Chapter 11
Selection Process

11.1 General

As already stated in Chap. 1, eco-efficient construction and building materials present less environmental impact than common materials. However, it is difficult to say if for instance concrete is more environmentally friendly than steel. Because it is truth that the former is responsible for some CO_2 emissions (0.8 tonnes emitted per tonne produced), on the other hand it uses local raw materials, and may even allow the incorporation of several industrial wastes. The second has the advantage of being recycled indefinitely, but its production involves a higher energy consumption and higher CO_2 emissions (3 tonnes emitted per tonne produced) and is prone to degradation by corrosion. It is then necessary to assess all the environmental impacts of a given material from cradle to grave. This methodology known as "Life Cycle Assesment" (LCA) was used for the first time in the US in 1990. One of the first studies using LCA assess the the resource requirements, emissions and waste caused by different packages of drinks and was conducted by the Midwest Research Institute for the Coca-Cola Company in 1969 (Hunt and Franklin 1996).

11.2 LCA of Construction and Building Materials

The LCA "includes the complete life cycle of the product, process or activity, i.e., the extraction and processing of raw materials, manufacturing, transportation and distribution, use, maintenance, recycling, reuse and final disposal" (Setac 1993). The application of LCA has been regulated internationally since 1996 under ISO14040, ISO14041, ISO14042 and ISO14043. Some of the biggest drawbacks of the LCA, rely on the fact of being very time consuming, implying vast amounts of data on the environmental impacts of materials for all the phases of the life

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Table 11.1 Different weightings for categories of environmental impacts (Lippiatt 2002)

Category	Univ. Harvard	EPA
Global warming	6	24
Acidification	22	8
Eutrofication	11	8
Fossil fuel consumption	11	8
Indoor air quality	11	16
Alteration of habitats	6	24
Water consumption	11	4
Air pollutants	228	8

cycle. The categories of environmental impacts commonly used in the LCA, may include the following:

- Consumption of non-renewable resources
- Water consumption
- Global warming potential
- Potential reduction of the ozone layer
- Eutrophication potential
- Acidification potential
- Smog formation potential
- Human toxicity
- Ecological toxicity
- Waste production
- Land use
- Air pollution
- Alteration of habitats.

However, it is understandable that the importance of each category is not the same for each country, being dependent on its environmental specifics. For example a product that consumes a large amount of water, poses a high environmental impact in a very arid country, but that's not the case if the product is produced in a country located in Northern Europe, so it makes perfect sense that the category of environmental impact on drinking water, has a different weight depending on the country where a product or material is produced.

Lippiatt (2002) refers to the case of assigning different categories of environmental impacts by different institutions (Table 11.1).

There are several tools that use LCA and to make an evaluation of the environmental impacts of construction materials such as: BEES (US); BRE. Envest (UK); ATHENA (CANADA); ECOQUANTUM and Simapro (The Netherlands). The software Building for Environmental and Economic Sustainability (BEES), is produced by the US Environmental Protection Agency and is available free of charge to any potential user. BEES has the following impact categories:

- Global warming potential
- Acidification potential

- Eutrophication potential
- Fossil fuel consumption
- Indoor air quality
- Alteration of habitats
- Water consumption
- Air pollutants
- Public health
- Smog formation potential
- Potential reduction of the ozone layer
- Eco-toxicity.

The material performance assessment is made by carbon dioxide units and its contribution for global warming. BEES has a limitation arising from the databases related to US processes, so this tool is recommended only for experimental and educational purposes. The BRE, Envest tool (Anderson and Shiers 2002) uses a notation based on eco-points normalized to the environmental impacts caused by a citizen in the UK during 1 year (100 eco-points). One must bear in mind that the methodologies related to LCA suffer from some uncertainties. In fact it is not possible to tell whether the emission of 1 ton of sulfur dioxide is more polluting than the emission of 3 tons of carbon dioxide or if water pollution is more serious than air pollution, or even if it is possible to know which is the most polluting, the electricity produced by a power plant or by a nuclear power plant. Ekvall et al. (2007) present a more detailed analysis of the LCA limitations. The widespread application of LCA to construction and building materials needs previous surveys on the environmental impacts of these materials throughout their life cycle, something that cannot be extrapolated from studies conducted in other countries due to the different technological and economic contexts.

11.3 Eco-Labels and Environmental Product Declarations

Eco-labels were created to favor the choice of products with enhanced environmental performance and provide a guarantee for a certain environmental performance certified by an independent entity. Since they are quite simple and their meaning is unambiguous these labels have obvious advantages when compared to LCA. Although the advantages of eco-labels are clear, it is important to understand the specifics of the environmental performance in which they are based. Some authors warn that the validity of eco-labels could be in jeopardy if their environmental requirements could be influenced by producer lobbies (West 1995; Ball 2002). On the other hand since the environmental performance of a product or material must include their transportation impacts, there is no way the eco-label can include this impact. So using a particular construction or building material with an eco-label, produced thousands of miles away from the location site, could

Fig. 11.1 Symbol of the German eco-label "Blue Angel"

Fig. 11.2 Symbol of the Canadian "EcoLogo"

be less preferable than the use of local materials, even without that eco-label. Most eco-labels are based on an assessment of the environmental impacts throughout the lifecycle of the product or material in the version "cradle to grave". Germany was the first country to establish in 1978 a labeling system based on environmental criteria with the designation of "Blue Angel" (Fig. 11.1).

Currently, the eco-label "Blue Angel" is applied on 11,500 products covering 90 different categories. This classification means the efficient use of fossil fuels, the reduction of GHG emissions and the reduction of the consumption of non-renewable raw materials, being reviewed every 3 years. The contruction and building materials that already received this label are the following:

- Bituminous coatings
- Bituminous adhesives
- Materials based on glass wastes
- Materials based on paper wastes
- Plywood panels
- External thermal insulation composite systems—ETIC's
- Thermal and acoustic insulation materials
- Wood panels with low VOC emissions
- In 1988 Canada established the label EcoLogoTM (Fig. 11.2), and currently almost 7,000 products are certified by it, including the following construction and building materials:
- Adhesives
- Paints

Fig. 11.3 Symbol of the Nordic eco-label "The Swan"

- Varnishes
- Corrosion inhibitors
- Floor coverings
- Gypsum plaster boards
- Recycled plastic plumbing
- Thermal insulation materials
- Steel for construction.

The use of the EcoLogo implies the respect for a set of environmental procedures dependent on each product. For instance, gypsum boards certified with this label must contain a certain percentage of synthetic gypsum and 100% of recycled paper. In the case of construction steel with the EcoLogo it must contain 50% recycled materials, less than 0.025% of heavy metals and has even to meet a series of environmental requirements during the extraction and production phases. In 1989 the countries of Northern Europe (Finland, Iceland, Norway and Sweden, Denmark only in 1998), created the eco-label "The Swan" (Fig. 11.3). "The Swan" covers 5,000 products of 50 different areas, as below with regard to the construction and building materials area:

- Wood
- Wood panels
- Filling materials
- Materials for floor covering
- Paints and varnishes
- Adhesives
- Windows and doors.

The European "Eco-Label" was created in 1992 (Fig. 11.4), is a system for a voluntary environmental classification for products with low environmental impact throughout its life cycle. The Eco-label applies to a large variety of products with the exception of food, pharmaceutical, medical and hazardous products and like "Blue Angel", involves a periodic review after 3 years. Concerning the construction and building materials, only paints, varnishes and hard floor covering

Fig. 11.4 European Eco-label

materials (tiles, natural stones, concrete, ceramic and clay) are already covered under this label:

- Interior paints and varnishes (2009/544/EC)
- Exterior paints and varnishes (2009/543/EC)
- Hard floor coverings (2002/272/EC; Baldo et al. 2002).

The documents related to the certification of paints and varnishes (Ecobilan 1993) show that its LCA, assessed the following environmental impacts:

- Global warming potential (CO_{eq})
- Potential for atmospheric acidification (increase acidic substances in the lower layers of the atmosphere)
- Eutrophication potential (excess of nutrients from agricultural fertilization)
- Non-renewable resource depletion.

Regarding the hard floor coverings the European Eco-label means that:

- The environmental impacts during the extraction of raw materials were minimized
- During the production phase there is a reduction in overall pollution
- Possible recycled materials were used
- The ceramic tiles are burned with a reduction in the firing temperature.

Eco-labels are advantageous to the final consumer (Kirchoff 2000), however its effectiveness is dependent on the knowledge that consumers may have about their existence and some surveys made in the European Union, indicate that the European eco-label is not well known. In addition to eco-labeling there is another form of environmental certification for construction and building materials known as environmental product declarations (EPDs). They are prepared in accordance with ISO14025 and contain the results of LCA (performed according to ISO14040), of the material or product for the following indicators (Braune et al. 2007):

- Consumption of non-renewable energy
- Consumption of renewable energy
- Global warming potential
- Potential degradation of the ozone layer
- Acidification potential
- Eutrophication potential.

Some authors present information for the development of EPDs for concrete (Askham 2006) and for aluminum (Leroy and Gilmont 2006). An evident disadvantage of EPDs relates to the fact that they do not guarantee a certain level of environmental performance, instead they provide a set of information about it, which only an expert in the field can assess (Manzini et al. 2006; Lim and Park 2009).

11.4 Some Pratical Cases

Several European associations of the concrete industry (BIBM, ERMCO, UEPG, EUROFER, and CEMBUREAU EFCA), in collaboration with the Dutch environmental consultant INTRON BV studied the possibility of minimizing the environmental impacts of concrete elements. One of the objectives of this study, was to develop the tool EcoConcrete, in order to evaluate the environmental impact associated with a particular element of reinforced concrete (Schwartzentruber 2005). Some authors (Gerrilla et al. 2007) compared the performance of houses built with wooden and concrete structures, reporting that the latter had an overall environmental impact only 21% higher than the former. Xing et al. (2008) compared the performance of two office buildings with different structures (reinforced concrete and steel) and found that the steel structure consumes 75% energy compared to the concrete structure and is responsible for half of the emissions GHGs, however, in operational terms the concrete structure exhibits a much lower energy consumption having an overall favorable environmental performance. Marinkovic et al. (2010) studied concretes with and without recycled aggregates and found that their environmental performance is dependent on the transportation distance, regardless of whether they are recycled or not.

Under the project Beddington Zero (Fossil) Energy Development (BedZED), 82 households and 3,000 m^2 of commercial or live/work space with low environmental impact were built in South London. The choice for the construction and building materials in the BEDZED project was made using the BRE. Envest eco-points system (Figs. 11.5, 11.6).

Desarnaulds et al. (2005) also used the BRE. Envest eco-points system to compare different sound insulation materials mentioning that the best environmental performance is associated with recycled paper, followed by rock wool and finally by polystyrene. Nicoletti et al. (2002) showed that ceramic tiles have an environmental impact throughout its life cycle that is over 200% higher than the environmental impact of marble tiles. These results are confirmed by more recent investigations (Traverso et al. 2010). Jonsson (2000) assessed the environmental performance of three floor covering materials using six different approaches:

- An LCA
- An Eco-label (The Swan)
- Two eco-guides (EPM and the Folksam Guide)
- An EPD
- An environmental concept (Natural Step).

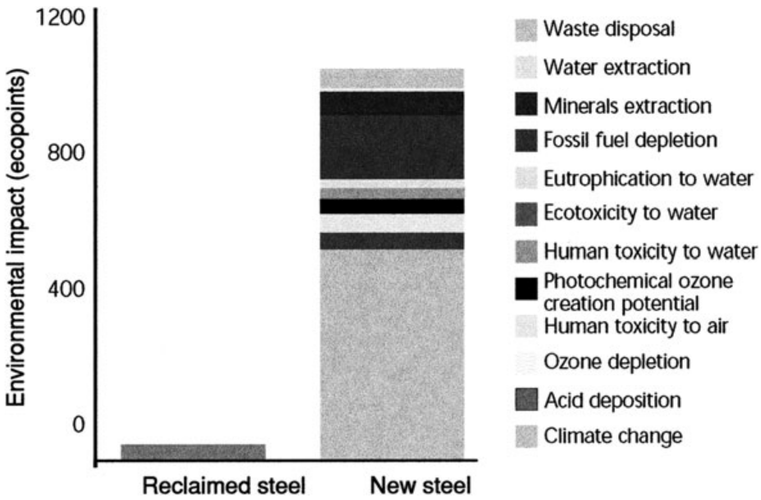

Fig. 11.5 Example of environmental profiling for structural steel (BEDZED2002)

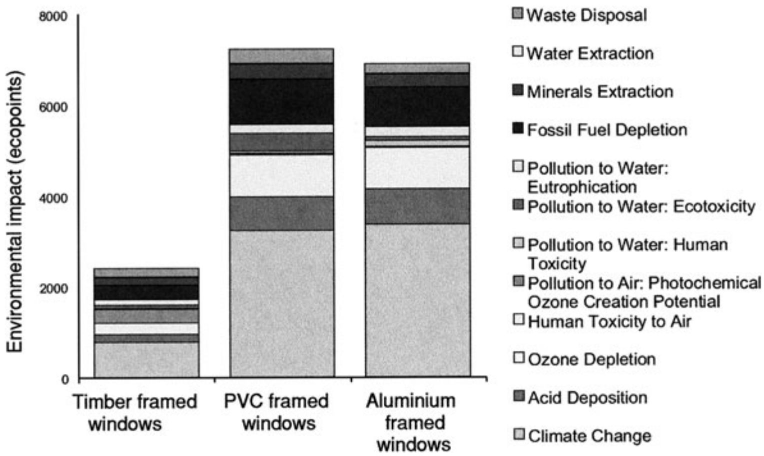

Fig. 11.6 Comparison of the environmental profile of different framed windows (BEDZED2002)

The results showed that while the LCA considers all environmental impacts in a similar way, some forms of sustainability assessment allow prioritizing certain impacts, either during production the phase or during the application of the material in the building. The results also show that only the LCA and the eco-guides allow the development of product rankings. Regarding the aggregation of the results, the eco-label has the best performance and the EPD gets the worst, making it difficult to understand the performance of a particular product.

11.5 Conclusions

Although LCA is the most appropriate way to scientifically evaluate the environmental performance of a given material, it is very time consuming and has some uncertainties. Besides the success of LCA is dependent on the existence (in each country) of lists on the environmental impacts associated with the manufacture of different materials and of the different construction processes. Another drawback of LCA is the fact that it does not take into account possible and future environmental disasters associated with the extraction of raw materials. This means that for instance the LCA of the aluminum produced by the Magyar Aluminum factory, the one responsible in October 2010 for the sludge flood in the town of Kolontar in Hungary, should account for this environmental disaster. Similar considerations can be made about the construction materials that were processed or transported using oil extracted from the Deepwater Horizon well in the Gulf of Mexico. Or even about the materials that were processed using the electricity generated in the Fukushima nuclear power plant. Only then construction and building materials will be associated with their true environmental impact. As for eco-labels they allow a more expedient information for a particular environmental performance, although its value is dependent on the entity and the assumptions that were on the basis of its allocation. Although eco-labels exist for almost 30 years, its use is still neglected by the construction materials market. In fact only a tiny fraction of the current commercial construction materials already have eco-labels. The emphasis in the respect for environmental values will lead to an increase in the number of material producers using eco-labels as a means of differentiation. As regards EPDs they have disadvantages similar to LCA, so it is not expected that in the coming years there may be an accelerated growth of products with EPDs.

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