ABSTRACT

Actors in the building sector need tools and guidelines to improve current practices and quality of buildings. These building environmental assessment tools and guidelines are based on criteria and indicators. Criteria are characteristics that are considered important, and indicators are measures corresponding to the criteria, and which can show the direction of change.

Since the field of environmental criteria and indicators used in environmental assessment of buildings is vast, the aim of this study is to clarify that field by analysing the current situation and constructively criticising it. Currently, there are standardised frameworks for developing indicators and assessment methods. These frameworks, however, do not provide specific indicators. There is an obvious need for standardised environmental criteria and indicators used in the environmental assessment of buildings.

KEYWORDS: Environmental Criteria, Indicator, Assessment, Sustainability, Building

1. INTRODUCTION

Green building and sustainable building have become popular research areas over the past decade. For example, there have been several international projects in the field; “A European thematic network on construction and city related sustainability indicators” (known as CRISP) (CRISP, 2004), “European Thematic Network on Practical Recommendations for Sustainable Construction” (known as PRESCO)

Also, standardisation of environmental building related issues has increased. The International Organization for Standardization (ISO) and the European Committee for Standardization (CEN) have been active in defining standardised requirements for the environmental assessment of buildings.

ISO Technical Committee (TC) 59 “Building construction” and its Subcommittee (SC) 17 “Sustainability in building construction” have recently published two technical specifications:


ISO/TS 21929 and 21931 are both technical specifications. After three years, they will be reviewed. They will then be confirmed for a further three years, revised to become an International Standards, or withdrawn (ISO, 2006a). These technical specifications are only frameworks. ISO/TS 21929-1, for example, provides framework for the development of indicators, it does not provide specific indicators.

CEN/TC 350 “Sustainability of construction work” develops voluntary horizontal standardised methods for the assessment of the sustainability aspects of new and existing construction works and standards for the environmental product declaration (EPD) of construction products. (CEN, 2005) Technical Committee (TC) 350 has three working groups. The estimated dates for the working groups’ standards are also mentioned:

- WG 1 Environmental performance of buildings
  - Framework for assessment of integrated building performance (Under approval, 09/2007)
- WG 2 Building Life Cycle Description
  - Assessment of environmental performance of buildings – Calculation methods (Under development, 11/2008)
- WG 3 Product Level
  - Environmental product declaration – Product category rules (Under development, 02/2010). (CEN, 2007)

1.1 Aim of the study

Since the field of environmental criteria and indicators used in environmental assessment of buildings is vast, the aim of this study is to clarify that field by analysing the current situation and constructively criticising it. The main focus is on environmental criteria and indicators used in the environmental assessment of building. However, sustainability criteria and indicators are discussed briefly to widen the viewpoint.
1.2 Content of the study

In the first section, the research area is briefly introduced, the aim of the study is stated, and the content of the study is listed. In the second section, the focus is on environmental indicators; the terminology used is briefly presented, and the types, roles and units of indicators are discussed. In the third section, the results from this study are highlighted, and the future of environmental indicators is speculated.

2. ENVIRONMENTAL INDICATORS

When discussing environmental issues in the building sector, the use of the terms is not well established. The inconsistent use of terms may cause confusions and misunderstandings. Cole (2005), for example, points out the interchangeable use of the terms “certification”, “rating” and “labelling”. Further, Kohler (1999) questions the definition of the terms “green” and “ecological”. To be able to discuss environmental issues on a scientific level, the terms have to be defined unequivocally. There is an obvious need for standardised terminology.

The standardised terminology needs to be agreed on and accepted by all actors in the building sector. Only then, can the terminology be adopted. Established terminology could form “a common language”. Dammann and Elle (2006) investigated if (and to what extent) a consensus on environmental indicators for buildings could form “a common language for green building”. According to them, “a common language” is unlikely in the near future.

Criteria are characteristics that are considered important and by which success or failure can be judged. Indicators are quantitative, qualitative or descriptive measures that when periodically evaluated and monitored show the direction of change. These definitions are stated in ISO 14050:2002(E/F), Annex A; Additional terms and definitions from Technical Report ISO/TR 14061. Technical Specification ISO/TS 21292-1:2006(E) has also adapted the definition of indicator from ISO/TR 14061. In addition, there is a note in ISO/TS 21929 that the terms and definitions given in ISO/TR 21932, when published, will apply. Currently, ISO/TR 14061 is a withdrawn standard, and ISO/TR 21932 is not yet published. Undoubtedly, the current situation of standards is confusing. ISO/TS 21929 has also defined environmental indicator as sustainability indicator related to an environmental impact, and sustainability indicator as an indicator related to economic, environmental, or social aspects. (ISO, 2006a)

The European thematic network on construction and city related sustainability indicators (CRISP) project is a well-known initiative to suggest sustainability indicators. According to CRISP (2004), “indicators are needed to define sustainability criteria and to measure the performance of the construction industry and the built environment”. The indicators are needed to evaluate strategies to improve the quality of life and to simultaneously increase the efficiency of resource use. Actors in the
building sector need tools, based on indicators, to improve current practices and the quality of construction. (CRISP, 2004)

2.1 Defining criteria and indicators

There are boundaries for defining criteria and indicators. The boundaries are terms that criteria and indicators must meet. Criteria are characteristics that are considered important and by which success or failure is judged. What is confusing is that the defined boundaries can also be called criteria. Indicators are measures which can show the direction of change. Indicators are measures corresponding to the criteria (characteristics). Sometimes, criteria (characteristics) and indicators are not differentiated; rather they are confusingly used as synonyms. A criterion may consist of more than one indicator. The nature and the units of the indicators may differ (Gerard et al., 2000).

The CRISP database includes 510 sustainability indicators (ecological, economic and social indicators). For example, there are several indicators for waste. One of them is "Waste (EcoEffect)". This indicator is a weighted average of construction waste, radioactive waste, slag and ashes, and hazardous waste. (CRISP, 2004) At the same time, building environmental assessment tool ESCALE is said to have 11 main criteria (energy resources, other resources, waste, large scale pollution, contextual fit, comfort, health, environmental management, maintenance and adaptability). The criteria are set out in a tree structure; main criteria can be divided into criteria, sub-criteria, detailed sub-criteria and elementary criteria. The main criteria "waste" is divided into three criteria; construction waste, operational waste and demolition waste. (Gerard et al., 2000) The current situation is confusing; one is talking about indicators and the other about criteria. But evidently, they are talking about the same thing.

There is an evident need for standardised terminology and hierarchical criteria structure. Firstly, there is a need to define the boundaries for criteria and indicators. According to CRISP (2004), the indicators should be objective, relevant, sensible and comparable. The results should be traceable. The indicators have to be measurable, and the appropriate data must exist and it has to be accessible. Furthermore, the indicators have to be understood by the users. There is a risk that excessive simplifying of the indicators may lead to a loss of important information. (CRISP, 2004) Theoretical and practical criteria have been suggested for evaluating the relevance of different indicators. (Malmqvist and Glaumann, 2006) Theoretical criteria emphasise validity, reliability and accuracy of the indicators. Practical criteria take costs, competence, intelligibility, and influence into account.
2.2 Categorising indicators

CRISP database includes 510 sustainability indicators. CRISP (2003) has categorised the indicators into three main groups; environmental, economic and social issues (Table 241.1). Sub groups of environmental indicators are also presented.

Table 241.1 Statistical analysis of the CRISP indicator database (CRISP, 2003).

<table>
<thead>
<tr>
<th>Sustainable Development Issue</th>
<th>Number of indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental / Natural raw material</td>
<td>89</td>
</tr>
<tr>
<td>Environmental / Bio-diversity</td>
<td>36</td>
</tr>
<tr>
<td>Environmental / Energy</td>
<td>112</td>
</tr>
<tr>
<td>Environmental / Pollution and waste</td>
<td>171</td>
</tr>
<tr>
<td>Environmental / Land use</td>
<td>84</td>
</tr>
<tr>
<td>Environmental / Other</td>
<td>38</td>
</tr>
<tr>
<td>Economic / all items</td>
<td>162</td>
</tr>
<tr>
<td>Social / all items</td>
<td>300</td>
</tr>
</tbody>
</table>

As seen in Table 241.1, environmental indicators added together make 530. Environmental, economic and social indicators added together make 1157. But altogether, there are 510 sustainability indicators in CRISP. So, there are indicators which belong to more than one category. Indicator "Emissions (EcoEffect)", for example, belongs to two categories; Environmental (environmental pollution) and Economic (production and consumption) (Table 241.2).

It is essential for the actors in the building sector that sustainability indicators are collected into a database, such as the CRISP database. How the database is structured and how the indicators are categorised into it, may confuse users. As mentioned, there are indicators which belong to more than one category. Also, there are indicators with similar names. There are, for example, several indicators for emissions: Eco-Quantum Emissions, Emissions (Ecodec), Emissions (EcoEffect), Emissions (MRPI), and REKOS Emissions, and several indicators for waste: Eco-Quantum Waste, Total Waste, Waste (EcoEffect), Waste (MRPI), and Waste disposal. Without a closer study, it is not possible to distinguish similarities and differences between the indicators. A comparison of two indicators is presented in Table 241.2. Also, the current situation of the terminology is confusing – which are criteria and which are indicators?
Numerous different criteria and indicators are used in environmental assessment of buildings. Already, CRISP database includes over 500 sustainability indicators. Are all these indicators needed? As mentioned earlier, there are several indicators under a similar name. Undoubtedly, there are overlapping content within similar indicators; same issues are measured within the indicators. If the overlaps were deleted and similar indicators were combined, how many indicators would be left?

Indicators are quantitative, qualitative or descriptive measures. These measures consist of measured variables. There are independent and dependent variables. “...two events are independent if knowledge of the fact that one has occurred gives us no clue as to the likelihood that the other will occur” (Milton and Arnold, 1995; p. 163). Considering this, different types of variables need to be distinguished and the correlations between them have to be clarified. This may reduce the amount of measured variables. It is not necessary to constantly measure dependent variables if they can be calculated while knowing the independent variables and the correlations.

By recognising the overlapping of indicators and distinguishing the different types of variables, the reduction of the number of indicators may be possible. On the other hand, what are the most important and essential criteria for environmental assessment of building? And what indicators correspond to these criteria the best?

Table 241.2 Comparison of two indicators (CRISP, 2003).

<table>
<thead>
<tr>
<th>Unit</th>
<th>Eco-Quantum Emissions</th>
<th>Emissions (EcoEffect)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit</td>
<td>kg/m² building area/year</td>
<td>percent (%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(impact/building/person)/</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(impact/society/person)</td>
</tr>
<tr>
<td>Type</td>
<td>Efficiency</td>
<td>Descriptive (performance)</td>
</tr>
<tr>
<td>Sustainable Development</td>
<td>Environmental</td>
<td>Environmental</td>
</tr>
<tr>
<td>Issue</td>
<td>(environmental pollution)</td>
<td>(environmental pollution)</td>
</tr>
<tr>
<td></td>
<td>Economic</td>
<td>(production and consumption)</td>
</tr>
<tr>
<td>Construction category</td>
<td>Buildings</td>
<td>Buildings</td>
</tr>
<tr>
<td>new</td>
<td>(new)</td>
<td>(new and refurbishment)</td>
</tr>
</tbody>
</table>

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2.3 Qualitative and quantitative criteria and indicators

The building environmental assessment tools use quantitative and qualitative criteria and indicators. Quantitative criteria and indicators can currently be confidently defined and assessed, for example energy use and water use. Qualitative criteria and indicators can currently only be described qualitatively, such as loss of biodiversity. Qualitative criteria are open to wider interpretation, and therefore their assessment is less certain. (Cole, 1999)

Furthermore, when the area of the assessment widens, new areas are often included. Some of these new areas are not defined properly, and according to Cole (1999), they may need more qualitative description in the measurement scale. Qualitatively expressed criteria are open to wider interpretation by assessors. Consequently, the interpretation of the results can vary considerably depending on the assessor. (Cole, 1999). If the results can vary depending on those making the assessment, the reliability of the assessment vanishes.

A criterion may consist of more than one indicator. The use of both types of indicators; qualitative and quantitative indicators, complicates the environmental assessment and the interpretation of the results. Use of qualitative and quantitative indicators forces to weight the indicators or to use a scoring system. Otherwise adding the indicators with different units is impossible. The significance of an indicator and a criterion relative to the others has to be discussed. Are they all of equal importance or is one more important than the other? Energy use can be divided into renewable and non-renewable energy use. Are these indicators of equal importance? The task becomes even more problematic when quantitative and qualitative indicators or criteria are compared, for example, defining the significance of energy use relative to loss of biodiversity.

2.4 Units

The definitions of the environmental criteria and indicators lead to another need: definition of the used units. A criterion may consist of more than one indicator. The nature and the units of the indicators may be different (Gerard et al., 2000). These situations may require determination of the weighting coefficient.

It might be difficult to achieve a consensus on units among all the actors in the building sector. Disagreements between different material producers are expected. Concrete industry, for example, may prefer different units than wood industry. The results give a different picture depending on the used units; concrete construction waste, for example, has high mass and low volume compared to wood (Trusty and Meil, 2002).

As an example, 10 m$^3$ of concrete construction waste is ~24000kg in weight, and 10m$^2$ of wood construction waste is ~5300kg in weight. On the other hand, the volume of 1000kg of concrete construction waste is ~0,4m$^3$, and the volume of 1000kg of wood construction waste is ~1,9m$^3$. 


From the viewpoint of image, concrete construction waste benefits if the amount of waste is expressed in unit of volume (m³), and wood construction waste benefits from using the unit of mass (kg).

Consequently, there is a risk that one may benefit at the expense of the other. Which units are the best? Which units serve the purpose best; which units are most beneficial in assessing environmental issues? There is a possibility that the units of waste should be mentioned using the units of mass (kg) and volume (m³). Another question is if “waste” is a sufficient environmental criterion. Should it be divided into sub criteria, such as “biodegradable waste”, “waste for combustion”, and “waste for landfill site”, which are measurable indicators? These issues should be considered broadly, because they have different dimensions. Combustion of waste, for example, produces energy and later, reduces the need of fossil fuels.

Furthermore, the transportation of the construction waste needs to be taken into consideration. The volume as well as the mass of the waste set requirements for the transport vehicles. Chopping the construction waste into portable parts requires energy. Chopping may need special equipment or machinery. These issues need to be included in the discussion.

2.5 Holistic point of view

Currently, building environmental assessment tools cover the life cycle of a building differently. Some tools, such as EcoEffect and LEED® cover the whole life cycle. There are also tools which are focused on a certain phase of a life cycle, for example EcoProfile is focused on the use and maintenance of a building. (IEA-BCS Annex 31, 2005) In addition, the used criteria and indicators vary among the environmental assessment tools. One tool may use several criteria and indicators for a certain phase of a life cycle, while the other tool uses only a few criteria and indicators for the same phase in question. Also, the tools may use same criteria for a phase, but different indicators to correspond these criteria. The key questions here are; which criteria are the most significant and which indicators correspond to these criteria best. The comparison of the criteria and indicators is difficult. Different actors in the building sector value them differently. An architect, for example, may value different indicators differently to an engineer.

From a holistic point of view, it would be essential that the whole life cycle of a building is covered in environmental assessment. The whole life cycle of a building covers all the phases and action from cradle to grave; from the production of raw materials to the demolition of the building and the disposal of the waste. Furthermore, the phases of the life cycle should have equal emphasis – no phase should be emphasised at the expense of the other. When building environmental assessment tools cover the life cycle differently or emphasise certain phases, the situation is confusing for the users of the tools. In addition, the results from the environmental assessment are not comparable.

While defining environmental criteria and indicators, it is essential that the whole life cycle of the building is covered equally and the different
phases of the life cycle are in balance. Furthermore, environmental criteria and indicators should not emphasize any actor in the building sector; neither the supply side nor the end user side. All the actors and their wishes should be handled equally. Different actors in the building sector emphasize different criteria and indicators, and even different units, as mentioned earlier. Also, some of the actors prefer more general indicators, for example “the use of raw materials”, while the others prefer more detailed indicators, such as “the use of renewable raw materials” and “the use of non-renewable raw materials”.

This impedes the formation of consensus on environmental criteria and indicators used in environmental assessment of buildings. The formation of a consensus is a big challenge. The task becomes even more challenging when sustainability is added to the discussion. In addition to environmental indicators, economic indicators and social indicators have to be selected as well. Broadening the scope of the indicators means more participants in the discussion. The more participants in the discussion, the more difficult it is to achieve a consensus.

3. DISCUSSION

As long as environmental criteria and indicators are not specified, clearly defined or standardised, the significance of the environmental assessments is minor. Consumers are not necessarily aware of emphases and areas covered by building environmental assessment tools. Furthermore, the comparison of the results of different tools is difficult, if not impossible.

There is an obvious need for standardised terminology and hierarchical criteria structure. The standardised terminology needs to cover all the significant areas, and to be agreed on and accepted by all the actors in the building sector. Once the standardised terminology is adopted, the boundaries for criteria and indicators have to be defined, agreed on and accepted by all the actors in the building sector. The most important criteria (characteristics) have to be distinguished and agreed on. The indicators, which correspond to these most important criteria, have to be defined. In addition, the units used for criteria and indicators have to be agreed on.

Currently, there are numerous different criteria and indicators developed for the building sector, for example CRISP database includes over 500 sustainability indicators. Continuous development of individual environmental criteria and indicators is possible, but it does not serve the purpose. To be able to assess the building from an environmental viewpoint, the significant criteria and indicators need to be distinguished. There is no point in assessing the building with numerous criteria and indicators if they are not relevant and do not serve the purpose.

There is a possibility to start the environmental assessment of a building with a few standardised indicators which are known to be significant. Later on, the number of indicators can be added, when there is more knowledge. Also, the existing indicators must be open to changes in the future. Which is more important; nature and the environment, or
humans? What is the situation now, and in the future? It should be the holistic viewpoint that counts. The wellbeing of nature, the environment and humans should all be taken into account – both now and in the future. It is important to distinguish the most important criteria and indicators for environmental assessment of buildings, without forgetting the wellbeing of humans. These viewpoints need to be discussed simultaneously, and they should be mediated.

Furthermore, economics is a very important factor. Therefore, it is not adequate to define environmental criteria and indicators. There is a need to define sustainability criteria and indicators; environmental, economic and social criteria and indicators. Also, these definitions have to be based on the best knowledge available. The focus has to be on the most significant criteria and indicators. There is no point in wondering about irrelevant issues or possible side effects if the main issues are not clear at the beginning. It is easier to broaden the scope later than to narrow it, and speculate the results.

It is more practical to have a building environmental assessment tool which clarifies ~80% of the significant environmental issues, than a tool which clarifies ~90% of irrelevant environmental issues.

4. ACKNOWLEDGEMENTS

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5. REFERENCES


