Overall assessment tool for sustainable office building design—towards consistent information and knowledge structure needed for innovative design

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ABSTRACT

In any evaluation tool, the question that always arises is what type of information and knowledge is needed? The other question, which is not less importance than the first, is must the tool's users (e.g. client, architect, etc.) know and get experience in all the knowledge archived, integrated and used in the tool database or library.

Success or failure of an evaluation often depends on the skill with which an evaluator selects and uses information-gathering techniques. These methods should be simple, clear, straightforward and should efficiently gather information needed.

In other words, an user can with some help and a simple and clear tool with simply integrated and encapsulated knowledge get some assessment and will be able to understand the consequences in the design process. And this assessment can support him to improve and change his design when required.

Information and knowledge to be analysed are normally difficult to obtain. The consistency of these information and knowledge in case of availability influence the capability of the assessment in finding out the consequences of the designer's decisions in any of the design phases. This assessment has also been substantially influenced by software development. At the same time, important steps have been made towards encapsulation and integration of knowledge and data needed for building design assessment.

These information and data needed for overall assessment regarding ecological aspects with respect to life cycle of office buildings have been discussed here. The data and knowledge requested regularly from designer and which helps him to avoid the design consequences will be one of the main tasks in this article.

INDEX TERMS

Office building; Level of aggregation; Ecological aspects; Sustainability sensitive parameters; Overall assessment; Consistency in input data

INTRODUCTION

The remarkable impression of the new high building design in The Netherlands is the efforts to be more sustainable. In addition to their unique shapes, it is also more due to their selected sustainable level of aggregation (e.g. workplace, room, floor, etc.) regarding sustainable building aspects (e.g. energy efficient building, sustainable materials usage, good indoor/outdoor environment, etc.). Many such buildings with these sustainable specifications can be noticed in the building market and could be used as a reference for knowledge library for consistence decision support system (DSS) (Abu sa'deh *et al.*, 2000).

The consistence of this Knowledge concerning the contrary will have a cause and effect on any environmental building aspect. That is, choosing the construction materials and their specification will substantially influence the performance of building energy and the glass percentage will have an influence on the comfort and the indoor environment of the building in general and so one the other aspects.

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LEVEL OF AGGREGATION

Diverse extensive studies have been made and delivered as starting points for the various parameters influencing sustainability and building performance.

The first step in all these studies is to define a standard level of aggregation. This level is so important that there should be assistance in the early design stage and can be perfectly chosen in the design process.

From an ecological point of view, the assessment of office buildings will be in five different levels in early design stages (see Figure 1). These levels can be assessed and evaluated in these stages and the relevant design decisions can be supported and, if necessary, be changed. The five levels have their own specific requirements. These different levels concern:

1. Workplace: it is the individual workplace area within the office room which does not exceed a few meters.
2. Office room: the room where two to four people work within an office floor with an area not exceeding 30 m^2.
3. Office floor: it is a work floor with many rooms, including toilets, elevators, stairs and corridors.
4. Office building: complete building with a number of office floors including different facilities on a building level (e.g. restaurant, storage, etc.).
5. Building environment: it is the highest level, including activities (e.g. transport, cyclists, etc.).

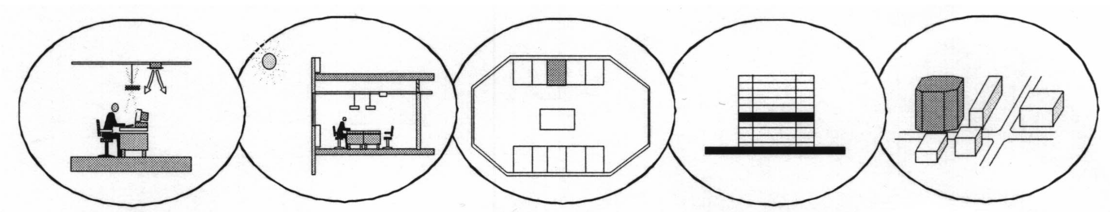

Figure 1 Different office building levels (Hill and Rutten, 1997).

All these different levels must be carefully ecologically evaluated within the design process by the proposed DSS tool.

ENVIRONMENTAL BUILDING ASPECTS

A design process that achieved the design main objectives in developing a sustainable and ecological building is the target with the consistence of building aspects. These selected aspects will be chosen based on extensive sensitivity studies and practically used in the market, and their influences on the sustainability proved. These aspects are diverse and are called as ‘parameters’ in this article.

These various parameters are listed below. The values of these parameters will be selected with the values already used to get reference in a knowledge library and as a part of the framework of the CBS (Case-based reasoning) package. This knowledge library is a way to match a new design with the sustainable cases stored in it to get a type of impression about this new design regarding its sustainability.

	Ecological aspect	
Level of aggregation	*Activity* Work cell activity (one or multi user desk) Room activity (room cell, restaurant, storage, bathroom,…) Floor activity (a group of rooms) Building activity (office building, hospital, school,…) Environment activity (any activities around building)	*Shape* Work cell boundary (geometry of the smaller zones in the room) Room boundary (geometry of the room itself) Floor boundary (geometry of any part of the floor) Building boundary (any geometry constituting a building) Environment boundary (geometry of building environment)
Level of aggregation	*Materials* Work cell element (desks, equipments) Room element (internal walls, finishing) Floor element (slab, isolation) Building element (foundation, slab, piles, building skin, facades, finishing, lifts, stairs, entrance) Environment element	*Energy* Work cell service (lighting, equipment) Room service (heating, cooling, ventilation, humidity, equipments) Floor service (lighting, heating, cooling, ventilation, humidity, equipment) Building service (lighting, lifts, equipments) Environment service
Level of aggregation	*Water* Work cell service Room service Floor service (fresh water, toilet's water) Building service (fresh water, toilet's water) Environment service	*Performance* Work cell performance (work cell climate) Room performance (room climate, indoor environment, temperature, etc.) Floor performance (performance related to the standards and norms) Building performance (long term performance) Environment performance (performance of environment, towards a building)

MAJOR SENSITIVE CONCEPTS

To achieve the maximum health building, some major sensitive concepts take more of our attention and concern than others but have more effect on the sustainability and performance of the building. Those sensitive concepts and measures can be described briefly as follows:

Energy Consumption
A number of the measures that have been taken to lighten the environmental burden relate to the building environment. This is hardly surprising, since as much as 50% of energy consumption is due to buildings (Melet, 1996); therefore, the building must be equipped with a minimum of building services, heat pump as a heat source that delivers heat to the low temperature wall and a floor heat system. A natural ventilation system with advanced electronically controlled inlet grills provides fresh air. A solar collector system produces DHW and PV cells generate part of the electricity and utilize maximum daylight. A mechanical cooling system must be avoided.

Materials
The materials used for construction must be chosen for their sustainability and comprise a low energy content for production, transport, etc. (van der Aa *et al*., 2002). There must be emphasis on the maximum use of recycled materials and in materials selection.

Water
Water must be used in an economical way, for example, the use of economy toilet cranes and douches. Rainwater may used in toilets to reduce water usage.

Indoor/Outdoor Environment
To reach a better indoor and outdoor environment, some requirements are needed. Adequate solar shading, sufficient internal mass and good operating ventilation systems are the required targets could be reached. The more the ventilation system is natural, the more optimum the indoor environment is.

As important as the indoor environment towards sustainable development, the outdoor environment, the indoor air quality and the problems associated with it regarding the three groups of indoor contaminants (physical, chemical and biological exposure) are also important (Senitkova, 2001).

RESULTS
Parameters and sensitive concepts have been used in examining diverse building design for both dwellings and for utility building design. These examples will be the basis for a knowledge library in a case-based reasoning tool. We can match any new design for office buildings with these examples to get an impression of how far the new design is from a sustainable building and try to improve it by this matching.

In the Netherlands some regulations are present for building designs with regard to building environmental aspects (e.g. Energy Performance Coefficient (EPC)): a criterion for limiting energy consumption in buildings.

Some of the results of these examples are summarized and are available as 'project examples of sustainable building' in The Netherlands (SEV, 1997). More examples are explained in other publications or articles. Some of the results of these examples are:

Sportcentrum (Sport Centrum), Nieuwland, Amersfoort—The Netherlands

- Energy: EPC = 25% better; RC = more than 3.0; HR Glass; Passive sun energy, etc.
- Water: Economy toilet; Douche and cranes.
- Waste: Divide building waste to five different parts concerning its type, etc.
- Indoor environment: good operating ventilation system, isolation for internal noise, adequate shading, etc.

Scholencomplex (Schools Complex), Rijkerswoerd, Arnhem—The Netherlands

- Energy: EPC = 20% better; RC = more than 3.0; HR Glass; Son boiler, etc.

- Water: Economy toilet; Douche and cranes and rainwater used for toilet.
- Waste: Divide building waste to 11 different parts concerning its type, etc.
- Indoor environment: good operating ventilation system, isolation for internal noise, adequate shading, etc.

Eco-Kantoor (Eco-Office), Bunnik—The Netherlands

- Energy: EPC = 45% better; high isolation values; no cooling installations; Sun collector for warm water; RC = more than 3.0; 10 m^2 PV cells; HR Glass; economy system for lighting; passive sun energy; high internal mass; etc.
- Materials: Flax as isolation (test); using wood; using red sand blocks (baksteen); etc.
- Water: Economy toilet; Douche and cranes and rainwater used for toilet.
- Waste: Divide building waste to five different parts concerning its type, etc.
- Indoor environment: good operating and natural ventilation system, isolation for internal noise, adequate shading, etc.

Project XX Example

Project XX in the experimental low energy office building that has become the offices of the XX Architecten Company in early 1999 in the City Delft-The Netherlands.

- Energy: So efficient is the building's triple-glazed that it resulted in low energy consumption. Double facade envelope where the thermostatically controlled extract fans will begin to operate at –70°C—the heat given off by 80 occupants and their electric office equipment being judged sufficient to maintain comfort conditions below that figure. Isolation values; no cooling installations; Sun collector for warm water; RC = more than 3.0; 10 m^2 PV cells; HR Glass; economy system for lighting; passive sun energy; high internal mass; etc.
- Materials: rectangular glass-clad structure resting on a concrete ground slab mixed with recycled aggregate and supported by steel piles. All materials used in the construction of the building XX are reusable, recyclable or biodegradable.
- Indoor environment: environmental control system, which provides cooling but contains no heating element, etc.

The results of this comparison with another reference project showed the difference in environmental impacts in percentage. These effects have been summarized to about 12 environmental effects and four main measurements: raw materials, energy usage, emissions and waste (Klomp, 1999b) (see Figure 2).

The meanings:
Percentage: Percentage
Grondstoffen: Raw Materials
Energie: Energy
Emissies: Emissions
Afval: waste
XX-Kantoor: XX-office
Referentiegebouw: Referenced Building

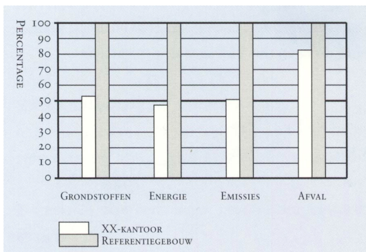

Figure 2 Environmental impacts of XX and the reference buildings.

CONCLUSION AND IMPLICATIONS

The design of healthy buildings is a complex job due to a large number of parameters and factors that must be addressed and the lack of knowledge about the effects of interactions among the diverse environmental parameters and the human and environmental responses to them (Senitkova, 2001).

In order to better evaluate and better understand the healthy and sustainable building and reduce the consequences of a bad decision in the early design stages we must adopt the data and parameters specified to be inputs of new office building design.

It is also important to have a good evaluation of the building to characterize the environmental aspects by a number of parameters as mentioned above. These parameters are well suited to describe the functional requirements in measurable terms. When the details of each of these factors are articulated, it is clear that the design of healthy buildings is a complex and challenging task.

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