European methodology for the evaluation of

Environmental impact of buildings

- Life cycle analysis -

EUROPEAN COMMISSION, DIRECTORATE GENERAL XII FOR SCIENCE, RESEARCH AND DEVELOPMENT, PROGRAMME APAS

REGENER PROJECT 1995-96 INFORMATION DATA SHEET

Editorial

Environmental quality : a new target for the building sector

Dr. Christophe Gobin *

Today ecological preoccupations are increasing and are to be part of the market.

Users pay more attention to environmental quality and to the protection of nature. Even though this demand is not fully translated into the market, given the economic situation, it may be seen as a competitive mean.

Therefore it is important for every industrial activity to include these preoccupations in a strategy of development. Dumez-GTM is using the concept of « sustainable development ». Beyond functional quality, and beyond investment value, it is important to have an analysis perimeter which allows for coherent choices. In this perspective the life cycle analysis is seen as an appropriate tool.

The scientific partnership under the leadership of the Ecole des Mines of Paris for the development of an applied methodology and its diffusion at the European level (REGENER program) is useful. This process allows to think of an operational instrumentation and to ask progressively professionals of the construction sector to participate in the constitution of a built environment which takes into consideration sustainable development of human activities.

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Guest

Life cycle analysis : a method for industry

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Accounting for the ecological impacts of products or services over their entire life cycle started in 1974 (first oil crisis), with Franklin's resource and energy profile analysis (REPA).Meanwhile this tool has developed into life cycle analysis (LCA) and additionally covers emissions and wastes associated with the life cycle, since the exclusive consideration of energy proved to be a too narrow perspective leading to suboptimizations.

LCA methodology was developed by academia, consultants, and industry; 'Code of Practice' by SETAC (1993) is now widely accepted, and standardization is well advanced (ISO TC 207/SC5: synthesized revised draft 14040). Industry, (especially consumer goods) uses the tool productively, for internal process optimization, information of authorities and public, and eco-labelling. Since data exchange between suppliers along the life cycle is crucial, SPOLD presently develops an international LCA data base network with a standardized format.

The first LCAs of whole buildings, materials, or infrastructure systems (e.g.water/sewage) have shown many interesting aspects distinctive for the building sector : complex functional units (use/reuse), extremely long life cycles, large mass flows, substantial energy turnovers (over the life time), large number of materials and components in highly complex arrays, wide choice of alternatives for optimization.

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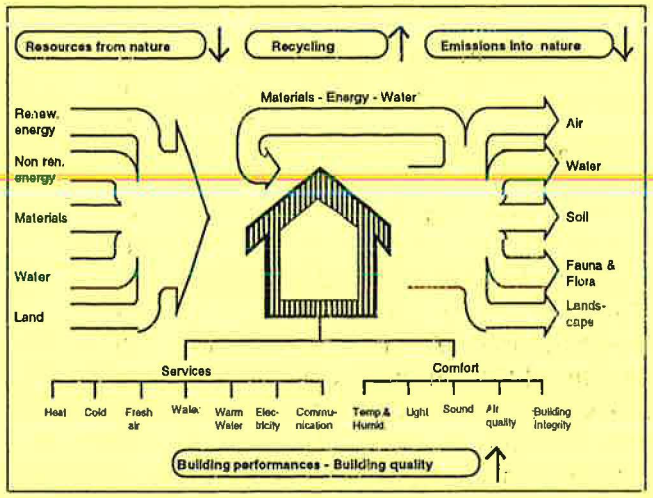
Life cycle analysis of buildings - Methods and databases

Research efforts and national energy policies have encouraged energy conservation and renewable energy technologies successfully, allowing the reduction of specific end-energy consumption. Since the oil crisis, the general objective of energy saving has shifted from the shortage issue to a more general objective of environmental protection. There is a need for scientific methods to assess the environmental impact of a building allowing one to choose among different low energy and solar technologies.

Existing methods including labels, declarations of content, positive and negative lists, and qualitative appreciations are not transparent and they are often only suited for a limited part of the design and building process. They furthermore do not include a life cycle perspective.

The inventory of mass and energy flows during the life cycle of a product is one generally accepted basis for the environmental impact evaluation.



The method of Life cycle analysis (LCA) has been developed by scientific associations like SETAC and has been widely accepted by industry and standardization boards (ISO). The complete LCA method has 5 steps. The steps « classification » and « evaluation » are called Life cycle impact assessment (LCIA).

LIFE CYCLE ANALYSIS (LCA)

- Goal definition
- Inventories
- Classification
- Evaluation
- Improvement

life cycle impact assessment (LCIA)

SETAC

LCA, which was mainly developed for industrial products with current life times of weeks and months had to be adapted to the building industry. Buildings are produced as one-of-a-kind products, their lifetime may be up to hundreds of years, they include a large and still growing number of materials, and their design process is complex involving many actors with often contradicting targets. The system limits in time and in space have been defined and models for the simulation of the life cycle (maintenance, refurbishment) have been developed. Specific functional units (adapted to the different steps in planning from design brief through the design and construction process to facility management) have been defined.

The main effect-oriented evaluation methods (based on emissions) were taken from the current methods developed inside the SETAC group by CML and others. Additional methods had to be added to take into account resource consumption.

One of the principal shortcomings of all of the existing methods is the lack of a coherent database with precombustion data, building materials and building processes. A new consistent data base has been established in REGENER and other projects including precombustion, transport and disposal emissions from the process analysis of the Swiss ECOINVENT. Inventories for more than 150 buildings materials have been established together with industry. All data are from the last 3 years and older literature values are no longer used. This database resulting from the collaboration of industry and research, funded by the EC, the German Umweltstiftung and the Swiss Department of Energy, is public.

The detailed life cycle simulation of buildings allows the development of a first series of design tools. Thus life cycle analysis provides a scientific base in the construction field. There are however still many open questions for research : What are the correlations between the existing and new evaluation criteria, do multicriteria methods allow one to handle the complexity of several evaluation criteria, what are the transfer functions for waste, how to integrate the resource consumption and possible recycling, how to appreciate the impact on the local environment (town and regional planning), indoor air pollution (sick building syndrome) , worker protection, user protection during refurbishment. This research effort will only be successful if it is based on a close collaboration of industry, research institutions and designers.

Design tools in the planning process

Design tools are considered to be instruments intended as aids in the planning process. In order to be as effective as possible they must relate to the problems confronting the actors involved and to the way in which external knowledge and information is used to tackle these problems.

Related projects

COMBINE (Computer Models for the Building Industry in Europe) aimed at developing an intelligent, integrated building design system through which the energy, services, functional and other performance characteristics of a building can be modelled and analysed in the design process.
A BRITE-EURAM project concerns the development of a framework for environmental assessment of building materials and components. Links have been established between this project and REGENER concerning the products data bases.
IEA Annex 31 is studying the energy related impacts of buildings and also considers LCA as an appropriate methodology.
SPOLD[1] (Society for the Promotion of LCA Development) is an industry association of large companies actively using LCA. Its objective is to catalyze the development and application of LCA by pooling the talent and the resources of industry and the other organizations interested in LCA.
CIB TG8 Environmental Assessment of Buildings. Objectives are to provide an international forum for coordination of research and exchange of information and to promote awareness of the above issues among those who commission, design, build, maintain and use buildings. The scope of the Task Group covers the effects on the environment of buildings, materials used and their construction and demolition. These will be considered mainly in terms of the global and local outdoor environment.

List of Conferences

4th European Conference « Solar Energy in Architecture and Urban Planning », Berlin, 26-29 March 1996

2nd International Conference « Buildings and the Environment », Paris, June 9-12, 1997

International Symposium of CIB workgroup W67 "Energy and Massflows in the Life Cycle of a Building", Vienna 5.-8. August 1996

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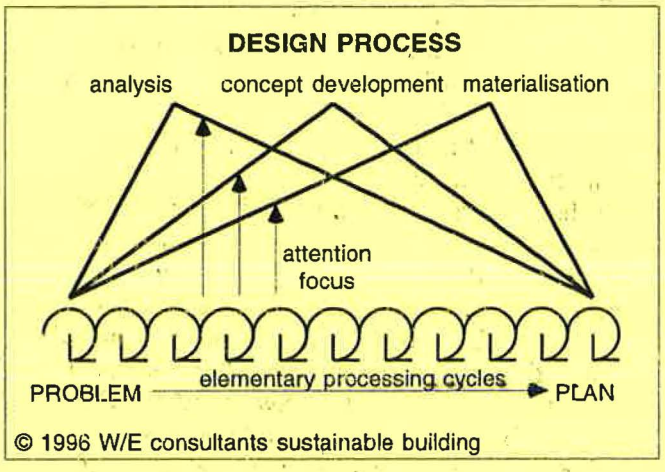
The design process of buildings is not linear. Design tools for LCA must be tailored to the main steps in the decision process. One question in the design brief is : do we need a new building or can we transform an existing building. In the building design the question are how does a design alternative relate to functional performance, costs, energy consumption and environmental impact. In the construction stage the optimal choice of building materials and building processes in relation to the ecotoxicological and humantoxilogical requirements are critical. At the same time the fuctional unit varies from very general m2 use surface to detailled building specification (e.g. pouring 1 m3 of concrete).



Existing tools, theories on designing and decision making, and consulting practice have been analysed in order to study the relations between phases and actors in the planning process and to derive a general scheme for design tools. Input and output have also been studied and the result of this work is a design toolbox, useful to any tool developer. Three methods try to taking into account this procedure. They differ in the determination of local system limits, national conditions of building practice, and performance specification .

ECOPT - ECOPRO- ECOREAL are three related tools for the different design stages combining cost calculation by elements, annual energy need calculation by the simplified CEN method and environmental impact by the CML criteria. They were developed at ifib.

EQUER is an LCA simulation tool linked to a thermal simulation code (COMFIE). The building description is STEP oriented. The resulting eco-profiles allow comparison of several designs. An English version, E-QUALITY, has been derived within the REGENER project and linked to the database collected by IFIB.

ECO-QUANTUM is a LCA calculation method for quantifying the environmental impact of a building, with respect to materials and energy. The outputs are eco-profiles, energy and mass flows, analyzed per phase, component and material. ECOQUANTUM has been developed by IVAM and W/E consultants.

Regional applications

Regional administrations were contacted for possible applications of the REGENER methods and concepts. A simplified technology assessment method is proposed in order to select the appropriate renewable energy technologies according to a regional context. Demonstration projects are under way or planned in order to disseminate ecological construction concepts and methods among architects. For instance a « high environmental quality » highschool programme has been launched in Greater Paris Area. This project will constitute a demonstration example of the approach. The Umbria Region will attempt to use the REGENER methods on a retrofitting programme concerning 8 buildings located in eight different towns of the region, considering the catalogue of energy conservation and substitution measures of the Umbria Energy Plan. Applications are also studied in Finland.

First sensitivity studies have been performed to illustrate a few possible applications of the LCA method. They show that environmental performance is the result of a good design but also of appropriate occupant's behaviour. Comprehensive information towards occupants must thus be delivered with a building. The method can also be applied when choosing a construction site, accounting for local networks (energy, water, waste management, transportation) and climatic conditions.

Comite 21, created in France after the Rio Conference, has organized an exhibition in Paris on ecological housing. A house has been built after an international architecture competition and evaluated using the REGENER tools. A very simple tool has been derived from the LCA methodology, allowing anyone to evaluate the environmental consequences of various actions : bioclimatic versus standard design, choice of the heating energy (gas, fuel, electricity or wood) and thermostat set point, waste sorting, water management, transportation. This will also constitute a good opportunity to disseminate the results of the REGENER project.

Future application of this project in the building sector could be to assess the environmental benefit of specific solar techniques (e.g. transparent insulation) or renewable energy sources (e.g. wood fuel).

Reports :

General REGENER reports :
- Introduction to Life Cycle Analysis of buildings
- Environmental assessment at the local level
- Application of LCA by target groups

REGENER research reports :
- LCA methodology for buildings
- Integration of environmental assessment in the building design process