Life Cycle Assessment for Construction Products:

an introductory guide for manufacturers and specifiers

Forestry Commission
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December 2004

Introduction

Today, businesses are faced with ever stricter environmental controls and changing markets in which consumers are becoming increasingly aware of environmental matters. Conserving raw materials, saving energy and reducing waste will not only benefit the environment but will also improve the economic efficiency of your business. It may have the added benefit of enhancing the user's perception and appreciation of your product (which in turn may improve your place in the market).

What is Life Cycle Assessment?

Life Cycle Assessment (LCA) is a 'cradle to grave' assessment tool for products or processes. LCA systematically and objectively identifies and quantifies the inputs and outputs for a whole life cycle or for individual life cycle stages, such as cradle to gate or cradle to site. LCA can be used when analysing the origins of environmental impact problems related to a particular product; comparing improved variants of a given product; designing new products; or choosing between a number of comparable products.

Environmental reporting

Agenda 21, the European Commission's Integrated Product Policy (IPP), and the Construction Products Directive (CPD) recognise environmental information to be an important issue. Already, the EU energy label, mandatory in the UK, is considered to be a 'regulated Environmental Product Declaration (EPD)' by Defra. EPDs in the building and construction sector allow us to obtain LCA – based information from construction product manufacturers.

Why do we need LCA?

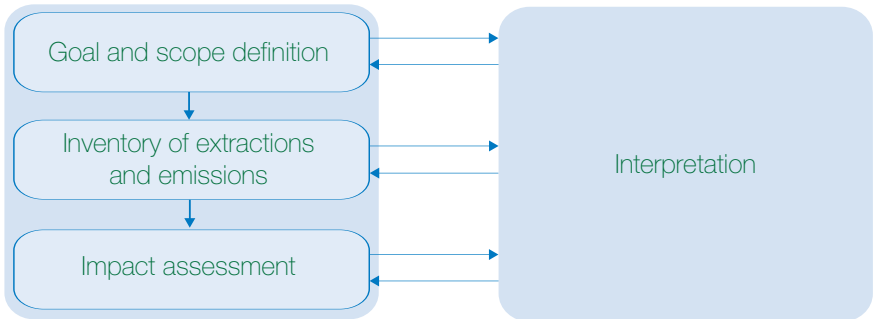
- To improve anything, you first have to measure it!
- Consumers are demanding products with environmental credentials.
- Manufacturers increasingly need to demonstrate their environmental performance and continuous improvement in their performance.

Various claims and counterclaims about 'environmental friendliness' cause a lot of confusion and they are meaningless unless they are supported by robust evidence. LCA identifies the material, energy and waste flows of a product over its entire life cycle so that the environmental impacts can be determined in a standardised way.

How is LCA done?

Figure 1 sets out the stages of LCA and this section describes these stages with particular reference to BRE's LCA methodology, which is tailored to the needs of LCAs for construction materials, components and buildings in the UK.

FIGURE 1 The phases of Life Cycle Assessment (according to ISO 14040), UNEP.



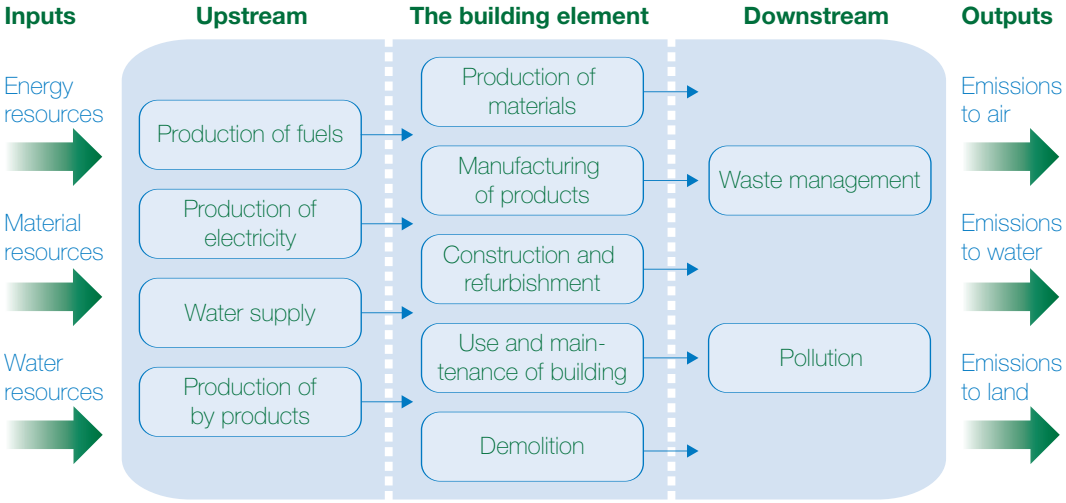
Stage 1: Goal and scope

This stage sets out the questions to be answered by the study; including why the study is being done, who it's for, what it's looking at, what environmental impact categories will be examined, the data needed and how the assessment will be done. LCA usually looks at achieving a purpose, like having 1 m^2 of external wall for 60 years (called the 'functional unit'. Different ways of making the wall could then be compared with each other. LCA can also be used to look at products, processes or services.

Stage 2: Inventory analysis

This is where the life cycle is mapped and all the data on inputs (materials, energy and fuels) and outputs (products, co-products, wastes and emissions) is gathered over the whole lifetime. The data is then converted into resources consumed, and emissions to air, water and land. The results are totalled for the whole life cycle into an inventory table.

FIGURE 2 The life cycle of a building element showing the inputs and outputs examined by LCA.



Stage 3: Impact assessment

This stage is broken into 3 steps:

- Classification
- Characterisation
- Valuation

Classification

In this step, all the resources consumed and emissions generated over the whole life are attributed to all of the environmental impact categories that they contribute to.

Characterisation

The characterisation step allows the total impact in each category to be calculated. BRE's method gives a Characterised environmental profile (all categories in different units) that looks at the 13 different environmental impact categories set out in Table 1.

One substance can contribute to several categories and many different substances contribute to each category. This is why each category has its own reference substance and the amount of impact in each category is expressed in terms of how much of the reference substance is needed to give the same effect as the contributing substances. For example, sulphur dioxide (SO_2) is the reference substance for Acid Deposition (AD), so all substances causing AD are converted to the amount of SO_2 needed to give the same effect: 1 kg of ammonia (NH_3) causes 1.88 times as much damage as 1 kg of SO_2, so 1 kg NH_3 is equivalent (eq.) to 1.88 kg of SO_2.

Because the impacts in each category of the Characterised profile are in different units, the level of impact in each category can't be compared to that in any other category. BRE's methodology allows all

TABLE 1 BRE's environmental impact categories.

Impact category name	What it means	Abbreviation
Climate change	Global warming or greenhouse gases	CC100
Acid deposition	Gases causing acid rain etc.	AD
Ozone depletion	Gases destroying the ozone layer	OD
Human toxicity to air	Pollutants toxic to humans	HTox Air
Human toxicity to water	Pollutants toxic to humans	HTox Water
Summer smog	Air pollutants causing respiratory problems	POCP
Ecotoxicity	Pollutants toxic to the ecosystem	Ecotox.
Eutrophication	Water pollutants promoting algal blooms etc.	Eutroph.
Fossil fuel depletion	Coal, oil and gas consumption	FFD
Minerals extraction	Metal ores, minerals and aggregates	ME
Water extraction	Mains, surface and ground water consumption	WE
Waste disposal	Material sent to landfill or incineration	WD
Freight transport	Distance and mass of freight moved	TP&C

categories to be compared by dividing the Characterised environmental profile by the environmental profile of 1 UK citizen's annual impacts; giving all categories the units of 'per year'.

This step is called *normalisation* and shows how the values in the Characterised profile compare with the environmental impacts caused by human activity at the national level. BRE results are presented as either the number of UK citizens needed to cause the level of impact in one year or as percentages of the annual impacts of 1 UK citizen; so an impact of 100% is the same as that caused by one person.

The Normalised environmental profile shows where the biggest environmental impacts are but it does not answer the question, "Is the biggest impact of my functional unit the most environmentally critical one?" This is the purpose of the final step of Impact Assessment: valuation.

Valuation

Up to this point, LCA is firmly objective – it only says what the impacts are. It maintains a breadth of information on a wide range of issues. But which of these products has the lowest overall environmental impact:

- a product with high global warming impact but low water pollution impact or
- a product with low global warming impact but causing significant water pollution?

This is why systems of weighting the results of the Normalised environmental profile have been derived.

Valuation is generally used to produce a single numerical score by weighting each of the impact categories and summing them up into a single Ecopoints score. It is possible to look at the Ecopoints score for all the ways of achieving the functional unit you are interested in and giving them a ranked score (e.g. an A, B or C rating as in BRE's Green Guides 2000 & 2002) or by directly comparing the numerical scores to make your choice.

The weightings in the valuation scheme developed by BRE were the result of consensus-based research funded by DETR (before they became a part of Defra) to attach importance to sustainable construction issues. Building on other Eco-indicator methods, the study used panels representing the perspectives of interest groups drawn from across the UK construction industry. These groups assessed economic, social and environmental sustainability issues. Through consultation with the panels, the research established the relative importance of different sustainability issues across the construction industry, finding a strong degree of agreement between the interest groups. The derived weightings for BRE's impact categories are used to calculate UK Ecopoints. BRE Digest 446 sets out further information on Ecopoints.

BREEAM, EcoHomes, Ecopoints, Environmental Profiles

BRE's Environmental Assessment Method (BREEAM) is a voluntary scheme for the environmental labelling of buildings, developed by BRE with private sector partners and sponsors. The basis of the scheme is a certificate awarded to the individual buildings stating clearly – and in a way that can be made *visible* to clients and users alike – the performance of the building against a set of defined environmental criteria scale from pass to excellent. EcoHomes, sponsored by the NHBC, is the homes version of BREEAM. It is a voluntary scheme for the environmental labelling of new and renovated homes. The Housing Corporation now requires an EcoHomes rating to award grants for social housing and several developers have committed to achieving the standard. English Partnerships requires the use of EcoHomes on all its developments and the WWF has made EcoHomes the basis for its high profile 'One Million Sustainable Homes' campaign.

One of the aims of BREEAM and EcoHomes is to encourage the use of materials that have lower impact on the environment, taking account of the full life cycle of the materials in question. BREEAM and EcoHomes include credits for selecting high environmental performance specifications for key building elements using the Green Guides for specific elements.

Green Guides ratings are obtained by calculating the environmental profile for all common construction specifications for a particular element, for example roofing. The range of impacts, from lowest to highest, is then divided into three (Figure 3). Any specification with an impact in the lowest (best) third of the range gets an A rating, in the mid-part of the range, a B rating, and in the part with the highest impact, a C rating. Rating are given to performance in each environmental impact category and in an overall, summary category.

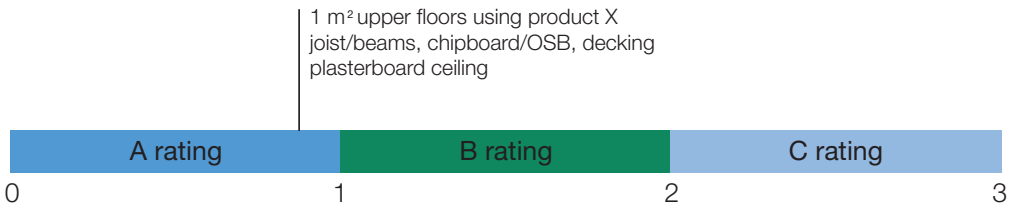
These results are of interest to specifiers seeking products with a lower environmental impact because products with a summary A rating have comparatively less environmental impact than B or C rated products. These ratings, in turn, are used by the EcoHomes and BREEAM schemes.

Green Guides are based on functional unit for building elements put together in their typical, as-built form. Manufacturers can apply to have their product profiled and actively promote their Ecopoint scores and hence their Green Guide rating. Manufacturers have the opportunity to present their customers with data in a variety of ways:

- In the form of a full Environmental Profile
- As an A, B or C rating where a Green Guide element exists
- As an Ecopoints score

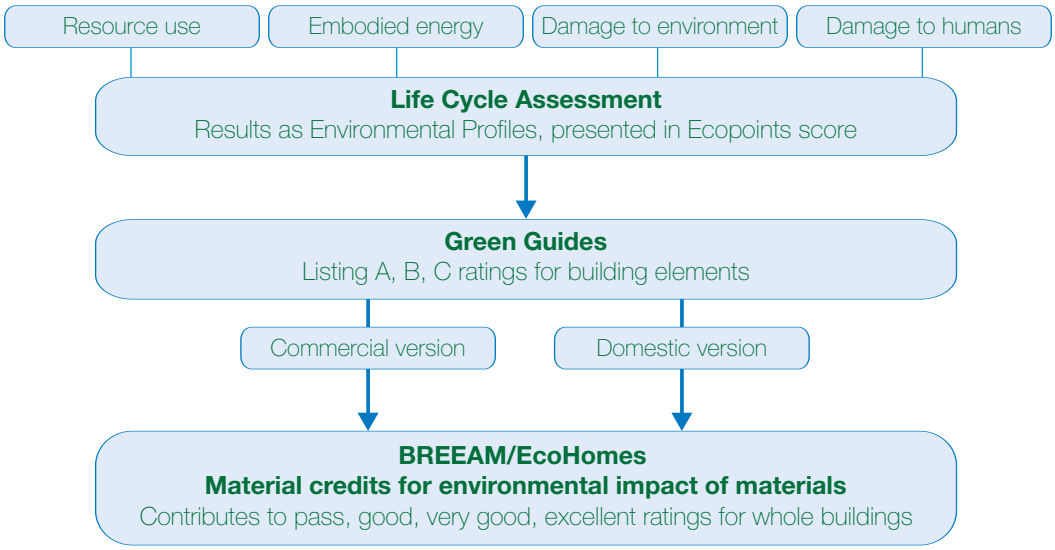
Manufacturers with certified environmental profiles are listed on the Environmental Profiles web site[1] as well as Redbook website[2], hosted by BRE Certification. Figure 4 shows the relationship of LCA, Ecopoints, Green Guides, BREEAM and EcoHomes.

FIGURE 3 Manufacturers can illustrate the environmental performance of their products within a building element on the Green Guide scale of A–C.



1. cig.bre.co.uk/envprofiles
2. www.redbooklive.com

FIGURE 4 An illustration of the relationship of LCA and BREEAM/EcoHomes.



Glossary

characterised profile: the amount of impact in each of the environmental impact categories. Many different emissions can contribute to each impact category. The different emissions in each category are converted into the amount of reference substance needed to give the same effect. Each category has its own reference substance, e.g. CO_2 is the reference substance for Climate Change, and the amounts of any Green House gases in the Inventory Table are converted to the amount of CO_2 needed to cause the same effect. The impact categories are in different units and the values cannot be compared.

ecopoints: the normalised profile values are multiplied by weighting factors developed for each impact category and the results summed to give a single figure.

environmental impact category: environmental issue being examined, e.g. Climate Change, Acid Deposition and Human Toxicity to Air.

environmental profile: the level of impact in each environmental impact category for the functional unit or product being studied.

functional unit: the materials needed to achieve the desired purpose (function).

input: material or energy that enters a unit process (can include raw materials and intermediate products).

intermediate products: material that has already been processed before being used to produce a product.

inventory data: table of amounts of resources used, and products and emissions produced to achieve the product or function being studied.

life cycle: consecutive and interlinked stages of a product system from raw material acquisition or generation of natural resources to the final disposal.

life cycle assessment (LCA): compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.

normalised profile: The characterised profile is referenced to the environmental impact for each category at the national or global level in one year (usually for 1 citizen), giving a 'normalised' profile; the values are directly comparable.

output: material or energy that leaves a unit process (may include raw materials, intermediate products, products, emissions and waste).

raw materials: unprocessed material that is used to produce a product.

reference substance: substance that is used to calculate how much of this substance would be needed to give the same environmental impact as each of the many substance contributing to an environmental impact category. For example, carbon dioxide (CO_2) is the reference substance for Climate Change (CC100), so all the other gases contributing to Climate Change are converted into the amount of CO_2 that would be needed to give the amount of Climate Change that each different gas would cause, e.g. 1 kg of methane causes 21 times as much Climate Change as CO_2 (for the 100-year timeframe), so 1 kg methane is equivalent to 21 kg of CO_2.

Further reading

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www.unepie.org/pc/sustain/lcinitiative

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ISBN 0-85538-651-7

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FCMS018/FC-GB(KMA)/NMS-1.5K/DEC04