

## EcoEffect - summary

Within the building sector, as in other sectors of the society, indicators that describe environmental impacts are sought as a way to improve decisions in the journey to sustainable development. Different methods and tools are developed to characterise or “measure” the environmental friendliness and the ecological sustainability of buildings. The EcoEffect method is one of such methods that has been developed at the Royal Institute of Technology in Stockholm and the University of Gävle in Sweden with support from enterprises and organisations within the building sector.

### The objective of EcoEffect

The EcoEffect method aims at taking a holistic approach of the environmental issues through studying five areas of assessment in parallel; Energy use, Material use, Indoor environment, Outdoor environment and Life cycle cost. The scope has been to, as far as possible, quantify the environmental impact and to present it in the form of environmental profiles, with bars showing the contribution to various environmental effects of a building. The results of an EcoEffect calculation can be summarised in a number of ways. The most simplified one shows the result of the assessment of internal environmental impact (indoor and outdoor environment) in relation to the assessment of external environmental impact (material use and energy use). The building in focus is shown as a dot (red dot in this case) in relation to other assessed buildings, as in figure 1 below. An aggregated environmental load index is calculated to simplify comparisons between buildings and properties respectively.

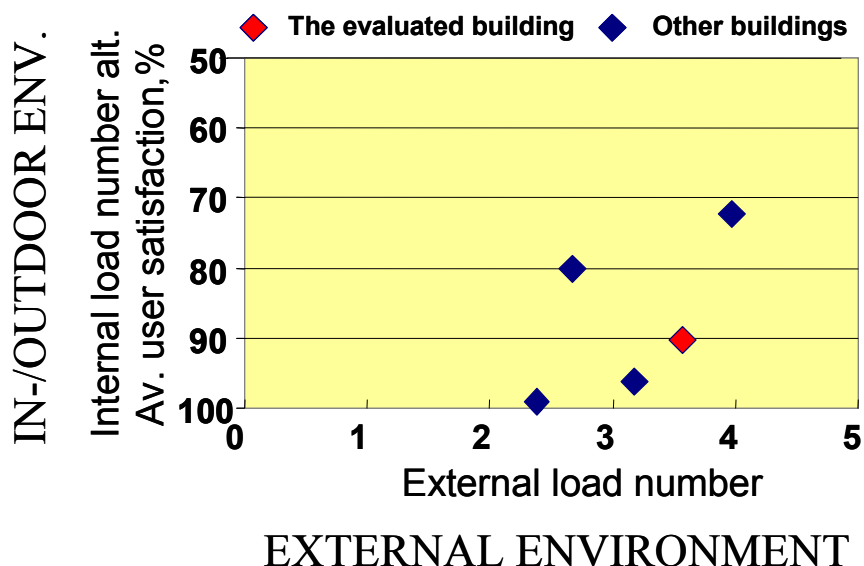


Figure 1. The most simplified form of presenting an EcoEffect assessment

The next level of presentation gives a more detailed picture, still in relation to another building or a special reference building as shown in figure 2. A number of even more detailed presentations are available through the EcoEffect software tool.

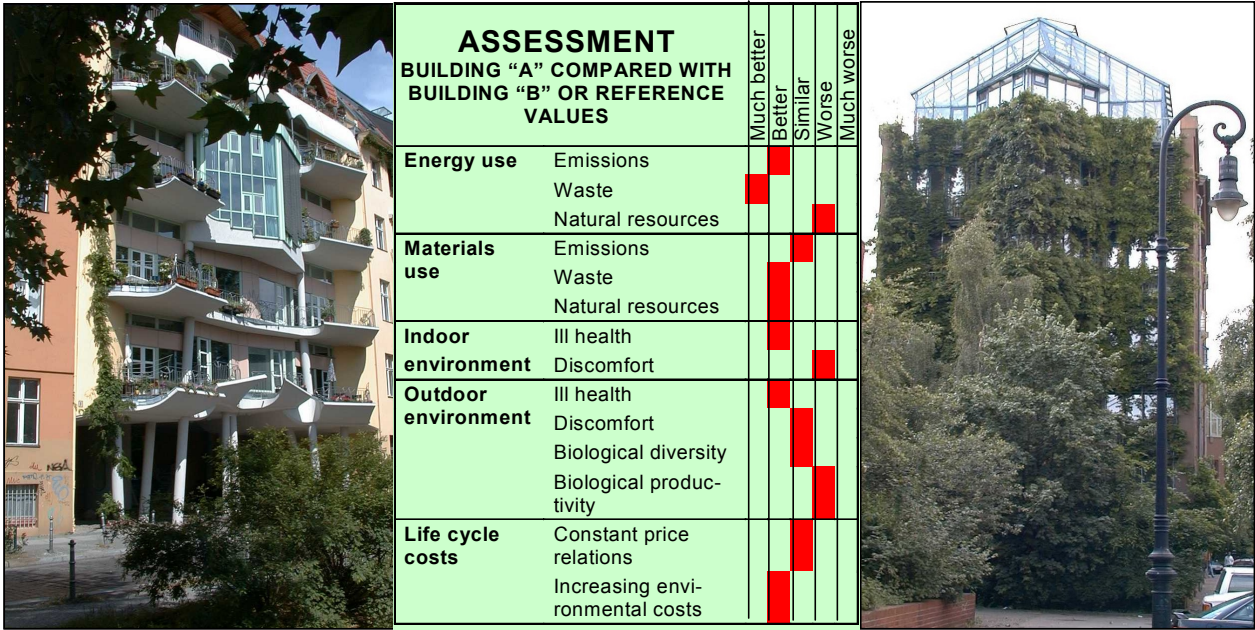


Figure 2. Aggregated EcoEffect results within the areas of: Energy use, Material use, Indoor environment, Outdoor environment and Life cycle costs.

The ambition has been to present the results of the EcoEffect assessment in a way that is easy to grasp and with the underlying basis and assumptions easily accessible in the program. Initially the method was developed for multi-residential buildings, but since the structures and principles are general, the method also has been applied for other types of buildings such as schools and office premises. An ongoing work right now is for example to apply EcoEffect on estate management.

The starting point of the method is three safeguard objects – human health, biodiversity and natural resources. The assessment has so far been delimited to property (real estate) related environmental impact. In other words, the characteristics of the building and its closest outdoor environment, i.e. the physical environment is assessed. The users of the building are assumed to use appliances, etc. in the intended manner and to have a “normal” behaviour. For existing buildings the corresponding assessments can also be made based on real usage of energy, water, etc. In this case, however, it might be difficult to conclude which impacts are caused by the building properties, the management of the building or the life style of the users. The importance of the location for the environmental impact through daily transports of goods and services is at present not included. However, impacts from transports of building materials from cradle to gate are incorporated. Some characteristic features of the EcoEffect method are shown in table 1.

Table 1. Characteristic features of the EcoEffect method

<b>Transparency</b>	The origin of all variables and results can easily be tracked.
<b>Problem focussed</b>	Calculations and results have a direct connection to various types of environmental impacts, for instance acidification, noise disturbance, etc.
<b>Facilitates comparisons</b>	Enterprises, properties, buildings and building elements can easily be compared through the environmental index.
<b>Function based</b>	Environmental loads are presented in relation to utility, for example per user.
<b>Measures hard properties and activities</b>	Environmental risks and consequences related to buildings and their surrounding area are shown.
<b>Holistic perspective</b>	As many measurable environmental impacts as possible are presented to avoid sub-optimising.
<b>improves environmental decision making</b>	The consequences of the requirements posed on indoor and outdoor environment can directly be read as loads on the external environment.
<b>Life cycle perspective</b>	The whole chain of environmental impact, from extraction of raw materials to usage of rest products/demolition concerning energy and material flows is incorporated (LCA) when data are available.
<b>Flow analysis</b>	Energy and substance flows are assessed.
<b>System boundary</b>	Properties (real estates) are chosen as the main objects of comparison. The reason for this is partly because there is an owner with possibility to intervene and partly because flows of energy, water, waste, etc. normally are measured at property level..
<b>Aggregation</b>	Weighting of results are offered. This is generally a precondition for making practical comparisons. The weights can be changed and used for sensitivity analyses.

### Life cycle analysis for energy and material use

In the EcoEffect method, LCA-methodology is used for calculating environmental impacts from energy and material use, using the property boundary as the system boundary. The total environmental impact from material and energy inflow to the property and outflow of waste, sewage and emissions to air, during an assumed life time, is expressed as a load for the usage of the property. The environmental impact is calculated per function; i.e. if multi-family housing is assessed, the load is expressed per resident. There are three kinds of environmental impacts (at intervention level) calculated for energy and material use namely, *emissions*, *waste* and *depletion of natural resources*. (Have a further look at table 2).

### Criteria assessment for indoor and outdoor environment

For Indoor environment, human health and comfort are the safeguard objects and for Outdoor environment it is both human health and ecosystems/biodiversity. For these areas, the present properties of the indoor and outdoor environment are assessed, i.e. the prevailing condition or status. When assessing existing buildings, significant areas concerning human health are investigated mainly through questionnaires to users. Some measurements and inventories are also carried out on the site. In the environmental profile of indoor environment two main presentations are made. One shows risks that the building can contribute to discomfort and certain diseases, *health effects*, and the other shows properties of the indoor environment as *environmental factors*. For outdoor environment both risks for health effects and conditions related to biodiversity on the plot are shown. The impacts are grouped on the areas *health and comfort*, *ecosystems*, *biological production capacity* and *potential for household waste recycling*, see further table 2.

The assessment of indoor and outdoor environment is based on criteria that give a value between 0 and 3, where 0 corresponds to *negligible impact* and 3 to *big impact*.

### Scenarios for life cycle costs

Costs for *investments*, *operation* (electricity, heating, water, sewage, waste) and *maintenance* are summarised over 50 years and used as the basis for the *environmental cost indicators*.

Thus, costs that are not evidently related to the environmental impact of the building, are not included, for example capital costs. Environmental costs can for instance be used as a means to study how investments contributing to lower operation costs and lower environmental impact can pay off in different scenarios of price development. The EcoEffect method uses 0 % and 3 % of price increases for environmental costs in relation to costs for other goods and services as standard scenarios for comparison.

### Summary of treated effects

Table 2 below gives an overview of the “effects” presented in the environmental profiles.

Table 2. Effects presented in the EcoEffect profiles

ENERGY & MATERIAL	INDOOR ENVIRONMENT	OUTDOOR ENVIRONMENT	LIFE CYCLE COSTS
<b>Emissions</b>	<b>Health effects</b>	<b>Health effects</b>	<b>Environmentally related costs</b>
climate change	<b>discomfort</b>	air pollution	constant price relations
stratospheric ozone-layer depletion	<b>SBS (Sick Building Syndrome)</b>	ground pollution	3% yearly increase in environmental prices
acidification	<b>intensified allergy</b>	noise	
nutrification	<b>cancer</b>	shade	
tropospheric ozone formation	<b>infections</b>	wind	
human toxicity	<b>intensified joint annoyance</b>	smell	
eco toxicity (particulates)	<b>sleeping problems</b>	<b>Eco system</b>	
	<b>enhanced sensitivity to the environment</b>	vegetation	
<b>Waste</b>		water	
building waste	<b>Environmental factors</b>	storm water	
radioactive waste	<b>indoor air quality</b>		
slag and ashes	<b>thermal comfort</b>	natural ground	
hazardous waste	<b>sound conditions</b>	produced vegetation bed	
	<b>light conditions</b>	<b>Miscellaneous</b>	
<b>Natural resources</b>	<b>electric environment</b>	storm water	
fuels	<b>tap water quality</b>		
metals	<b>surface layer quality</b>	household waste	
minerals			
biomass			
<b>Chemical compounds</b>			

A distinctive feature with EcoEffect when compared to other methods, is that properties of buildings or activities are directly related to environmental effects. Changes in flows and the physical environment can directly be read out in changed environmental effects. Thereby the method can also be used to formulate quantitative targets for every environmental effect. An

example may be that a certain building should not contribute to the climate change effect more than with a given amount.

In EcoEffect, the magnitude of the environmental impact of material and energy use is given for a time period, for example 1 or 50 years. When using the a single year, it is the environmental impact of the flows of operation and maintenance that is made relatively noticeable. These data can be used for internal comparisons and external presentations, such as annual reports. For the longer period, the entire life cycle of the building is included, from production of the materials all through to demolition and reuse or landfilling.. Together with the annual operation flows this can be conceived as the total environmental impact of the building, which may be of interest for a developer or an owner. In case of selling, the buyer might be interested in understanding the potential environmental impact of the remaining life time of the building, i.e. also including the possible environmental problems that may occur due to demolition in the future.

The assessment of indoor and outdoor environment of a property is only concerned with the operation phase. Here, both variations during the day and night, such as noise, as well as seasonal variations, such as thermal comfort, are included. Changes in the physical environment and operation flows affect the assessment. Thus, the assessment of indoor and outdoor environment can rather be characterised as a status declaration for an average year, mainly expressed in terms of environmental effects. Such an information can for instance make a basis for a dialogue with the tenants, for identifying activities of improvement or, externally, to point out a quality to the surrounding world or a possible buyer.

### Data needed for assessment

A practical difficulty when trying to calculate environmental effects, is to obtain the data needed for the assessment. If you use a CAD-programme or computerised maintenance and media control programmes, it is a matter of a technical procedure to extract the data necessary for EcoEffect or similar assessment methods. The preconditions for these issues will be studied during the project. Until then, data are handled manually. The effort needed to collect data depends on the wished level of accuracy and if one wants to make a complete EcoEffect assessment. If the main focus, for example, is the environmental impact of energy use, measured or simulated figures for energy use will suffice. The data necessary for a complete EcoEffect assessment can, for the time being, be summarised according to table 3.

*Table 3. Data necessary for an EcoEffect assessment*

	Existing building	Planned building/refurbishment	Property manager (proposal)
<b>General</b>	Descriptive data of the building, number of users, area of premises, site area.	Descriptive data of the building, potential number of users, area of premises, site area.	Name, yearly turnover, total let area.
<b>Energy</b>	Simulated and/or measured energy use the latest 3 years by energy source.	Simulated yearly energy use by energy source.	Simulated and/or measured energy use the latest 3 years by energy source
<b>Material</b>	Inventory of built-in hazardous materials and substances. (possible extra; amounts (kg) of the biggest material groups)	Calculated use of various materials.*	Product and material consumption the latest year, kg. (Substance flows)

<b>Indoor environment</b>	Questionnaire to users. Measurement of radon gas, electro magnetic fields (EMF) and tap water temperature. Inspection of installations and present or potential moist problems.	Review of the environmental objectives related to indoor environment of the developer (program phase). Review of building documents related to indoor environment (in the end of the production phase).	Part of the area let out for which the following are carried out: - users' questionnaire - measurements of radon, EMF, and tap water temperature a - material inventory
<b>Outdoor environment</b>	Questionnaire to users. Inventory of vegetation and ground	Review of building documents related to outdoor environment	
<b>Life cycle costs</b>	Costs for water, sewage, energy, waste treatment and maintenance/repairs the latest 3 years.	Calculated yearly costs for water, sewage, energy, waste treatment, maintenance/repairs, production and demolition.	Costs for water, sewage, energy, waste treatment and maintenance/repairs the latest 3 years.

\* A recycling credit might be calculated for those materials for which a recycling document have been signed by the manufacturer.

### Presentations and comparisons

All together the environmental profiles show around 50 different bars. In order to facilitate interpretations and comparisons, a weighting procedure of the results is offered, generating a smaller amount of indicators/environmental or load indexes. The weights used in the computer programme have been generated through problem analysis, which means that questions and issues are well structured and weighting aspects well defined. It is also possible to enter other weights in the programme or to skip the weighting procedure. Since the possibility exists to review and change the weights, the significance of the weighting procedure become clear in different practical cases. Figure 3 shows some examples of weighted environmental profiles of EcoEffect.

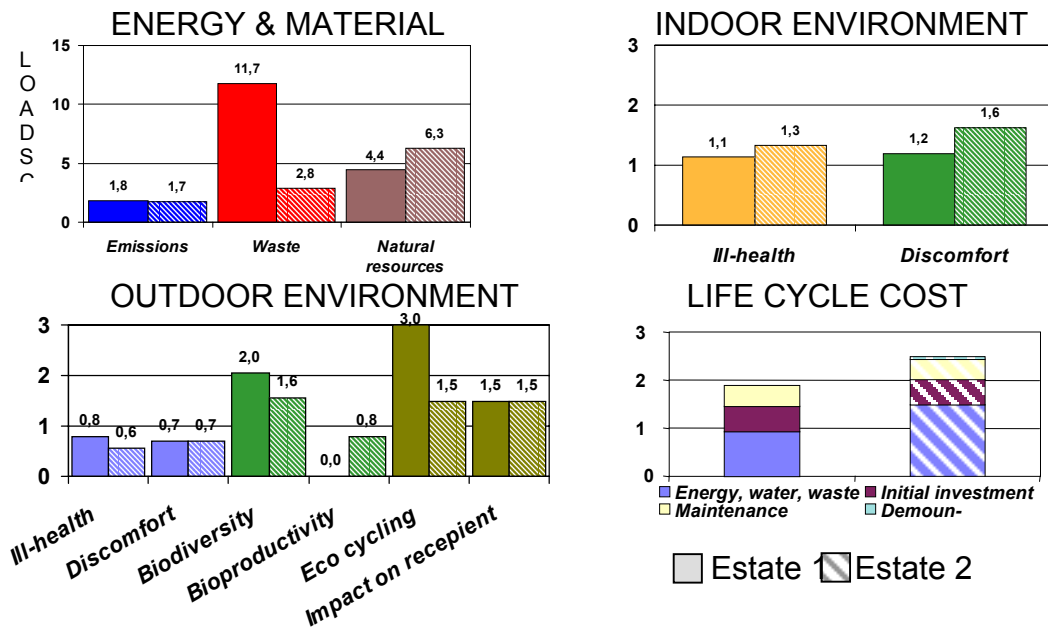


Figure 3 Presentations of a few indexes through weighting facilitates comparisons of environmental impact from various properties, buildings and building elements.

### Using EcoEffect in practice

A computer software that calculates environmental effects according to the procedure mentioned above, has been developed. The software is accompanied with a database where environmental data for different energy sources, building material, reference values, etc., are found. The software is developed in such a way that the user can choose different level of information.

At the moment, we are working with adapting EcoEffect in order to make it practically applicable in the processes of design of new buildings and management of existing buildings. The software is supposed to be used for recording the most eco-efficient solutions or to follow up quantitative environmental goals. The method is especially useful for companies working with environmental management systems (e.g. ISO 14001 and EMAS). The environmental review necessary for starting the environmental management process can be accomplished with EcoEffect and quantitative objectives and goals can be expressed in terms of environmental effects. However, a pedagogic key issue can be mentioned. In general, the companies present their activities as kWh not in the form of environmental effects, such as CO<sub>2</sub>-equivalents. The kWh can be produced in different ways, affecting the environment in various ways. These effects are not seen in the companies' presentation. Likely, making companies think in terms of CO<sub>2</sub>-equivalents instead of kWh is a slow process. One way to handle this problem is to start to formulate objectives in environmental effects, but then also translate them into more commonly used and operational indicators. For instance, if a goal is formulated to reduce the contribution to the climate change with a certain percentage, it can be achieved either by reducing the energy use or to shift to another fuel with less contribution to the greenhouse effect. EcoEffect can be used for analysing alternative strategies in this respect.

If a property owner her/himself uses EcoEffect software, this implies that she/he has to put in data for consumptions and flows and results from questionnaires and inspections on her/his own. As soon as these figures are put in manually or automatically via CAD or maintenances programmes, environmental loads can easily be calculated and compared with the same loads for other buildings or with formulated environmental goals. If the result is less favourable than expected, it is possible to click on the bars in the profile and exactly see the underlying cause for the result, i.e. the flows or properties of a building that cause the negative result. There are also possibilities to try out how the result can be improved through various activities, for instance choosing a different type of energy production or to reduce the energy use.

In case the client only delivers data of the building to a consultant or institution carrying out the EcoEffect assessments, the client should indicate what kind of presentations he/she desires or let the consultant propose improvement measures based on decreasing impacts. The EcoEffect software is easy to use for all people with some kind of experience of computers. Testing the programme by oneself is of course the best way to start understanding how various properties and activities affects the outcome in environmental effects.

### **Participating companies and organisations 2000-2003**

The EcoEffect project is supported by the following organisations and companies:

Formas

IB/BFR

White Arkitekter

Hyresgästernas Riksförbund

SABO

Svenska Bostäder

Örebrobostäder

Fastighetsverket

Fastighets AB Tornet

HSB

NCC

JM

Svenska Fjärrvärmeföreningen

BLP Arkitekter

Stockholms Stad

Sollentuna kommun

Skanska

Vasakronan

Diligentia

ACC inomhusklimat AB