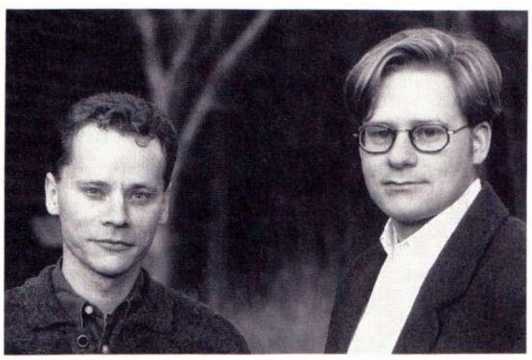
Environmental Evaluation of Buildings – A Survey of Possibilities and Problems

by Martin Erlandsson & Dag Lundblad



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There are different ways to assess environmental impacts caused by the building market and there are also different users of assessment methods. This article suggests how different concepts can be developed and applied to evaluate building products and constructions from an environmental point of view. Some crucial issues regarding different life cycle phases are also discussed.

NATURE ITSELF can be regarded as self-destructive. The number of animal species varies in cyclic periods and is today decreasing (Wilson, 1989). Erosion and the decomposition of rock occur naturally with or without the intervention of the human being. Nature has in fact adapted to this natural degradation in different ecological systems (Tiberg, 1993). However, it should be noted that human activities do affect the environment crucially. The human being is the only species who is able to exterminate himself. Human activities speed up the time frame, which means that nature does not have the time to adapt to all new situations. The need for environmental assessment seems to be a critical issue for our existence.

Environmental goals

The overall environmental goal could be expressed as follows

> maximize the social benefit of a resource or a performed service with minor environmental impact. (Erlandsson, 1994.)

The maximization of the social benefit if our actions is dealt with in the theory of utilitarianism. In criticism of the theory of utilitarianism it is argued that social benefit is not comparable between different individuals, since they experience the same service in different ways (e. g. Glover, 1977). This means that the maximization of the social benefit mentioned in the goal above will be hard to fulfill in practice. Also, environmental impacts may be

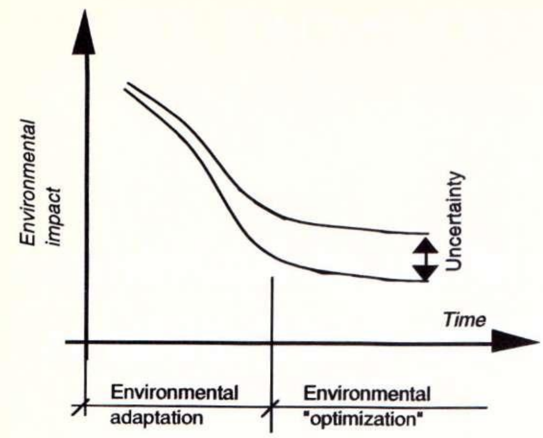

Figure 1. Assumed result of environmental improvements.

hard to assess. Nevertheless, it is often possible to analyze such impacts in a quantitative or qualitative way. Thus, it would seem reasonable to modify the goal mentioned above to correspond to a more attainable goal. With the knowledge we have today we can endeavor to

> minimize the environmental impact of a given social benefit described as utilization of a product (Erlandsson, 1994.)

With this new goal it is consequently not argued if a product is needed or not – merely how its impact should be reduced. Hence, there is no strict scientific method for comparing different environmental discharges, nor is it possible to reach a consensus as to how the evaluation should be done in the foreseeable future. Different assessment methods do exist but no single method is generally in use (e. g. Steen et al, 1992; Ahbe et al, 1990; Heijungs et al 1992). Another approach to assessment is based on fundamental ideas of how nature works and how the humans adapt to it (Robèrt, 1993). Examples of such normative environmental principles are given below:

- The extraction of resources must be equal to or less than their re-creation;
- The less that is produced, the better for the environment;
- Commonly, an unfamiliar substance affects nature more than a historically known substance;
- A product that can be reused or recycled is normally better than a product made of virgin raw materials discarded after use.

If the principles mentioned above are put into practice, it is most likely that a consensus will be reached and also that initial environmental improvements will result.

After an initial environmental study of the adaptation phase, reliable improvements are assumed to be possible (figure 1). However, after a number of improvements have been observed it is often not so easy to evaluate the consequences of a proposed action. This creates a need for a better environmental assessment method than the one based on given environmental goals, as set out above. But even in the future, with a development of assessment methods, it will in practice be impossible to achieve a minimum of environmental impacts. So we will never acquire the knowledge that enables us to evaluate impacts to that degree. Because environmental data is so uncertain and assessment methods are based on such different assumptions, environmental assessment should be treated with caution.

Assessment concepts

We have recognized that products in general can be subjected to an environmental study, since they have a given social benefit. Life-Cycle Assessment is frequently used by big manufacturing companies to assess products. The concept, Life-Cycle Assessment, LCA, *(Swe. livscykelvärdering)*, studies a product from cradle-to-grave, or in other words from the earth and back as discharges to any recipient. The problem is that the resources used in a product cannot always be described by a cradle-to-grave flow analysis. In the ecocycle society, discarded products will end up as raw materials for new products and may result in a cascade of products fullfilling different functions. If two different products are to be compared as part of an assessment, their functions have to be the same. In reality this is often not the case. Different approaches are applied when the same resources are used in different products or functions. This means that the results from different LCAs of similar products sometimes vary. This phenomenon is recognized as a system boundary problem (Erlandsson, 1993). Therefore, it has been found convenient to divide the life-cycle into lifetimes (figure 2).

A demarcation line is drawn between each product with a given function – a lifetime. Each lifetime describes how the product is used. In this concept, called Life-Time Assessment, LTA, *(Swe. livstids-värdering)*, the product system boundary is defined by the market (Erlandsson et al, 1994). Since the market defines the aluminum in an engine in a car as one product and the same recycled aluminum in a number of cans as different types of products, it makes no sense to talk about Product Life-Cycle Assessment. The conclusion is that:

> Life-Time Assessment, should be used to *evaluate products.*
> Life-Cycle Assessment should be used to *study flows of resources.*

These two methodologies have different approaches which complement each other. The LCA follows the use of resources (in one or more products) and ensures sustainability. LCA is defined as following all resources used from the cradle to the grave. This means that LCA often includes more than one product. The LTA deals with one product only, which makes it possible to compare different alternatives that meet the same demands. In an LTA the subsequent use of a product does not have to be known, the mere fact that it has another area of use is enough. This simplification is very important, especially to long-lived products where the subsequent use cannot be accurately predicted. It should be noticed that there are a number of theoretical and practical problems regarding LCA which are not discussed in this article. However, whether the concept of LTA is accepted or not, it is possible to re-calculate the data and add any assumed final use to create an LCA.

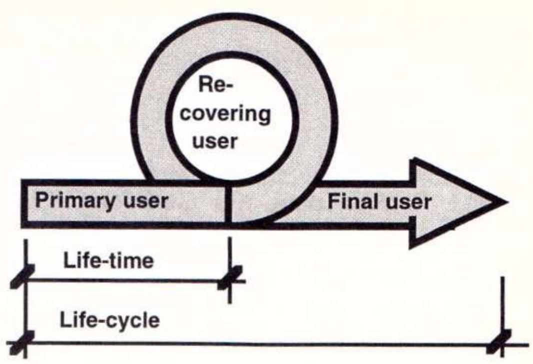

Figure 2. Lifetime as a part of a life-cycle (Erlandsson et al, 1994).

Some crucial issues for building components

Many difficulties arise when the environmental impact of products with long service lives is assessed. A lot of environmental data for different products is missing although information is available in the literature. Location of a building component affects maintenance requirements as well as the indoor environment. Thus, in the future inventory data must be related to the applications. Some issues that are of special interest for building products are discussed below.

Impact during usage phase

The degradation of building products affects the indoor as well as the outdoor environment. The interaction between different materials sometimes causes a lot of damage, mainly because of the close relation between high moisture content and unsuitable combinations of products. The aim of maintenance is to keep the product in proper working order so that its service life is prolonged. In spite of this poorly executed maintenance has in some cases shortened the service life. The impacts during the usage phase of a product could be as important as its impact during manufacture. One report that supports this view deals with the environmental effects of floor maintenance (Lundblad, 1994). However, adequate data from the usage phase is still missing and more research is needed. Further, there is a need for proper methods to assess the impacts of emissions caused by the degradation of products. An assessment project of this kind is in progress, in Denmark (Nielsen and Wolkoff, 1993). Statistical data of the risk of failures during the usage phase should be taken into consideration in any assessment of a building product.

Service life prediction
The service life of a product is directly related to its environmental impact. Where two products are equal but one has twice the service life of the other, this product has half the environmental impact. There are few adequate test methods to predict the service life of building products. A higher degree of accuracy in service life prediction will be possible with a better understanding of degradation mechanisms and the in-service conditions of building products. This will perhaps lead to products with better durability and fewer negative effects on the environment. Aesthetic aspects also play an important role in predicting the service life of some building products. A poor design or changes of fashion are good reasons for replacing products. An aesthetically limiting value can arise long before a product's technical service life has reached its end. On the other hand, the aesthetic values of a product will in many cases be determined by its technical qualities. It is therefore important that a product's technical performance prevents it from (unwanted) "aesthetic aging". In some cases aging provides the products with a surplus value. This is for instance the case with roofing tiles.

Dismantling
Compared with products that have to be combusted or put into a landfill, products that can be reused or recycled are often preferable from an environmental point of view. To facilitate reuse and recycling it is essential to build for destruction with flexible joints. A technical development of reused components on its own is not sufficient – there also has to be a market that demands these kinds of products.

Conceptual approach for environmental assessment of constructions

The issues described in the chapter above have to be implemented in a building product related assessment model. This overall view is absent today. A useful concept is based on the Life-Time Assessment methodology. One suggestion is that the quantitative part of the model takes into account constructional and operational data. A qualitative part of the assessment is to evaluate how different products in a construction are combined. Depending on the application of a product, different kinds of impacts will arise. This means that the function of a product must be evaluated against the environmental effects of use in a specific application. The research work on the building product related assessment method, described above, will bring us a little closer to a model for assessing buildings or other types of constructions.

The complexity of environmental assessment models of buildings makes great simplifications necessary today. A building is for the most part not a static system but a dynamic system where actions are taken all the time to satisfy new needs. This makes it impossible in reality to make "true" environmental assessments since nobody can predict what will happen in the future.

However, to conduct a conceptual LCA of a construction in its entirety it will be necessary to take into account the following; all maintenance, replacing of discharged building components, operation and service, modernization and the final demolition phase. A simplification is to study the individual lifetimes of a construction (figure 3). The lifetime will be defined as the time from construction to modernization. In this case modernization is considered as an alternative to dismantling the building and erecting a new construction. The use of LTA leads to less unreliability regarding questions related to the time frame.

It should be recognized that energy related screening environmental studies have been performed upon buildings (e. g. Rauhala, 1992; SBI, 1993). For example, energy flows used for heating, ventilation, water supply and warm water heating during the service life of houses will fundamentally affect the environmental impact.

With all the simplifications necessary to make an environmental assessment of a building, do we really have to assess a whole building or is it enough to look at building products from a overall quantitative perspective ? Whatever assessment method is used, the aim must be to achieve a minimum of environmental impact. The problem is that the level of details decrease, from an assessment at product level to a whole construction, because of assumptions and simplifications made on the way. On the other hand an assessment of a whole construction gives "soft" information about conditions that are not dealt with in a product assessment (BREEAM, 1993). These conditions are, for instance, land values, access to daylight, facilities for sorting refuse. Both assessment methods are required today and the basic research work on how to improve the building product assessment methodology will hopefully lead to better building assessment methods.

Purchasers of assessment models

Who will become users of environmental assessment models? Different groups in the building market will be interested in new assessment models. Some of the building product manufacturers are already using LCA. The development of existing product assessment

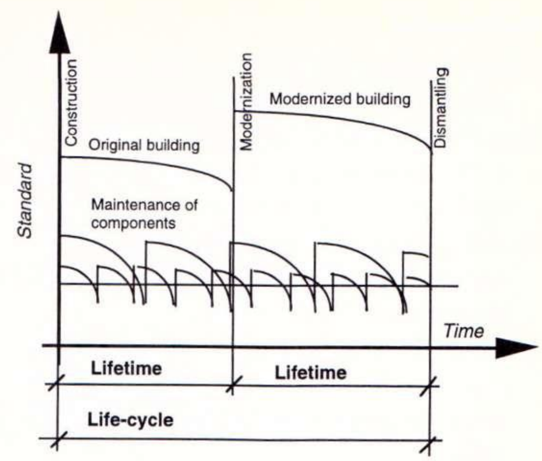

Figure 3. LTA and LCA of a construction.

methods and software for computers will help both manufacturing industries in product development and architects and technical consultants to choose the right combinations of materials.

It is most likely that demands for more environmentally sound constructions will come from governmental bodies as well as consumers. Other interested parties are banks and insurance companies who are are a part of different projects involving great financial risks.

In the Swedish building market responsibility for the demolition of a construction will probably lie with the owner (Blix, 1994). The administrator or owner might in this case require a guarantee from the construction company, concerning how the dismantling of the construction can be performed in an environmentally sound way. Finally, it can be stated that a number of participants in the construction process will have to perform different types of environmental assessments. For this reason it is most important to continue the development of assessment models.

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