the same range.
- The independence and competency criteria required by the certifying bodies.
- The framework in which the LCA results concerning a product, process or service must be communicated as well as the type of information to be presented, in order to ensure proper interpretation and application of the data.
- Determination of the study scope in a consistent and integral manner allowing a high level of harmonisation in the presentation of the environmental data, thereby assuring the comparability and analysis of the results

Each type of declaration should be adapted to different audiences and objectives. However, it is clear that only the Type III declarations currently allow a complete, reliable comparison across products. They avoid incomplete and possibly biased interpretations and **allow genuine B2B relationships**.

Type III declarations based on full life cycle assessments are good tools for relationships between construction professionals.

User training: a certain level of prior knowledge is desirable in order to interpret and use LCA information correctly.

5 PRACTICAL CASE VERSIONS FOR THE BUILDING SECTOR

5.1 INTERNATIONAL SYSTEM: « EPD »

As outlined earlier, there is an international system devised by ISO which is used to define the framework of LCA-based environmental declarations (type III).

Let us return to construction, with the examples of interior paint and insulating material. Although they are both construction materials, they cannot be analysed in the same way because their use, application and lifetime are all different. Conversely, aerated concrete and Monomur bricks have to follow the same rules scrupulously because they both have the same function and thus depend on the same **product category rule** ("PCR", introduced above). When a type-III Environmental Product Declaration is performed under the international system, compliance with this PCR is mandatory.

A PCR is established by a certifying body (anywhere in the world) whose requisite qualities are described in the standard (recognised expert, independence, etc.) If a PCR does not exist for a product category (characterised by function), this body has to perform in-depth research and consult its international peers along with experts and industrialists in order to construct the rule.

This process is entirely led by the market and the certifying bodies (usually national), thus creating positive competition and full delegation of the organisation modes. The PCR are not centralised at worldwide level, but with the national certifiers or alliances of certifiers. The system is currently being built. Certain national databases are already in operation:

- In France, see paragraph 5.3.
- In Germany the « Institut Bauen und Umwelt e.V. » or « IBU » ;
- In Sweden, Environdec ;
- In Norway and Japan ;
- Lastly, a big American database called « The Green Standard » is currently being created.

Also of note is an attempt to network PCR and EPD internationally, called GEDNET, launched by Germany.

If, for example, a product manufactured in the USA is seeking certification, the certifying body must ensure that a PCR exists for the family to which the product belongs. If the PCR already exists, it has to be used in order to guarantee the harmonisation of declarations. If the PCR does not exist for this product type, a new PCR has to be developed before certification can be performed. At present, there are however PCRs that cover the majority of construction materials.

To summarise…

Life Cycle Assessment

ISO 14040

Conducted by an industrial firm and an independent consultant

+

PCR

Carried out by a certifying body

=

EPD ISO 14025

ISO 21930: Sustainability in building Construction - Environmental declaration of building products

5.2 EUROPE: A FUTURE PCR FOR ALL BUILDING MATERIALS

In 2004, the **European Standardisation Committee** (CEN) gave a mandate for the drafting of specific European directives providing a generic PCR for construction products, in order to be able to supply **Type III environmental** declarations that are comparable across Europe. In 2005 the CEN started up a work group focused on the inclusion of sustainable development in construction, CEN TC350, with the ambition of including environmental, economic and social aspects. A work group deals with the standardisation of construction materials.

As things stand today, the work is not finalised and is likely to be finished in April 2011. France is militating to obtain a European system similar to the one defined in France (see below). The generic PCR for building materials will allow the creation of a single European database that can be exploited with computer aggregation tools to simulate construction works.

The draft European standards are available here (CEN website www.cen.eu).

To summarise:

- For "**European EPDs"**: FprEN 15942, planned for April 2011, is the general framework of declarations for building materials.
- In preparation, the **calculation methods linked to these European EPDs**: PR-EN 15804 planned for mid-2012.
- The general framework for the assessment of construction works, PR-EN 15643 (social, economic and environmental performance), with the complete corpus planned for early 2012.
- The future basis for European certification of construction works: PR-EN 15978, Contribution of construction works to sustainable development (real calculation method), for 2012.

In parallel, the european LCA platform was put in place by the European Commission in September 2005. The objective was to improve awareness and the credibility of LCA methods in decision-making by organisations and legislators by harmonising the LCA methodology, in particular:

- Inventory data : one of the main deliverables of this project is the European Reference Life Cycle Database (ELCD) which offers inventory datasets for various systems (mainly energy and materials) at European level;
- Impact assessment methodologies: the European platform issues recommendations for the choice of indicator evaluation methods.

5.3 FRANCE: "FICHES DE DECLARATIONS ENVIRONNEMENT ET SANITAIRES"

France, with its NF P 01 010 standard, has adopted a building industry version of the ISO 14025 standard for the production of the French environmental declarations, called *Fiches de Déclarations Environnementales et Sanitaires* (FDES)[10].

This is a "generic PCR" for building materials. While 16 environmental impact indicators have been definitively set, the elements specific to products are set by industrial firms in the FDES, for example the typical lifetime of the material (which varies greatly from one material to the next), and the functional unit.

As well as environmental impacts, the FDES provide a framework for the recommended publication of health impacts.

It is possible, although not compulsory, to have the FDES verified by an AFNOR-approved third party, thus making it a Type III environmental declaration as per ISO. Otherwise it is a self-declaration.

This system is pioneering: NF P 01 010 have been operational since December 2004. It currently gives professionals a database containing more than 500 products (at end 2010) (INIES database).

The database **allows computer programmes to aggregate the impacts of materials in a life cycle assessment of the whole building** (detailed later in the document).

[10] Environmental and Health Product Declaration

5.4 THE TOOLS AVAILABLE TO BUILDING PROFESSIONNALS IN FRANCE

- **FDES** are generally type II declarations (self-declaration) that can also be certified by an independent body (when the company voluntarily decides to do so) and thereby **become declarations assimilated with type III**. FDES are based on the calculation and disclosure of LCA results, but the standards applied do not require product family categorizations of the PCR type. An FDES only applies to construction materials.

The existence of an EPD or FDES is not in itself proof of the product's environmental superiority, but simply that a procedure to assess its environmental impacts has been carried out.

- **EPD** are type III environmental declarations (certified by third parties) based on LCA and produced in accordance with the specific rules for each product family in order to provide a very high level of comparability and harmonisation. Product categorisation rules are valid internationally and take precedence over local considerations.

- Categorisation rules have been defined by electricity-materials industrial companies in order to present environmental declarations for their products: the "**Product Environmental Profile" (PEP)**. This system is in the process of converging towards comparability with the FDES, among other things in order to enter the INIES database and be used by computer tools.

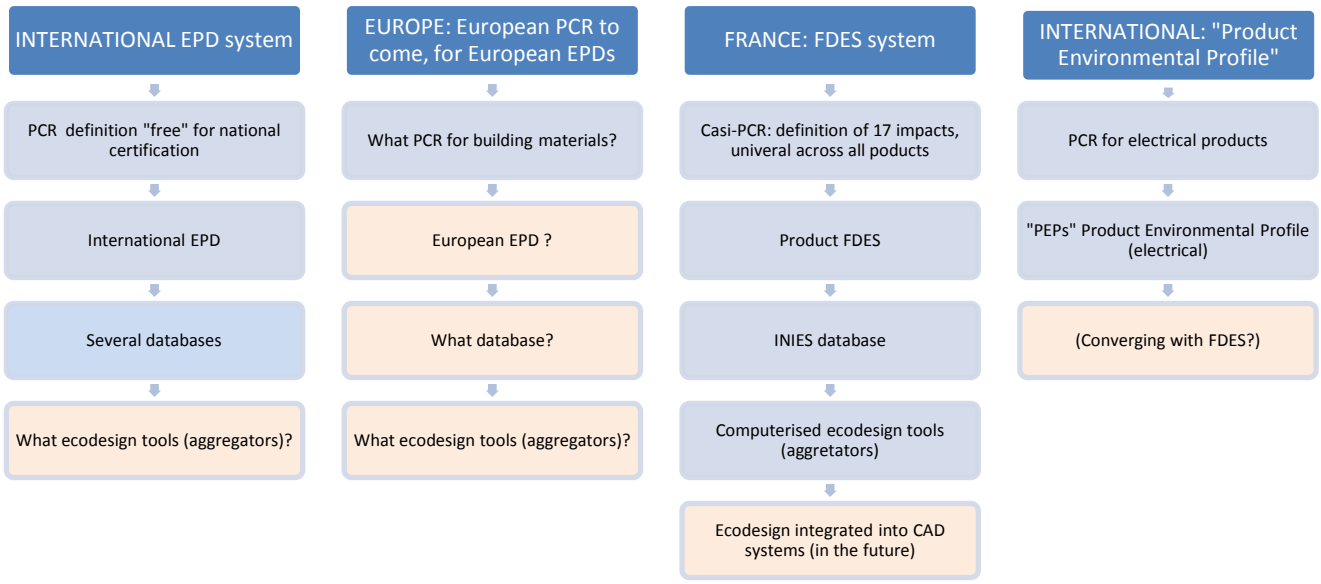


Figure 6 – State of international, European and national development (existing systems in blue, future ones in pink)

Important reminder: our report shows that the existence of an environmental product declaration **is not in itself a sign of environmental quality**. It is proof that the company has, as a minimum, undertaken a transparent procedure for identification and communication of the impacts of its product.

No sign or mark of quality may result from the effort of having an LCA performed unless the absolute performances measured in these environmental declarations are correlated with levels acknowledged as universal. The presence of an LCA is a good sign; it is minimum proof of the firm's awareness of, and its move towards, ecodesign and, ultimately, excellent environmental performance. In order to achieve a quality mark, a type I environmental label needs to be built on absolute, verified criteria.

6 SPOTLIGHT ON DRAFTING AN ENVIRONMENTAL PRODUCT DECLARATION

We think it necessary to explain how environmental product declarations should be filled out: they are very complex or even impossible to compile **unless simplifications are implemented**. Here we take a look at the main ones.

6.1 UNDERSTANDING A COMPLEX SYSTEM

The LCA follows a modelling method which breaks the product's life down into elementary stages and processes in order to pinpoint the impacts associated with each operation or each material used. However, with most industrial products which are manufactured using sub-products that are also industrial, the **system can become fairly complex** (due to the number of chemicals and compounds involved), sometimes involving processes that make virtually zero contribution to the end result.

It is therefore essential to define limits for the system and the scope of the study in order to simplify and facilitate the study. This simplification and standardisation process is done in accordance with good practice in the domain and on the basis of ISO-type standards, particularly those in the 14040 series.

To apply LCA to building materials, it was necessary to standardise and simplify the procedures. Indeed, with the energy required to manufacture a material, the energy mix upon which the industrial process relies, and the number of components or products under consideration, **there is a whole world of possibilities** for which common rules have to be set.

It is a good idea to be aware of the simplifications and assumptions before working on environmental declarations.

6.1.1 IMPACT ASSESSMENT

Let us take the example of greenhouse gases: although carbon dioxide is the biggest and best-known cause of global warming, there are other substances that affect the climate (those known as Kyoto substances as they are included in the protocol of the same name: NOx, SOx, ozone, etc.)

In order to assess the impacts of incoming and outgoing flows (emissions, consumptions), we use impact assessment methods which, in our global warming example, convert substances that cause global warming into a common indicator called "climate change", measured in CO2 ton-equivalent, generally over 100 years. For this conversion we use characterisation factors, in particular **Global Warming Potential** (GWP) for climate change.

Table1 - Atmospheric concentrations in volume, residence time and global warming potential of the main greenhouse gases (source IPCC 2007).

Greenhouse gas	Formula	Pre-industrial concentration	Current concentration	Residence time (years)	GWP over 100 years
Carbon dioxide	CO_2	278 ppm	387 ppm	15 - 200	**1**
Methane	CH_4	0,7 ppm	1,7 ppm	4	**25**
Nitrous oxide	N_2O	0,275 ppm	0,311 ppm	120	**298**
Sulphur hexafluoride	SF_6	0	0,032 ppb	3 200	**22 800**

It is sometimes worth reducing the inventory in order to simplify the LCA down to the main contributing flows. What does this mean? That the hundreds or even thousands of flows relating to the materials can be simplified in order to make the calculation feasible. Two examples:

- Inventories for FDES include the greenhouse gases listed in the Kyoto protocol if they are not negligible.
- The Carbon Balance includes more greenhouse gases than the Kyoto protocol list.

We thus create a simplified model making the calculation possible.

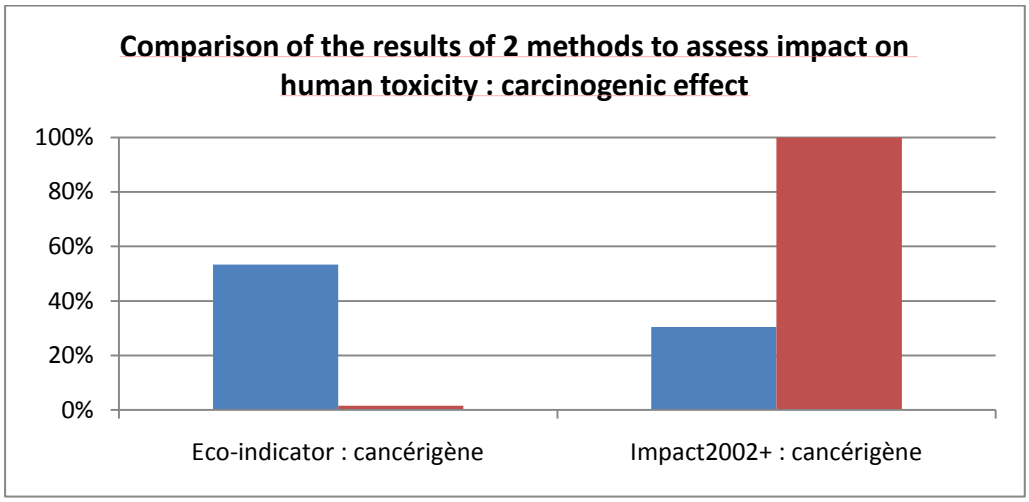
Table 2 – Influence of characterisation factors: inventory reduction principle

Detailed model (N substance flow)		Simplified model (p grouped substances)	
Substance Flow	Characterisation factor	Substance Category	Characterisation factor
S_1	F_1	T_1	G_1
S_2	F_2		
S_3	F_3	T_p	G_p
S_n	F_n		

Simplification and standardisation are necessary in order to make the analysis possible and obtain interpretable results. There are necessary approximations, hence the importance of referring to a high-consensus standard for each impact. The quantification of impacts is based on scientific models that produce values with a real level of uncertainty but which tend to improve over time. To be prudent, we should consider the level of uncertainty to be 20% in general.

Some impacts have been better studied and documented than others. Greenhouse gas impacts are one of them, due to the urgency of the climate issue. Other impacts (including FDES for example) are more difficult to determine.

To illustrate the influence of the impact assessment method used on the results, a comparison of the two energy systems with two different methods to evaluate impacts on human toxicity reverses the trends.

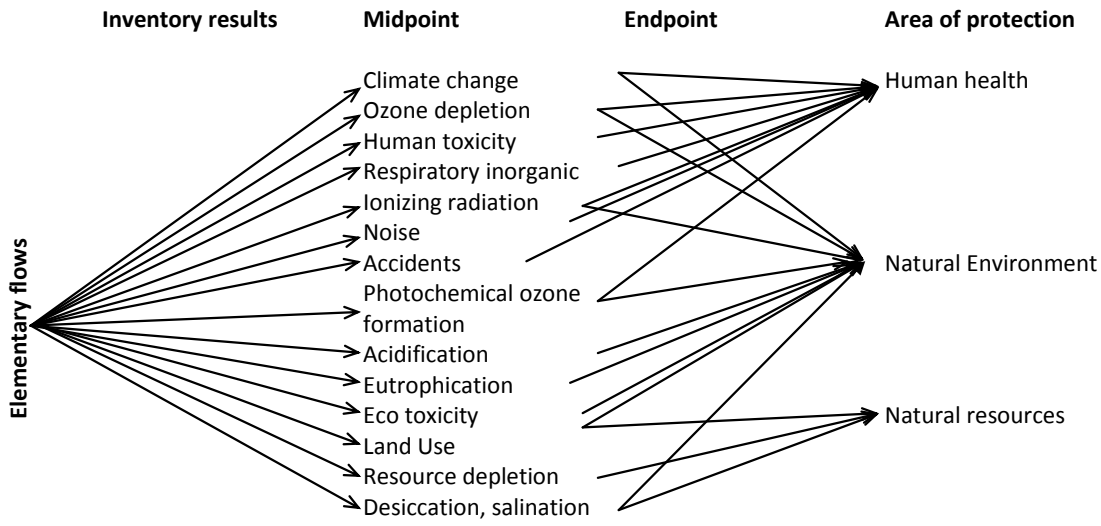


6.1.2 MAIN EXTRAPOLATIONS

Among the impacts that can be studied, there are two types of damage categories:

1. **Midpoint categories**, which convert inventories into a midpoint category score. The impact may be found at any point in the cause-effect chain. Generally speaking, the "further" the impact is from the cause, the less reliable the impact. For example, the human toxicity indicator is less reliable than that of climate change (see example above).

2. **Endpoint categories**, which convert these midpoint scores into damage to human health, ecosystems and/or natural resources; the impact studied corresponds to the final effects in the cause-effect chain (for example, a number of years of life lost for the human health indicator).



Midpoint damage is the cause of **endpoint damage**. For example, climate change is the cause of biodiversity loss. Toxicity is the cause of cancer, and thus of lower life expectancy.

It should be noted that according to the latest advances of the European LCA platform, only the midpoint impact assessment methods for climate change and ozone layer depletion are recommended and considered as satisfactory. No methodology for evaluating endpoints is sufficiently advanced to be taken into account; their use is experimental and therefore not recommended at present.

These endpoint assessment methodologies are complex and consequently a matter of academic debate. However, they will be interesting indicators when there is a consensus about them, as they translate physical-chemical effects into a “political” language.

6.2 IMPORTANCE OF INITIAL ASSUMPTIONS

6.2.1 VOLONTARY ASSUMPTIONS

The manufacturer or industrialist who drafts an EPD or FDES has scenarios that he must confirm in the declaration: geographical location of the production plant, environmental quality of the process used there, supply sources, etc. Here we will list the most important voluntary assumptions.

Second notion: the transparency of the initial assumptions is fundamental to the environmental declaration. Some of these assumptions are voluntary.

6.2.1.1 ENERGY MIX ASSOCIATED WITH PRODUCTION

The energy mix supplying manufacturing plants conditions a portion of the impacts (greenhouse gases, energy, etc.). We give an illustration here.

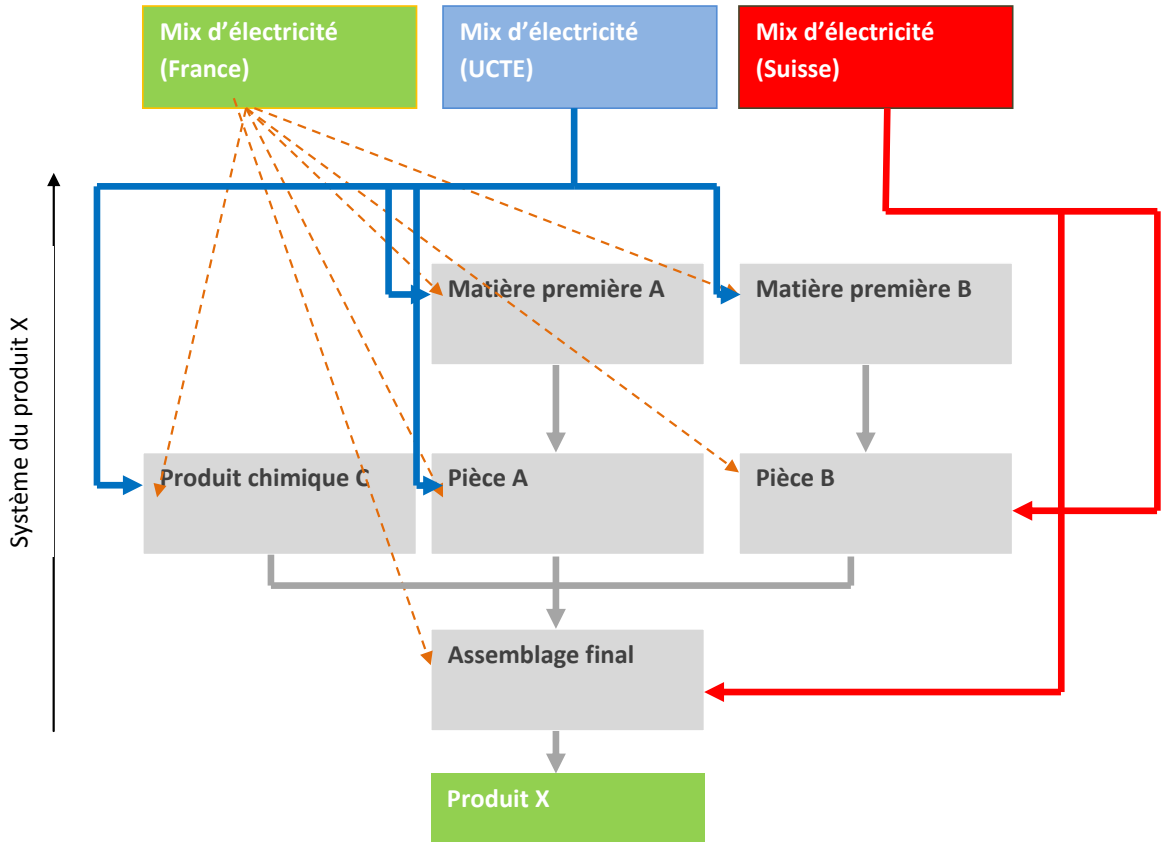


Figure 6 - Example of energy assumptions and influence on the end of the product

6.2.1.2 SHARE OF TRANSPORT

The location of the production plant in relation to its supply sources and its distribution point conditions the "modal" share of the LCA, i.e. the part relating to transport, provided that it is counted (certain LCAs are cradle to grave, while others are "cradle to factory gate" or "cradle to gate", in other words only going as far as the non-distributed finished product).

The French FDES system stipulates cradle to grave accounting.

In France the difference in impact between rail and road transport is probably large.

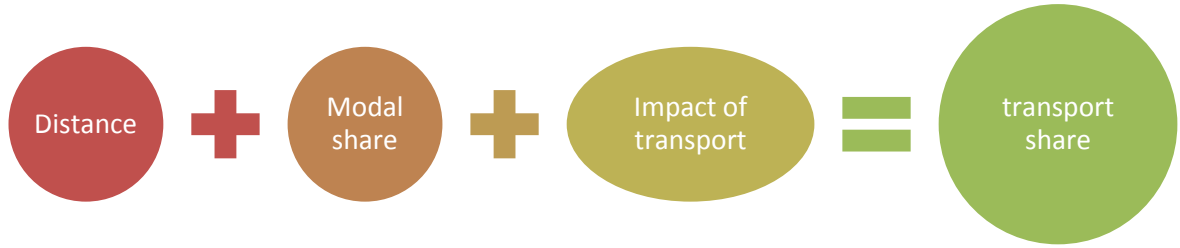


Figure 7 - Source CSTB / Communication on the COIMBA project

FDES generally consider an all-inclusive share for transport, which is one of the assumptions to be remembered when FDES are consulted. Transport is considered as a statistical average of the distances travelled, weighted by the modal share (usual transport mode).

Some computer programmes will soon allow the manual entry of a dependent adjustment to transport, for greater realism. This is an important variable which shows the interest of local loops (use of local materials).

6.2.1.3 USE AND END OF LIFE SCENARIOS

Large variations in impacts originate from scenarios of use and end of life.

Use-scenarios involve the maintenance, cleaning and natural decomposition of the product. As for the **end of life**, it is important to know whether the product is scrapped, reused for energy (incinerated) or recycled (and in what proportions).

These assumptions have a fundamental impact on the global environmental balance. A material reused for energy purposes will have a higher global warming potential (greenhouse gases) but its waste balance will fall sharply. If it is reused in other materials, the share of both these impacts diminishes.

If the company has contributed **to the set-up of a recycling system**, the environmental performance of its products is usually much better. This recycling may be entirely proprietary (the company only recycles its products), industry-led (example of the de PV Cycle association which recycles the production of the photovoltaic industry), or already included in complex recovery systems (steel, aluminium).

At all events, depending on the standard, inclusion by the company of these factors in the environmental declaration (EPD or FDES) is possible if the recycling system is already in place. There is no “promise of a future world” in the assessment of a material: **the results must be based on actual practice.**

It is not rare for an industrial firm to develop one EPD per main economic zone, with different practices. For example, across several products, the carpet manufacturer InterfaceFLOR develops an American EPD based on recycling and a European one based on energy reuse.

Similarly, in the FDES it is not possible to use prospective assumptions.

In France for example, a national agency with strong awareness of industrial waste practices would be able to set end of life scenarios independently.

Environmental declarations must be based on actual use and end of life practices.

Industrial firm with a head start in terms of recycling practice, or whose products have a negligible end-of-life impact, will have a genuine advance in terms of environmental performance

The ecodesign with a head start in terms of recycling practice, or whose products have a negligible end-of-life impact, will have a genuine advance in terms of environmental performance.

6.2.2 INDUCTIVE ASSUMPTIONS

6.2.2.1 VARIATIONS INTRODUCTED BY DIFFERENT ASSESSMENT METHODS

The mechanisms which control the future predictions for pollutants and their environmental effect are complex, and the models used are not always unanimously accepted. Thus, different **impact assessment methods** (CML, IMPACT 2002+, etc.) do not use the same weighting factors to convey the potential contribution of a flow to the overall environmental impact. For a single product (with unchanging entry data and inventory), the use of different impact assessment methods can produce different values calculated using different potential impact indicators. For certain indicators which do not have a general consensus (e.g. eco toxicity), the discrepancies can be significant. As a result, the data recorded for the impacts of certain basic products may vary between different databases.

The differences are often minimal for impacts which are well known and have been calculated for a long time, but they are often more significant for impacts for which the methods of calculation are less developed.

Table 3 - Differences in impact data found in different databases, for 1 square metre of flooring

ıe potential impacts for one square meter of carpet

14641 East Don Julian Road
City of Industry California 91746

PCR Impact Category	Impact	Units/m2
US TRACI		
TRACI, Acidification Potential	2.08	mol H+ Equiv.
TRACI, Eutrophication Potential (Water & Air)	0.012	kg N-Equiv.
TRACI, Global Warming Potential	11.33	kg CO2-Equiv.
TRACI, Ozone Depletion Potential	3.3×10^{-7}	kg CFC 11-Equiv.
TRACI, Smog Air	6.2×10^{-7}	kg NOx-Equiv.
CML 2002		
CML2002, Acidification Potential	0.041	kg SO2-Equiv.
CML2002, Eutrophication Potential	0.01	kg Phosphate-Equiv.
CML2002, Global Warming Potential (GWP 100 years)	11.55	kg CO2-Equiv.
CML2002, Ozone Layer Depletion Potential (ODP, steady state)	2.9×10^{-7}	kg R11-Equiv.
CML2002, Photochem. Ozone Creation Potential (POCP)	.004	kg Ethene-Equiv.
CML2002, Abiotic Depletion	9×10^{-7}	kg Sb-Equiv.

In the table above, we have selected an entry with comparable units (TRACI and CML are in fact two standards, whose results coincide for the results which we are comparing).

We can see that the Global Warming Potential is almost identical, but slightly different (An absolute variation of 0.22, **less than 2%).**

6.2.2.2 INDICATORS TO BE TREATED WITH PRECAUTION

Certain indicators should only be used with a solid understanding of their context. **Total primary energy used in manufacturing a product** is, in an FDES report, added to the potential primary energy contained in the material.

If this latter piece of information may be useful, as it allows you to measure competition for resources between sectors (e.g. between the use of biomass to generate heat and the use of wood in construction), the addition of the potential energy to the energy used in manufacture is not necessarily useful, as not all products taken from the environment are in competition against use for heat generation.

If the total primary energy used in manufacture can be seen as removing resources from nature (in a non-renewable manner), as construction products are not intrinsically intended to be used to generate energy, calculation of potential energy reflects badly on this material while failing to actually provide a quantitative assessment of the product's impact on nature.

A natural industry, and a natural way of trapping carbon, is thus badly served by this calculation. This should change as future versions of the French and European standards are developed.

We need to identify the ingredients which make up these indicators, and if possible to return to the raw or intermediary data when the final indicator turns out to be too vague.

6.3 CONCLUSIONS: BALANCING ASSUMPTIONS AND UNCERTANTIES

In conclusion, uncertainties exist and results are always somewhat approximate. In the long term it is hoped that environmental declaration systems could take these uncertainties into account.

Comparability also requires alignment of the following variables:

- Is packaging accounted for in the calculations?
- Do these figures cover the same scope? Which parts are modal?
- Do these figures refer to the same functional unit?
- Technical performance (standard, acoustic quieting, UPEC etc.)
- What 'typical product life span' figures were used for these calculations?
- What are the end-of-life assumptions?

We cannot directly compare two different environmental declarations unless they are aligned in respect to these variables.

It is important that ecodesign programmes are transparent about the hypotheses which underpin them, and allow users to correct these hypotheses where necessary to better reflect the reality of a situation.

Finally, a fundamental question is whether the overall impact of the building is stated at a global level for a given indicator. If the impact on global warming is known, and traditionally estimated to account for 40% of the overall impact of human activity, the contribution of construction is significant (or even massive), and should be accounted for in our assessment methods. There is no firm data on the influence of construction on other forms of environmental impact (acidification, Eutrophication etc.).

6.4 THE STATUS OF "GENERIC" FDES DOCUMENTS

In order to get started and make building impact calculations usable as soon as possible, the first FDES declarations were 'generic'. Sponsored by professional syndicates representing families of materials (e.g. the FDES for 'stone and concrete block walls'), these FDES provide average data for the whole sector, with each environmental impact figure **the average of total impacts, weighted according to the market shares of each industrial manufacturer**.

These initial documents made it possible to calculate the impact of a 'generic' building (made of 'average' products, not specifying suppliers). If one product family was not covered by an FDES, it would be very difficult to calculate the total LCA for the building.

In this respect generic life cycle assessments provided the first environmental impact simulations, and are sufficient until individual projects are covered by their own environmental declarations.

But these 'generic' FDES will rapidly become outdated because:

- They do not allow for ecodesign via product comparison (as the average figures do not correspond to any real products).
- Manufacturers whose products have a lower environmental impact, thanks to an ecodesign policy, for example, will not receive recognition for this under the generic scheme. It will be in their interest to establish their own FDES declarations to publicise their work.

Ultimately a 'generic' approach is only logical for certain products (for example the 20cm breezeblock, produced by many small businesses) where the product is standardised. It is still preferable to be more precise.

In the same way, FDES documents compiled without details of the distribution of the impact throughout the whole life cycle will be rapidly surpassed by new declarations **which present specific details for each phase**. This new form of declaration will be standard in the new European system currently being created.

The choice between generic and specific data will depend on the progress of the project. In the early design phase, it is a matter of comparing different architectural and technological options (for example wood, concrete, steel etc.). At this stage generic data is more suitable. At the detailed design stage, specific product data will allow planners to choose between different suppliers.

6.5 THE FRENCH SYSTEM AND THE INTERNATIONAL SYSTEM

This table offers a comparison between the two most well-known systems.

Points of comparison			EPD*	FDES
Scope of standard			International	National
Age of standard			2009	2004
Requires product category rules which are standardised for each product family (PCR)			Yes by family	Yes, not by family but covering all construction products
Language of standards and declarations			Any	French
Information determined by the framework standards (or by the PCR)	Types of product covered		Fully specified	
	LCA information to be provided (types of product, scope, stages, presentation of the information, quality etc.)			
	Other non LCA aspects	Health factors : toxicity, pollution etc.	Partial**	Expanded (6 indicators)
		Installation phase and active service period	Included	
		VOC emissions	partial	
		performances/quality	partial	
		Other certifications of the product	Included	
		Waste	Included	
	Functional units		Fully specified	
	Duration of declaration		limited	Unlimited
Standardised LCA	Reference standard		ISO 14040	
	By family of products		By PCR	By sector (building)
Validation and independence	LCA checked by experts		Compulsory	Not compulsory
	Verifying agents are independent		Guaranteed	Primarily a self-declaration scheme
	Qualifications of the verifying experts in this field		Specified by the standard	If verifying experts are used, they should be AFNOR accredited
Comparability	Of products within the same family		Yes	Complicated, requires double-checking of hypotheses and variables
Usage	France		International	France
	Economic sector		All	Construction industry
ICT resources	Centralised database		No single database	INIES, single database
	Aggregators available for project ecodesign		In development	Yes (at least 3))
Public	B to B dialogue tool		Excellent	
	B to C dialogue tool		Possible but complicated	

*EPD after a PCR produced by a certifying body

**Health indicators are generally less strict in EPDs than FDES documents, and only assessments which have received a broad scientific consensus are retained: there are fewer such assessments in the domain of health

Both systems are being developed, and updates are made regularly. The current trends of development are:

For the EPD system

- System for searching centralised national databases - 'national sanctuaries for EPD' - interlinked national systems. Hence the attempts to establish a network of national certifying bodies;
- Developing new programmes, or improving existing ones, to allow EPDs to be processed by aggregators which are capable of calculating the environmental impact of a whole project;
- A 'building products' PCR could clarify the situation in this market towards the end of 2011, paving the way for a unified European system.

For French FDES

- Moving from self-declarations to Type II certifications, certified by accredited third parties,
- Compulsory quantification of impacts at different stages,
- Develop software functions allowing users to correct and adjust different assumptions used to make calculations.

French standardisation authorities are currently working to ensure that European regulations incorporate many of the principles of FDES.

7 AGGREGATORS : WORKING WITH ENVIRONMENTAL DECLARATIONS

It's not just a matter of having the documents (FDES, EPD), it is what you do with them!

- For *the contractor*, progress in product ecodesign.
- For *the designer*, justifying design decisions with reference to an environmental philosophy.

There is a link between voluntary environmental certification of a project (e.g. HQE) and FDES. The interested parties prove their environmental performance largely by referencing the relevant product declarations. Yet these documents, collected for certification purposes, are not always well-used or even well-understood.

It seems highly likely that future project certifications will see increasingly close links between intrinsic performance in terms of environmental impact and more effective exploitation of FDES (as with 'HQE Performance').

Collating and manipulating such large quantities of information is difficult, and requires the use of aggregating software. The following is a non-exhaustive overview of the programmes available.

7.1 DESIGN SOFTWARE WITH PRODUCT LCA

GaBi 4 is the leading software for modelling products and systems with an emphasis on life cycle. The programme is offered by PE International. It includes information on the life cycle of a large number of materials and processes, with regular updates to take account of the latest scientific advances and provide a reliable resource for evaluating materials, products, services and processes.

SIMAPRO is a scientific Life Cycle Assessment (LCA) tool developed by PRé Consultant, a firm of consultants and editors based in the Netherlands. SimaPro is designed to serve a number of different purposes:

- Advice to facilitate ecodesign decisions
- Very advanced functions: customisable LCA, uncertainty analysis, substance tracing etc,
- Simple to use: ergonomic interface, easy to import and export files as spreadsheets or in other formats...
- Around 7,000 materials and processes modules with the standard edition, and sector-specific data including data for the electricity/electronics industry.

ADEME PRODUCT REPORT: this tool, developed in partnership with the University of Cergy-Pontoise using the Ecoinvent database, allows users to generate a model for the future performance of a product, taking into account the major stages of its life cycle: the materials of which it is made, the processes used in its manufacture, means of transport, energy sources. Estimates of environmental impact are calculated with reference to eight indicators, allowing users to compare different scenarios for the same product.

7.2 PRODUCT LCA DATABASES

The following is a non-exhaustive survey of the LCA databases available in France.

7.2.1 ECO INVENT

http://www.ecoinvent.ch/

The Ecoinvent centre was founded in 2000, and represents an association of LCA research institutions including departments of the federal polytechnic institutes of Zurich (ETHZ) and Lausanne (EPFL), and other institutions such as the Paul Scherrer Institut, the Swiss Federal Laboratory for Materials Testing and Research (EMPA) and the Federal Institute for Research in Agro-ecology and Agriculture (Agroscope FAL Reckenholz). The aim of Ecoinvent is to provide industry, public authorities and research institutions with transparent and detailed life cycle inventories, in order to improve the environmental performance of their products, processes and services. The data in our study will be taken from the latest version – Version 2.0, released in 2008. The comprehensive nature of the data and the transparency of the calculations make this database an international reference standard for LCA professionals.

7.2.2 LA BASE INIES

(www.inies.fr)

The INIES database is the French benchmark database for the environmental and public health properties of building materials and products. FDES are supplied by manufacturers or professional syndicates in the format specified by standard NF P01-010. The running of the INIES database is overseen by a supervisory board and a technical committee. The supervisory board, headed by the Directorate for Construction and Town Planning, is responsible for maintaining the ethical standards of the INIES database. The technical committee oversees the gathering and processing of data, and updates the content of the database.

The INIES database currently holds more than 500 FDES records.

7.2.3 DEAM™

(https://www.ecobilan.com/fr_deam.php)

The TEAM™ programme (cf. infra) comes with a basic database called DEAM™ Starter Kit, containing aver 300 modules that can be used to construct practically any system. These modules cover processes from fuel production through to the different modes of transport used, and from production of basic chemicals through to the process of moulding plastic.

The modules provided with the DEAM™ Starter Kit represent only a fraction of the full range available, listed in Ecobilan's general catalogue of environmental modules (known as the DEAM™ Database - Data for Environmental Analysis and Management).

7.2.4 ÖKOBAU.DAT

A German resource including over 700 specific and generic EPDs, collated and published on the internet by the organisation BMVBS. This database, like the INIES and ELODIE systems, contains the data required for entries to the software programmes GaBi, BUILD-IT and LEGEP (see below).

7.2.5 THE FOUNDATIONS OF A EUROPEAN DATABASE ELCD

The European LCA Platform offers a database of inventories on its website : the European Reference Life Cycle Database (ELCD) includes inventory data for different systems (principally energy and materials) throughout Europe. However this database was compiled very quickly, and is not transparent about the hypotheses on which its data are founded, making it unsuitable for use by experienced professionals and difficult to understand for the industrial parties concerned. As a result, several industrial federations have not given their approval to the data contained in this database.

7.3 AGGREGATION SOFTWARE FOR CONSTRUCTION WORKS

The following are the programmes available to French designers. It should be noted that it is not always essential to use an aggregator based on a database of environmental declarations.

LCA experts may, if they wish, perform a full LCA for a district or building, focusing on certain impacts, by returning to the raw data in order to circumvent the inaccuracies which arise from approximations made in the calculation process.

In this way French experts use the product tool SIMAPRO in order to achieve greater precision and to work more freely. Calculations are thus left to the experts.

For day-to-day design purposes, and in order to ensure that operations can be reliably reproduced, it is important for designers to learn how to use a good aggregator.

7.3.1 ELODIE

Developed by the CSTB, ELODIE is a programme for LCA of construction works. The programme takes account of the contribution of construction materials and products to a building's environmental impact, as well as its energy and water consumption when in service. The ELODIE software is expected to develop rapidly to cover all professional requirements. Users will soon be able to assess the same project at different phases in its life cycle: design stage, operational phase, rehabilitation. Future versions of ELODIE will include other tools and functions, taking account of factors such as acoustics, quality of interior air, aesthetics etc.

7.3.2 THE TEAM BÂTIMENT TOOL

Developed by PriceWaterHouseCoopers and their ECOBILAN subsidiary, TEAM™ Bâtiment system is also an FDES aggregator, including a confidentiality function for sharing resources during architectural competitions, and a module for entering and translating international EPDs. The programme offers modelling options for 'buildings and districts', and can extrapolate from available data to compensate for lacunae in the information provided.

ELODIE is partnered with the INIES database, which collates environmental and public health declarations (FDES), and other FDES libraries.

ELODIE has been developed in collaboration with building professionals, with respect for standard XP P01-020-3 and the work of the Sustainable Building Alliance (SBA).

7.3.3 ECO-BAT

ECO-BAT is a Swiss programme developed by LESBAT (Laboratory for Solar Energy and Building Physics) which at the time of writing aggregates results from around sixty sources for six key indicators.

7.3.4 EQUER

EQUER is a construction LCA tool first launched in 1995 by the Ecole des Mines de Paris –ParisTech (energy and processes centre). Graphical data entry (using the ALCYONE programme) makes it easy to enter project data and compare different versions. Chaining to dynamic thermal simulation (the PLEIADES-COMFIE programme) allows for calculations which take account of the influence of choice of materials on energy consumption and related impacts. EQUER uses the LCA ECO-INVENT database, which takes into account over a hundred different processes involved in a building's life cycle (energy, water, waste, transport…). A version based on the INIES database is currently in development. The software has also been updated to allow calculations for whole districts.

7.3.5 PRODUCT LCA CALCULATOR (EIFFAGE CONSTRUCTION)

An internal tool developed by Eiffage Construction allowing users to compare different products on the basis of their environmental performance, then calculate the environmental impact of these products when applied in a building project. The programme contains data on the impact of over 500 products or product families with reference to ten different indicators. As a tool for analysing and comparing the environmental performance of construction products, this software allows users to compare products and whole projects, adjusting construction variables. It is also possible to enter consumption data for the building, in order to assess construction impact in comparison with operating impact. The programme also includes a 'Materials Carbon Balance' function.

7.3.6 GABI BUILD-IT

A programme founded on the aforementioned ökobau.dat database, developed by the consultancy firm PE International. Like ELODIE, this software allows users to aggregate EPDs at project level.

8 LINKS BETWEEN ENVIRONMENTAL DECLARATIONS AND PROJECT CERTIFICATIONS

A programme founded on the aforementioned ökobau.dat database, developed by the consultancy firm PE International. Like ELODIE, this software allows users to aggregate EPDs at project level.

United Kingdom	BREEAM and Eco-Profiles
France	HQE and FDES
Germany	DGNB and EPD or life cycle assessment
USA	LEED: no reference to LCA (currently being studied by US GBC)

9 PROJECTS RELATED TO LCA

9.1 TIGHTENING OF EUROPEAN REGULATIONS

9.1.1 THE ECODESIGN OR EUP DIRECTIVE, CURRENTLY BEING EXPANDED.

Whether they are individual products or whole buildings, the priority is effective ecodesign. The European Commission has long been keen **to promote ecodesign**, while providing supporting materials allowing users to better understand the methods and tools involved.

The first directive in this field dates from 2005[11] and concerns only ecodesign of electrical products, with a view to improving their performance. According to the International Energy Agency, as much as 15% of energy consumption in Europe may be attributed to appliances left on standby mode. The 'Ecodesign' directive aims to achieve a 55% real-terms reduction of this figure by 2020.

This directive was significantly revised in 2009[12] to cover ecodesign in general, recommending LCA. Nonetheless, the directive still only concerns electrical products which consume large amounts of energy.

The European Commission sees this directive as a cornerstone of European policy on sustainable construction. A forthcoming revision[13] will launch product labels and policies on environmental conditions for public procurement and tax credits.

The leading ideas for expansion of this directive concern water distribution in buildings, insulating materials and windows and doors. The goal is to obtain a **fully revised directive by 2012**.

This directive falls under the control of the Energy, Transport and Environment Directorate of the European Commission.

9.1.2 TOWARDS A EUROPEAN"BUILDING ECOLABEL"

The European Commission (Environment Directorate) hopes to launch an official Ecolabel for buildings, and has entrusted the Joint Research Centre with the development of this label. The JRC conducts technical and scientific research to assist the Commission in its policy decisions.

The Ecolabel will cover materials. A broader consultation is currently being planned.

[11] Directive 2005/32/EC of the European Parliament and Council, July 6th 2005
[12] EPBD Recast: Directive 2009/125/EC of the European Parliament and Council, October 21st 2009
[13] Communication COM(2008)399 of the European Commission.

9.1.3 REACH

The European Regulation on Registration, Evaluation, Authorisation and Restriction of Chemicals, REACH, establishes a single European system which prohibits the use of certain substances and limits the use of others, in order to protect human health and the environment. While LCA produces a general quantification of environmental impact, this regulation aims to halt or reduce the use of the most harmful substances, predominantly carcinogens, mutagens or reprotoxiques chemicals (chemicals which damage human reproduction).

9.1.4 CONDITIONS OF SALE FOR PRODUCTS: A DIRECTIVE UNDER REVIEW

Another policy of the European Commission worth mentioning is the regulatory project to establish harmonised conditions for the sale of certain construction products, aiming to replace Directive 89/106/EEC concerning construction products and adapt its conditions to current requirements, to update them and to set out a European legislative framework including safety, health and environmental protection guarantees which cover the whole life cycle of a product, from its design to scrapping.

9.1.5 SB ALLIANCE – "COMMON METRICS FOR KEY ISSUES"

The SB Alliance aims to establish a set of key indicators common to all environmental certifications used internationally. The hope is that in the near future it will be possible to compare the performances of buildings from all countries in a single database. The specified environmental indicators are calculated using the methods of Life Cycle Assessment.

9.2 PUBLIC HEALTH FACTORS

Health considerations are one of LCA's weak points, as they are not officially included in the list of compulsory criteria. FDES and EPDs attempt to include the health consequences of products, but do not always adhere to a specific, recognised standard.

Work needs to be done to establish some uniformity of data in this field.

- FDES declarations do not currently specify criteria for the nature and source of any health information provided. Health information is lacking for many products, and even when provided it is hard to compare products on this basis because this field is still under development. Nonetheless, we do have some firm information concerning the chemical compounds which affect interior air quality.
- The international EPD system requires product categorisation rules to calculate environmental impact. Yet products in the same category which can be compared on environmental performance cannot always be easily compared in terms of health issues.

Public health considerations are becoming increasingly important, but they remain very difficult to process and analyse. A cross-disciplinary approach with contributions from different healthcare specialists is required.

However, it is interesting to observe the way in which progress is being made in certain fields, such as the declaration of all substances present in products required by the European REACH regulations.

Public health regulations are constantly evolving, with the launch of various environmental and health labels which set limits for atmospheric emissions and restrict the use of certain substances.

But we must remember that there is not always a system of equivalence between these labels...

9.3 FRENCH REGULATIONS

9.3.1 PROJECT FOR ENVIRONMENTAL PRODUCT LABELLING

An environmental labelling system, announced at the GRENELLE Environmental Conference

In light of GRENELLE II,[14] and particularly article 40, the Ministry is launching a programme of environmental product labelling for building materials, with the intention of improving indoor air quality.

Law GRENELLE II, article 40, extract

"With regard to interior air quality, from January 1st 2010 all construction and furnishing products, as well as wall and floor coverings, paints and varnishes and all products whose purpose or side effect is to release substances into the surrounding atmosphere, will be covered by a compulsory labeling system, dealing particularly with their emissions and contents of volatile pollutants. These products must be free of substances classed as carcinogens, mutagens or toxic to reproduction in categories 1 and 2 (CMR1 and CMR2), as defined in the European regulations.

Within a year of publication of the present law, the State will publish a study on the necessity of expanding these measures to other categories of widely-consumed products likely to pollute interior air in homes or enclosed public spaces, including cleaning products or products intended to release volatile substances into the atmosphere. Systems of measurement and information on interior air quality will be put in place in establishments frequented by vulnerable persons or the general public."

A decree is currently being prepared.

With a view to the labelling system for construction and decoration products announced in the GRENELLE agreement, the AFSSET[15] has developed a measurement protocol and established a list of 165 compounds which may be emitted by construction and decoration products, and which might affect human health.

For the moment, the AFSSET protocol concerns only construction products, i.e. all products manufactured for long-term use in construction projects, and decorative products used to cover walls, floors and ceilings. But the agency is planning to extend the scope of its reflections to cover furniture items and commonly-used products such as cleaning materials and air fresheners.

Implementing this labelling system would put us on a par with countries which have already implemented similar measures, such as Sweden, Germany and Japan. In Japan, measures of this kind allowed the authorities to reduce from 30% to 1%, over a period of just 5 years, the number of houses which exceeded the Japanese guideline limits of formaldehyde.[16]

[14] Law n° 2009-967 of August 3rd 2009, concerning the implementation of the recommendations of the GRENELLE conference.
[15] National agency for health and safety in food, the environment and the workplace.
[16] Source: actu-environnement.

10 SCOPE AND LIMITATIONS OF LCA EXPANSION, OTHER ASSESSMENT TOOLS

10.1 EXPANDING LCA TO COVER A DISTRICT, OR WHOLE REGION

One of the major advantages of LCA is that it takes into account the whole life cycle of products and systems. Nonetheless, when considering a whole region, it does not allow you to visualise the movements of flows in and out of a territory generated by the presence of a building. But Materials and Energy Flow Analysis (MEFA) counts the materials, water and energy which go in and out of a region, thus allowing us to optimise flows within a territory, to the benefit of territorial or industrial ecology.

This is why companies which work in waste management, energy supply and construction – such as GDF SUEZ – developed a methodology in 2009 combining LCA with Materials and Energy Flow Analysis (MEFA). The pairing of these two processes **allows for both a comprehensive understanding of environmental impact in a given area** (impact on climate change, depletion of energy resources, acidification of the atmosphere etc.) and a clear picture of the recycling loops which could be established within the area (e.g. reuse of waste materials, recovering energy from grey water etc.).

Experiments with LCA and MEFA have been running since 2005, in partnership with various local authorities (Lille, Longjumeau, Caudebec-les-Elbeuf, Valenciennes, Bayonne). These experiments have helped the towns involved to identify the weak points of existing districts and buildings, and/or helped inform investment decisions (renewable energy installations, travel arrangements etc.).

The aim is to arrive at a tool which provides effective operational support to the Climate and AGENDA 21 schemes, and the Environmental Approach to Town Planning programme developed by ADEME.

Life cycle assessment has been applied on an urban district level as part of the European 'Eco-housing' project, the ADEQUA project and the ACV neighbourhood project (the National Research Association's Sustainable Towns programme).

10.2 DYNAMIC LCA FOR THE OPERATIONAL LIFE SPAN OF A BUILDING

This part of LCA consists of calculating the environmental impact of a building during the time it is in service, and is also based on calculated averages:

- Average annual consumption
- A standard formula accounting for the sources of electricity production in France

But our energy mix is changing, and the balance is not the same in the peak of winter (high dependence on fossil fuels)[178] as it is in the summer off-peak period (more nuclear). The diagram below charts the trends in French electricity consumption, broken down by use and by method of production.

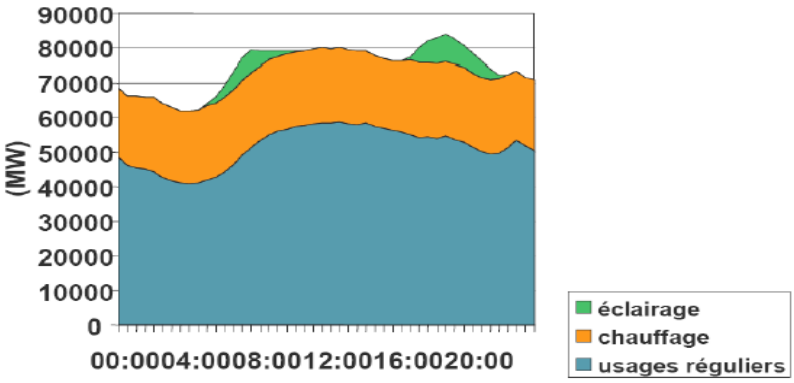
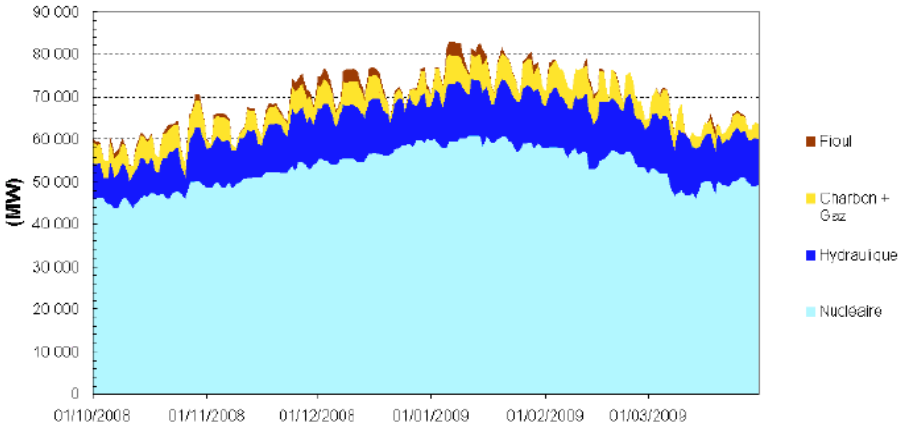


Figure 8 – Consumption (in MW) over the course of a winter's day, broken down by type of use.
- Source RTE

Figure 9 - Power required by method of production, Winter 2008-2009
- Source RTE



Research projects are currently in progress with the aim of expanding LCA tools to permit 'dynamic' estimates, i.e. estimates which take account of developments in the load and environmental quality of the network. A green building should be able to minimise (as far as is possible) its demand during the daily peak period (using the thermal inertia effect, load shedding etc.). This remarkably environmentally-friendly approach would not be taken into account by a 'classic' LCA.

Once such initiative is the PREBAT 'COIMBA' project funded by the National Research Agency.[18]

[17] The Sido-Poignant Report, findings of a Parliamentary working group investigating ways of managing the peak in electricity demand, April 2010.

[18] Participants : CSTB, Ecole des Mines de Paris, NOBATEK, IZUBA Energies et ENERTECH.

Such advances should also allow calculations which include the influence of the modal share of transport.

New computer technology should enable us to test the validity of various hypotheses, and thus to better reflect the realities of the project under consideration.

Eco designers using this new technology will be able to predict in detail the results of any modifications they make.

10.3 PRIVATE INITIATIVES

The « CRADLE TO CRADLE®[19] » or C2C private method, was launched in 1987. Management of this system was entrusted to a private international agency, with the aim of replicating the success of the method in countries worldwide via partnerships with local consultancy firms.

This simple, very cross-compatible method is less a product certification scheme than a system which helps industrial clients to develop their ecodesign capacities. Ecodesign consultants assess environmental impacts and, in collaboration with technicians from the company, draw up development plans. The company technicians will thereafter have to rely upon LCA-based quantitative analysis methods in order to ensure the implementation of these plans.

C2C certified products meet 5 requirements: any materials likely to re-enter the environment must be non-toxic or even environmentally beneficial (e.g. organic cosmetics or fully compostable t-shirts); products must be reusable; they should use energy from renewable sources; they must respect the water system and they must respect social regulations. There are no immutable functional laws and LCA is not used systematically; the emphasis is placed firmly on progress, regardless of starting point (initial environmental impact assessment) or target performance.

As for the transparency of the C2C certification, we do not have access to the data and details of the methods used to reduce environmental impact (which are generally confidential), which restricts B2B communication and does not allow C2C results to be analysed by aggregators. C2C certification demonstrates that the company involved is making progress in its ecological performance.

We should remember that the point of the C2C method is to manage the transition to ecodesign, which can also be achieved using LCA-based analyses.

[19] Registered trademark

10.4 LIMITATIONS OF LCA

LCA cannot do everything, even if it is currently the most ambitious standardised method currently present in the construction industry. There are some obvious limitations:

- Local impact linked to on-site integration is not considered by LCA. To give an extreme example, if an eco designed building were to contribute to the destruction of biodiversity in the local environment, this impact would not fall within the scope of the LCA study, and thus would not be quantified. Nonetheless, new building projects involve other impact analysis studies which complement the LCA method.

- Health and safety consequences are not yet covered (see above) in a systematic, universal manner.

- It is an approximate method.

- FDES records are complex and hard to read, and it is very difficult to compare them 'on the spot'. They often cover a whole family of products, making comparisons between different brands impossible. Moreover, comparisons are not always informative at individual product level.

- While FDES documents are available for more and more construction products, the procedure is only rarely carried out for fixtures and fittings (bathroom items, heating, lights, ventilation etc.). Moreover, certain product families are very small, or not yet established.

11 PRACTICAL QUESTIONS

1. **I want to ecodesign a building. How should I manage my project using these new tools? I want to change the way I use products to improve the overall environmental performance of the project.**

   Ecodesign is not only a matter of how you manage your construction materials, as location of the building and optimisation of surrounding natural resources play a major role in what we call 'bioclimatic design', and thus environmental performance.

   The problem of choosing materials is not only a question of local capacities for manufacture and end-of-life management as understood by LCA, but also of the direction the construction project takes as a result of the priorities defined by the client.

   Indeed, these priorities will inform and justify choices of materials which are more or less environmentally friendly. If we compare two materials offering different environmental benefits (one for carbon emissions, the other for water consumption), it is the client who will decide between the two, motivated by a desire to prioritise the reduction of the carbon footprint or of the water footprint of the project.

   The use of EPD/FDES documents is highly recommended during the decision-making process, with all attendant precautions of use. Software tools will allow comparison of environmental variables based on the information provided in environmental declarations. It is important to critically analyse the different assumptions and, if necessary, personally correct certain variables. You should bear in mind the conditions of the project at hand when conducting such comparisons.

2. **What are the LCA requirements in relation to the different environmental building certifications (HQE, BREEAM, LEED, DGNB)?**

   ### BREEAM

   This certification has a number of different grades: PASSABLE, GOOD, VERY GOOD and EXCELLENT or "OUTSTANDING". BREEAM takes a comprehensive approach to environmental issues, allowing real estate designers and developers to prove to town planners and to their clients that their buildings are environmentally friendly, with:

   - A simple, informative scheme for final assessment of the building. This scheme is transparent, easy to understand and based on proven scientific research.
   - A positive influence on the design, construction and use of buildings.
   - A high quality standard and rigorous certification and verification procedures.

   The link between LCA and construction products is made by the GREEN GUIDE TO SPECIFICATION. Assigning an overall rating to a material is the preferred method.

   ### HQE Certification

   French certification is based primarily on FDES declarations: Target 2 of the HQE standards, specifically sub-sections 2.2 and 2.3 (limitation of environmental and health and safety impacts), requires that FDES declarations for construction products are collected, and that impact

calculations are made. The aggregating programmes described in section 6.3 above can help with this requirement.
More broadly speaking, HQE covers the broad outline of bioclimatic design given in Target 1 (integration of the building into its environment) as well as the building's energy conservation credentials (cf. Target 4 – Energy).

LEED « Leadership in Energy and Environmental Design »

This certification uses a points system. Certificates are awarded at different levels (bronze, silver, gold, platinum). This certification scheme relies upon compliance with and proof of a standard. LCA is not currently a requirement, but this may change.

3. **When choosing materials, what's in a label?**

As we have seen, you should always ask questions about labels and certifications! To be clear: take a critical look at the meaning of any label, and be wary of self-proclaimed environmental credentials.

The different classes of product information are as follows :

- Class I labels, or ecolabels, are logos from voluntary schemes which involve independent assessments.



- Class II labels are from private certification schemes and self-declarations. These are environmental claims made by the producer (or distributor) on their own behalf, and thus not subject to third-party verification. International standard ISO 14021 was published in 1999 to enforce an ethical code for self-declarations.


- You should seek out Class III declarations or standardised information and make the relevant comparisons yourself: e.g. FDES/EPDs/PEPs.

4. What should I be asking my suppliers to be sure of the environmental impact of their materials?

Ask to see EPD or FDES documents! If a material represents a major component of your project, you should seek out up-to-date information and ignore generic declarations. It is possible to compare two different environmental declarations with or without the help of computer software, and you should always pay close attention to the assumptions and averages used to calculate the data provided.

If no FDES or equivalent declaration exists, it is always best to choose products bearing the certified ecolabels listed above.

5. How can I predict the emissions of Volatile Organic Compounds (VOCs) into my interior air caused by materials I use? What should I check?

For all materials which will be in contact with the interior air (wall, floor and ceiling materials), ask the supplier for the results of VOC and formaldehyde emission tests. These results are sometimes given in FDES documents.

A simple measure is to use products which bear the eco label, as they often produce lower emissions.

You should bear in mind that while the quality of interior air is affected by the decorative materials used, it is also largely determined by the furniture present and the upkeep and ventilation of the building…

6. What are the benefits of a district-level LCA?

Conducting this assessment on a broader scale allows you to take account of the interactions of different variables: between water and energy (recovering energy from grey waters), between waste and energy, all impacting climate change to a greater or lesser extent. This analysis can be a very useful resource when making environmental decisions.

The district, block or city zone is the level at which 'energy positive' status must be achieved between consumers and producers of energy and fluids, our target for 2020.

7. How can I use LCA to add environmental aspects to my call for tender?

The use of LCA depends greatly on the framework of reference. Do you wish to obtain a comprehensive summary of the building's environmental impact, for information purposes? A classic LCA operation, even one based on generic FDES documents, will be sufficient.

But it is often important to look into the variables on which the LCA was based. You can then guide competing candidates by explaining clearly which impacts are most important to the project commissioner.

Like the tools used and standards referenced, the assumptions employed for calculations (scope, life span, methods) should be clearly specified. The scope of the analysis is also crucial (LCA on the building materials used or impact of the building and its consumption). [20]

If it is well managed, LCA can be a very useful tool when making decisions concerning environmental variables.

[20] You should seek good advice before setting such environmental conditions. For help with setting conditions, contact us.

12 FIND OUT MORE

Documents and product databases

- Buildings Common Carbon Metric by UNEP SBCI
- EPDs information about building materials
- Purchasing ISO standards : www.iso.org
- Reference for Embodied Carbon in concrete www.sustainableconcrete.org.Uk
- Reference for International EPD® System: www.environdec.com
- Life Cycle Assessment (LCA) Database Projects: http://faculty.washington.edu/cooperjs/Research/database%20projects.htm

Organisations

- Sustainable Building Alliance – common metrics for key issues
- CD2E (Création Développement éco entreprises), Loos en Gohelle, project coordinators of CAPEM (Cycle Assessment Procedure for Eco-Material) and directors of the AVNIR platform.
- The CODEM Picardie site, section on eco-materials (information sheets on the different eco-materials available on the market).
- European Commission – Joint Research Centre. Life Cycle Thinking and Assessment.
- Chaire PARITECH Chair fo Ecodesign of Built Environments and infrastructures.
- Bouygues Construction, in partnership with Ecole des Ponts Paris Tech and the Fondation des Ponts, the Ecole Centrale Paris and Centrale Paris Développement, Supélec and Fondation Supélec, and the Centre Scientifique et Technique du Bâtiment (CSTB), have recently established a chair for research and teaching on sustainable construction and innovation.

IFPEB is at your disposal for all questions concerning the contents of this report. Please don't hesitate to contact us, by email ifpeb@ifpeb.fr or by phone on: +33 5 56 79 44 25.

13 APPENDIX I – ENVIRONMENT IMPACT OF MATERIALS IN HIGH PERFORMANCE BUILDINGS

A few examples to accompany the introduction: the influence of the construction process on the active life of a building. A few examples of impacts on a specific individual house or residential building should suffice.

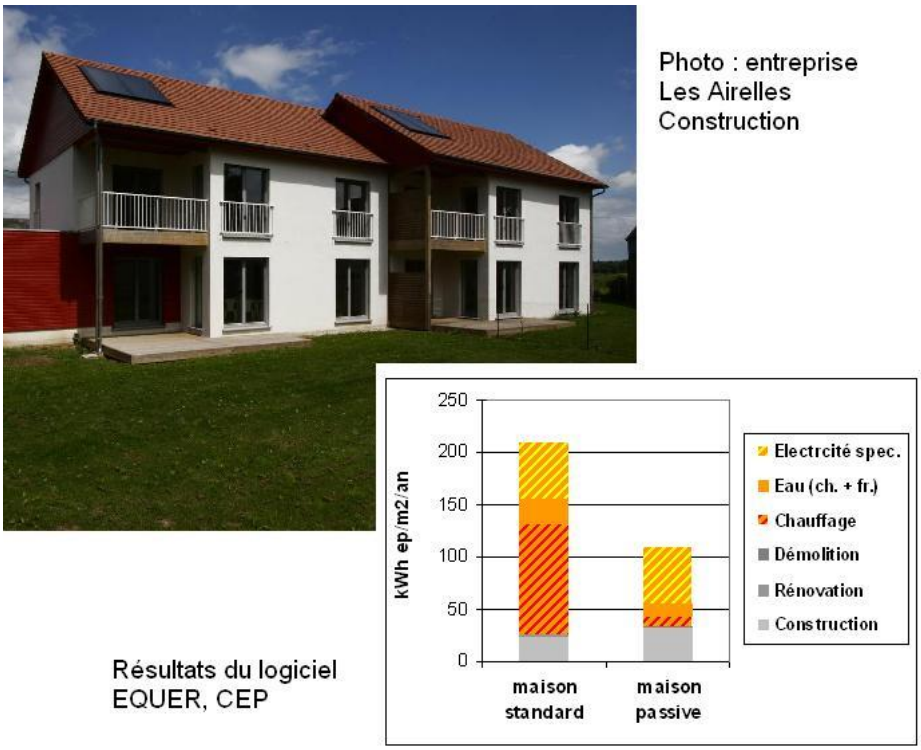


Figure 10 - Energy performance over the life time of passive houses in Formerie (Oise, France, 2007)

In the case of highly energy-efficient buildings, such as 'passive' houses, the energy required to manufacture the building materials and components plays a major part in the overall energy balance. The graph shown above presents the results of a comparative calculation, for equivalent lifestyle variables, between a passive construction and a standard modern house. Energy consumption is reduced by roughly 50% in the passive house, but the building process uses more energy.

14 APPENDIX II – FORTHCOMING OR IN USE STANDARDS

	FRANCE	CEN TC 350	ISO TC59/SC17
Methodological framework and general principles		prEN 15643-1 (General framework for sustainability assessment of buildings) prEN 15643-2, 3 et 4 for each aspect of Sustainable Development (environment, society, economy)	ISO 15392 (published in 2008) (General principles of sustainability in construction), ISO TS 21929-1 (published in 2006) (sustainability indicators)
Products standards (EPD regulations)	XP 01-010 (2001) **NF P01-010 (**2004) supplements in force, for clear regulations : - of CO2 storage - of recycling	**PrEN 15804 (2010)** currently being studied French standard - A single PCR - Modules (but with compulsory C to G) - Method of communication	**ISO 21930 (published in 2007)** Conforms to ISO 14025 - Framing text -French standard - Compulsory "Cradle to gate"
Project level standards (assessment of building's performance)	NF P01-020-1 XP P01-020-3	WI00350002	ISO TS 21931-1 (published in 2006) ISO/DIS 21931-1 : to become an ISO standard

15 CONTENTS

16 AKNOWLEDGMENTS

Many thanks to the review panel, including the following experts:

- *Julien HANS, CSTB*
- *Bruno PEUPORTIER, MINES DE PARIS – PARITECH Engineering School*
- *Jean LATTANZIO, Cabinet d 'Architecture L'EAU*
- *Serge SIDOROFF, SNC LAVALLIN*

The editors

- *Nicolas DHOYE, Sustainable construction research centre, Expert, BOUYGUES CONSTRUCTION*
- *Valérie BICHLER, Project leader, Research and Innovation Department, LCA Expert, GDFSUEZ*
- *Ingrid JOUVE, Quality and Environment Manager, IRD2 Centre (Innovation, Research and Sustainable Development), EIFFAGE Construction*
- *Isabelle BOYEAU, LCA specialist, IRD2, EIFFAGE Construction*
- *Benoît CHAUMET, EDF*
- *Laure RONDEAU - DESROCHES, Communication and Partnership Manager, INTERFACE FLOR*
- *Agustin LUCARDI, Communication and Partnership Officer, InterfaceFLOR GLOBAL*
- *Cédric BOREL, Director of IFPEB, Core Founding member of France GBC*