DEVELOPMENT OF AN ENVIRONMENTAL RATING TOOL FOR BUILDINGS THROUGH A NEW KIND OF DIALOGUE BETWEEN STAKEHOLDERS AND RESEARCHERS

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Abstract

Buildings need to be more environmentally benign since the building sector is responsible for about 40% of all of energy and material use in Sweden. For this reason a unique cooperation between companies, municipalities and the Government called "Building-Living and Property Management for the future", in short "The Building Living Dialogue" has going on since 2003. The project focuses on: a) healthy indoor environment, b) efficient use of energy, and c) efficient resource management. In accordance with the dialogue targets, two research projects were initiated aiming at developing an Environmental rating tool taking into accounts both building sector requirements and expectations and national and interna-tional research findings. This paper describes the first phase in the development work where stake-holders and researchers cooperate. It includes results from inventories and based on this experience discusses procedures for developing assessment tools and what the desirable features of a broadly accepted building rating tool could be.

Keywords:
Environmental rating; buildings; stakeholder collaboration; environmental indicators; environmental assessment tools.

Introduction

The Swedish building sector is responsible for about 40 % of all energy and material use in Sweden, caus-ing different types of environmental problems (Ecocycle Council, 2001). In addition, as many as 600 000 to 900 000 people in Sweden live in dwellings with an indoor climate that has a negative effect on hu-man health and wellbeing (Norlén & Andersson, 1993). In Sweden, the roadmap to environmental sus-tainability, of which the built environment is a vital part, comprises 16 National Environmental Quality Objectives which have been adopted by the Swedish Parliament and are to be achieved within a generation (Environmental Objectives Council, 2005). One of these targets, 'A Good Built Environment', states that

Cities, towns and other built-up areas must provide a good, healthy living environment and contribute to good regional and global environment. Natural and cultural assets must be protected and devel-oped. Buildings and amenities must be located and designed in accordance with sound environmental principles and in such a way as to promote sustainable management of land, water and other re-sources.' (Environmental Objectives Council, 2006).

To face the sustainability challenges of the sector, major stakeholders in the Swedish building and prop-erty sector, including the Swedish government, municipalities and companies, have entered The Build-ing Dialogue, embracing a number of commitments for each participant (Building, Living and Property Management for the Future, 2009). One of these is to ensure that all new buildings and 30 % of existing buildings should be assessed with respect to health and environmental performance before 2010 (Build-ing, Living and Property Management for the Future, 2003).

A general and broadly accepted tool for rating of environmental performance is expected to have a large impact on management, retrofit and new designs of buildings. In accordance with the commit-ments, two research & development projects were initiated with the aim of developing such a rating tool, applicable to both residential buildings and offices. Since a wide range of stakeholders are in-volved, an underlying expectation is that the proposed tool should utilise different types of current and future incentives, for instance tax reductions, subsidies, etc. to stimulate environmental improvements. This paper presents working procedures and results from the first phase of one of the research projects mentioned.

Objective and Outline

The objective of the research project is to develop a system for environmental rating of buildings, taking into account building sector requirements and expectations as well as national and international re-search findings. The rating tool shall encompass the indoor environment, efficient use of energy, effi-cient resource management and avoiding hazardous substances.

This paper presents, discusses and draws conclusions from the first research phase of the project, which consisted of literature studies, interviews and questionnaires. An inventory of current bills, legislation and policy targets is presented in the first chapter, together with the findings of an interview study with key informants representing authorities, sector companies and potential incentive providers. An inventory of national and international tools for environmental assessment of buildings was carried out and is pre-sented in the following chapter. These studies form the basis for an understanding of the local context in which the rating tool should be implemented. The discussion focuses on conclusions drawn from these inventories (seen from three different points of views – that of society, the sector and the scientific community). The extent to which they are in harmony or contradictory is examined. Finally some key features and elements of the anticipated rating tool, drawn from the dialogue with the stakeholders, are presented.

Method

The rating tool is being developed by researchers in collaboration with a group of companies and mu-nicipalities who support the work practically and financially. They participate in seminars and interviews and will test modules of the rating tool during the development process.

There are a number of features that should be considered when choosing the research approach. Firstly, the aim is to tackle and suggest a solution for a 'real-world problem'. Secondly, there is a normative purpose, as the tool should be used to improve the environmental performance of buildings. Thirdly, the problem area is complex, since the tool will cover a wide range of environmental and health aspects. Scientific knowledge from many fields needs to be collated and analysed in order to extract the most important aspects to be considered in the tool. However, since the aim is also to achieve broad accep-tance by the sector stakeholders, people's views and opinions need to be considered, which in turn increases the complexity.

In studying and working with similar problems and projects, a traditional, disciplinary research approach has often proved ineffective. Instead, it is argued that a transdisciplinary approach is necessary when dealing with real-world topics, human activity systems and normative and complex issues. In addition, the local context is highlighted as being important and the research process may commonly be action-orientated (Gibbons et al., 1994; Checkland, 1999; Lawrence, 2004). A transdisciplinary approach in-volves researchers from different disciplines working together to get a mutual understanding of the problems involved. In addition, when stakeholders from outside the academic world are participating, this calls for a practice-orientated solution to the problems (Gibbons et al., 1994; Lawrence 2004).

The project team consists of a group of researchers with different backgrounds, as well as an implemen-tation leader whose main role is to coordinate and communicate with all the participating stakeholders. More than 20 different companies and municipalities are participating in the project. They represent property owners, municipalities, developers, small and large construction companies, material suppliers, sector organisations, etc. The project team will consult with these stakeholders in all phases of the pro-ject. This is important since it produces an iterative process in which concepts, ideas and suggestions are debated continuously and therefore lays the ground for acceptance of any tool eventually pro-posed by the project team. Thus, the possibilities for a practical application in the future will increase.

Interviews and workshop

As one of the first steps taken opinions and requests from stakeholders were gathered. Business stake-holders, mainly involved in construction, maintenance and management, were involved in the process through workshops and were interviewed by telephone. In-depth interviews were carried out with stakeholders in government, insurance and banking companies. These three actors were identified in a previous report on environmental rating of buildings as potential providers of economic incentives (Building, Living and Property Management for the Future, 2003).

During one workshop in 2005, around 60 representatives of companies in the construction and mainte-nance sector and relevant authorities expressed their expectations and opinions about the develop-ment of an Environmental rating tool for buildings. A report from the seminar is available in Swedish (www. byggabodialogen.se).

Business stakeholders were interviewed in 14 structured interviews, with a questionnaire sent out by e-mail before the interview, and the interviews lasted for 30-60 min. Notes were taken during the interview. Examples of questions asked were: What is your interest in an Environmental rating tool, what are the driving forces for joining a rating tool, what kind of parameters should be included from your perspec-tive, are there intrinsic values for classifying a building, will incentives be necessary?

In addition, seven in-depth semi-structured interviews were made with stakeholders with the potential to provide incentives, hereafter referred to as incentive stakeholders (2 persons at two banks, 3 persons at two insurance companies, 1 official at the Ministry of Sustainable Development, 3 officials at the Ministry of Finance and 1 economic political advisor at the Swedish parliament). The interviews lasted for about one hour and notes were taken.
Results from the interviews and the workshop will be more explained and discussed in a separate article by Åsa Svenfelt, KTH.

Investigations of tools

To improve our knowledge of existing tools, an inventory was made of Swedish and international tools. It was naturally much easier to obtain information about Swedish tools. Through the snowball approach, some 37 Swedish tools were identified. The term 'tool' was in this case very widely interpreted and in-cluded tools that purely dealt with energy or building materials or indoor environment, etc. A question-naire was sent out to all these 37 in order to collect information on use, kind of buildings, purpose, phase, software, input data needed, structure of tool, impact category, existing database, etc. and 27 answers were received. Reasons for not answering were: that the tool was obsolete, it was a variant of another tool, it had been integrated into something else, etc. Only three tools had the life cycle perspective included in some form.

International tools were sought via the Internet and sources like CRISP (2001), IEA Annex 31 (2001), Build-ing Energy Software Tools Directory (2006) and Building Environmental Improvement Links (2006) . From these different sources, 13 tools were selected for a more thorough description and analysis. The basis for selection was e.g. inclusion of a life cycle perspective and the level of sophistication. It was ex-pected that more could be learned from the comprehensive tools. These altogether 40 tools were then classified according to their main focus into the following catego-ries (Table 1):

The majority of Swedish tools dealt with energy, resources and indoor environment and the assessments were made through criteria. The tools dealing with choice of building material were mainly based on banning certain hazardous substances. The international tools were more comprehensive.

Category	Swedish Tools	Foreign Tools	Sum
A1	7	6	13
A2	2	5	7
B	3, 1 (B+D)	--	4
C	3, 1 (B+C)	--	4
D1	10	--	10
D2	---	2	2
Sum	27	13	40

Table 1: Number of Different Types of Environmental Assessment Tools Inventoried (Source: Authors).

A. Tools that capture energy, resources and indoor environment
A1. Based on criteria
A2. Based on criteria and LCA
B. Tools on energy
C. Tools on indoor environment
D.Tools treating choice of building materials and construction
D1. Based on criteria
D2. Based on criteria and LCA

Results

Expectations of the tool

All stakeholders interviewed had few opinions about what the Environmental rating tool should cover in terms of environmental or indoor problems/qualities. The two bank interviewees considered soil con-tamination a risk and believed that the bank would benefit from the inclusion of such aspects into the tool. Furthermore, the opinion at both banks was that maintenance costs should be included since they are important for property valuation. For one insurance company interviewee, precautionary measures to avoid fire and water damage were important since such damage is comprehensive and resource-demanding. The other insurance company interviewee emphasised choice of building material as im-portant, primarily because destruction of materials with hazardous substances is expensive and avoid-ing them would reduce risk for the insurance company. The Ministry of Sustainable Development inter-viewee cited energy use and that the tool should cover both fixed performance characteristics and more dynamic behaviour-related characteristics.

Many comments were on a general level and often concerned the usefulness of the tool and its relation to other tools. For most of the business stakeholders interviewed, it was important that the tool should be easy to use, simple in its layout and at the same time based on scientific knowledge. Positive character-istics in the view of business stakeholder were for example transparency, comprehensibility and flexibility. Further LCA inclusion, environmental information about building materials, independent management and third part verification were viewed as positive. Negative aspects mentioned were expert depend-ent, costly and complicated and not covering all kinds of buildings.

Driving forces for environmental rating

All interviewees believed that economic or other incentives were not a prerequisite for willingness to classify buildings, but incentives would speed up the process. Previously discussed incentives (Building, Living and Property Management for the Future, 2003), i.e. tax reductions and better conditions for in-surance and financing, were mentioned. Tax reductions were considered important for private property owners and reduced insurance fees were mentioned by several interviewees, while conditions for fund-ing were mentioned by only a few. Other possible incentives or driving forces mentioned were e.g. lower fees from supervisory authorities, longer intervals between compulsory controls, subsidies for envi-ronmental investments and environmental taxes on hazardous substances/emissions. Incentives pro-posed by authority stakeholders (Ministry of Sustainable Development) included exemption from legisla-tive tools, although this would be difficult as there is just minor regulation for these purposes, mainly mandatory control of ventilation. It is difficult to justify why environmental performance would give an advantage over other issues, e.g. adjustments for the disabled. Public procurement was also empha-sised as an important incentive.

Business stakeholders identified several driving forces for joining an Environmental rating tool. Market expectations were considered important in a long-term perspective. Several interviewees foresaw an upcoming focus on environmental performance of buildings at purchasing/leasing events. Public prop-erty owners stated that environmental performance was considered important in their sphere and there was a political pressure to deal with this issue. The interviewees also cited demands from authorities as a driving force and believed that it is better to be prepared and to participate than to be forced by legis-lation. The implementation of the European Parliament Directive (2002/91/EC) on the energy perform-ance of buildings was mentioned by practically all business stakeholders as an important driving force. Several intrinsic values of environmental classification were anticipated, e.g.:

– Improved knowledge about the building
– Support in purchasing, selling and leasing (function as environmental product declaration)
– Improved security for users (providing information and improving indoor environment)
– Improved market price for buildings of better environmental rating
– Decreased maintenance costs

Potential for incentives

Most of the incentive stakeholders expressed an interest in an Environmental rating tool. Both bank em-ployees anticipated that a rating could influence the valuation of a property. If it were to include as-pects important for the bank from a risk perspective, such as need for soil remediation or risk of water damage, it would provide important information about the state of the building and could be included in the assessment process. The interviewees at the insurance companies also saw some benefits of a rating tool. However, at one company the interviewees did not think that a rating tool would prove useful for the insurance business, mainly because insurance risks were not believed to be related to environmental load or quality. The other insurance company had a different perspective and regarded the major damage risks (fire and water damage) as environmental risks, since repairing those damages demands resources and affects the environment severely.

At the Ministry of Sustainable Development, the interviewee regarded an Environmental rating tool as potentially beneficial from an environmental policy perspective, as it could stimulate development of new environmentally benign products and contribute to the fulfilment of the National Environmental Quality Objectives – depending on the extent to which the tool is in line with those objectives. Further-more, a development where policy tools supported environmentally beneficial behaviour was regarded as positive and an environmental rating connected to tax reductions could be an important step in that direction. In the current property tax system, environmentally beneficial measures such as installing en-ergy-efficient windows or a heat pump increase the assessed value of the property and hence increase the owner's property tax burden.

The interviewees at the Ministry of Finance were positive towards a rating tool, but not towards providing tax incentives/reductions for buildings of better environmental performance. The main reason was that the property tax system is not suitable for governance. The interviewees argued that all attempts to influence the assessed value of a property would fail because adjusting/reducing the assessed value (in order to reduce the property tax) would increase the market value of the property, which in turn would increase the assessed value, and in the end increase the property tax. The alternative, according to the interviewees, would be selective taxes on environmentally detrimental materials. The interviewee at the Swedish parliament raised objections to this approach and argued that selective taxes only deal with the materials used, not how they are used. Furthermore, this interviewee argued that the real problem with using the property tax system for the purpose of supporting environmental performance of build-ings is that the principle of market value as the basis for taxation would have to be abandoned. This principle should be abandoned for higher purposes if necessary, but a stronger political will would be required in order to achieve this.

Another possibility for supporting environmental performance of buildings would be subsidies for envi-ronmental investment. Such policy tools are already in use in Sweden. The interviewee at the Swedish parliament argued that these measures are not as efficient as a decreased property tax since there are difficulties in communicating the motives for increased taxes for environmental investments even if the money spent is paid back somewhere down the line through subsidies.

Banks could theoretically provide two kinds of incentives; lower interest rates and longer repayment periods. But none of the interviewees at the two banks identified any possibilities to provide incentives for environmentally classified buildings at the moment. If it was possible to ensure that a building of a superior environmental rating was also managed better than normally, the rating could influence the bank's risk assessment positively. However, the risk assessment only constitutes a small part of the total assessment of the value of the property. If environmental performance of buildings were more appreci-ated in society, buildings of better environmental performance would be more in demand and hence more expensive. In such a situation, an Environmental rating tool could be important in credit rating too.

At one of the insurance companies there seemed to be a potential for providing incentives for buildings of better environmental performance. Lower fees for insurances and discounts on the excess would be possible, but only if it could be shown that buildings with better rating also have less damages. The other insurance company saw no cause for providing incentives for rating, since the company insures against damage that is not environmental. The situation would be altered if environmental load implied eco-nomic consequences for the company, which it currently does not.

Characteristics of assessment tools

Typical for most tools is that they are developed or intended as commercial products. The scientific background is seldom presented or documented. Therefore the system boundaries are not discussed and the choices made not defended. The topics assessed also differ from tool to tool. A general prob-lem is that weighting systems, which are generally applied, are of different kinds. The procedure of de-fining the necessary set of weightings is seldom shown. Statements such as 'weights are based on expert views' are common, but the experts concerned and the basis on which they have established their weighting are not presented. These features make results from different tools almost impossible to com-pare. The commercial interests make shortcomings and methodology discussion less popular. A conclu-sion is that more scientific examinations of methodologies and debate about possible approaches and result presentations are urgently needed. Since many companies have invested much money and la-bour in different individual tools, it is important that they at least to some extent can use their experience or databases in a new common rating tool.

In the type A category, i.e. containing energy, resource use and indoor environment, there are 9 Swed-ish and 11 foreign tools. Among the Swedish tools the two which are developed in the public domain includes life cycle assessment (LCA) and apply well described weighting systems. Six tools are consult products used commercially. The last one is a criteria tool for single family houses launched by the Nor-dic Ecolabel (2009). Most of the foreign tools were deliberately chosen because they included LCA. Some of them as BREEAM (2009), CASBEE (2009) and LEED (2009) are more or less dominating their na-tional markets.

There is an abundance of energy tools, type B, ranging from very sophisticated as IDA (2009), to simple interactive tools on the web. Type C concerns indoor environment. In Sweden there are at least three tools to investigate and classify indoor environment in existing buildings. There are a number of tools to simplify choice of building materials without hazardous substances, type C. They are ranging from envi-ronment product declarations to ban lists, product databases and a priority guide launched by The Swedish Chemicals Agency.

Discussion

Design of an assessment tool for existing buildings

The first question is what areas to include in an assessment tool for existing buildings. Should this be based on what is in focus at the moment, on sector or national or goals, on environmental impacts from individual buildings or the building sector, on commonly assessed problems or predicted problems in the future, etc.? On a general basis, it is sensible to argue that problems related to emissions and resource depletion associated with energy and materials use and possible negative impact on the building users' health should be included in an assessment tool. The main environmental building problems are found in these areas.

Going from the systems perspective to selection of specific indicators within each area is difficult for several reasons. Dose-response effects are rarely enough well known. The consequences of choosing materials and constructions are often poorly known. Searching for hazardous materials in existing build-ings take time and is costly, etc.

In this work we will use two basic approaches for selection of assessment issues. One is based on identi-fication of the most important environmental problems and the other on identification of established political goals and commitments made by the sector. The latter include the commitments made by the sector and the government within the dialogue project Building, Living and Property Management in the Future. These commitments are of interest since one of the aims of our project is to develop a rating tool that can be used within this commitment. Furthermore we look at the National environmental qual-ity objectives and including their sub goals, which reflect stable societal goals in the environmental arena.

For assessment of specific issues indicators are often used. An indicator is a quantitative, qualitative or descriptive measure that - when periodically evaluated and monitored - shows the direction of change (ISO 14050). Indicators are used in the absence of precise measures and knowledge or when it is too costly to make more accurate evaluations, hence their frequent use for environmental assessments. However, indicators can naturally be more or less accurate, or show one aspect of a problem that is multidimensional, etc. So, choosing indicators is always a compromise between theoretical and practi-cal demands. To improve this process, we suggest that the following subset of theoretical and practical aspects is considered:

- Theoretical aspects
o Validity (to what extent is the problem measured?)
o Accuracy (how accurately is the problem measured?)
o Repeatability (do repeated measurements produce the same result?)

- Practical aspects
o Influence (to what extent can the manager influence the indicator?)
o Intelligibility (how easy is it to communicate the indicator?)
o Cost (how costly is it to collect data needed for calculations?)

The problem oriented approach involves the following step by step work:

- Listing the problems related to the use of a building within the areas emissions, resource deple-tion and health
- Prioritising among this problems based on severity and extent of each problem
- Listing all possible indicators related to the selected problems which alone or in combination can describe the problems that should be assessed
- Assessing these indicators with reference to their theoretical and practical significance includ-ing costs (see below)
- Making a preliminary selection of indicators for the tool according to the previous point
- Testing the selected indicators on real buildings
- Reviewing costs and practical aspects before the final selection of indicators.

Some notions about assessment tools
The problem of how to design a building with a specified environmental performance often

arises. At the design stage the building cannot be evaluated, only the risk for failures in the completed building based on drawings and descriptions can be assessed. An assessment tool for an existing building is sel-dom suitable as a tool for design. To be efficient, a separate design assessment tool must be developed which is adapted to the design process and based on efforts to avoid the problems that an assessment of the future existing building tries to measure.

Calculation of environmental impacts due to use of energy and materials has to be normalised to make comparisons between different buildings possible. The most common basis for normalisation is per m2 floor area, for example MJ/m2. However, the unit m2 has severe drawbacks. In life cycle assessment, products should be compared with reference to their environmental load per functional unit. The aim is to facilitate the possibility to choose the product that gives the least environmental impact for a given service. To apply this view to buildings the service of each building category must be defined. This is not as difficult as it sounds, as every building is designed for a special purpose, i.e. residential buildings are designed for a specific number of residents, offices for a specific number of working places, schools for a specific number of pupils and teachers, etc. For this reason it seems more logical to use for instance MJ/user or MJ/person and hour as a measure for comparison of energy use. Using m2 means that build-ings with large areas are favoured compared with buildings for the same purpose with less floor area. This is the opposite of what is intended, since the small building with the same construction often uses less energy.

Many assessment tools only consider the environmental performance of a building, but some also assess potential, e.g. the ability to adapt to a new use, another energy source, etc. This is of course to encour-age adaptability in general, given that this is favourable from an environmental point of view. However this facility might soon be obsolete because of demand for changes that cannot be foreseen today. The stimulus to create adaptable buildings is mainly relevant at the design stage where a choice is at hand. Some tools also favour processes like environmental education, documentation and following up procedures etc. This might improve the environmental performance of a building but it is most uncertain. When aggregating scores for performance, potentials and processes the result becomes very ambigu-ous.

There is a clear demarcation line between pure additive systems and hierarchical systems with weight-ings. The additive systems, where points are gained according to criteria for each issue and then added to an overall score, suffer from the different value of different scores. In various areas it is normally possi-ble to assemble different amounts of scores. This amount should reflect the different significance of the areas judged by someone or a group. For example energy use is generally judged as more important than other areas, but the question is, how much more important? There is no answer to this question unless a specific method to assess the significance is used. Since one score is the smallest unit, many areas give just one score even if there are obvious differences in their environmental significance.

On the other hand, hierarchical systems with several levels tend to give other kinds of bias.

When a ba-sic assessment score is multiplied with different weightings for each level, differences are generally lev-elled out and many buildings appear similar. Another problem with the hierarchical systems is that when a certain indicator is not applicable for one building, it becomes difficult to compare it with other build-ings. Whether this aspect is set at zero or at a mean value, the result will be biased. The fewer hierarchi-cal levels a tool uses, the more transparent is the result.

For every assessment a scale is needed. To establish this at least two points have to be defined. One may be zero and the other some kind of reference point, e.g. representing a typical value for a stock of buildings, a statistical value (mean, median, mean + std, etc.) or an environmental goal level (national, sector, goal, etc). Since the statistical reference is the most neutral, it is preferred but sufficient data are often lacking. Consequently many tools use a mixture of references. For transparency, a single principle for choice of reference would be appreciated.

If zero is not chosen as one endpoint of the assessment scale, for instance because no building will reach even the vicinity of a zero impact, another point has to be chosen. Two options are for example to choose BAT (best available technology) as another reference point or the performance of a specific building that has a good reputation of being an example of a 'green building'. It is obvious that both these options are very subjective. In the first case the choice is not based on environmental evaluation but on an opinion of what is good technology for the environment. Many new green buildings show numerous examples of such valuations. Some tools do not use a linear scale since the better the per-formance is the more difficult is it to make further improvements a building.

Result presentations and communication

It is natural to partly communicate results with diagrams, e.g. in two or three dimensions as found in common computer programs like Excel and Access. However, assessment results normally consist nor-mally of independent values. That makes it preferable not to connect them with lines in a diagram, since this might give an impression of a continuum and thus sometimes create a temptation to interpo-late. Even if it is obvious that interpolation is impossible, it is clearer if discrete values are shown inde-pendently.

Pictures and patterns have the advantage of being easier to comprehend and remember than figures. For this reason it has become popular to make presentations in a polar diagram (also called spider, radar and rose diagrams) with coloured or striped areas in between. In this context, however, pictures also have some drawbacks. Apart from it being inappropriate to fill in the space between discrete val-ues from a general point of view, the impact of the image depends not only on the scores but also on the order in which they are put (see example in Fig. 1). Further disadvantages are that if some of the main indicators are missing, the figure cannot be completed and used for comparison. Further, if an indicator is to be added or subtracted in the future, the previous memorised patterns are no longer valid for comparisons.

All assessment tools use computer programs for data handling and presentation, but the intelligibility and transparency differ greatly. A comprehensive content should still be simple to handle and results should be easy to understand. A hierarchical tool design at least to some extent resolves the intelligibility problem. For laymen, who only are interested in summarised results, the upper part of the hierarchy might be enough to look at, while building or system specialists are able to spot causes and decisions built in to the tool on the lower levels.

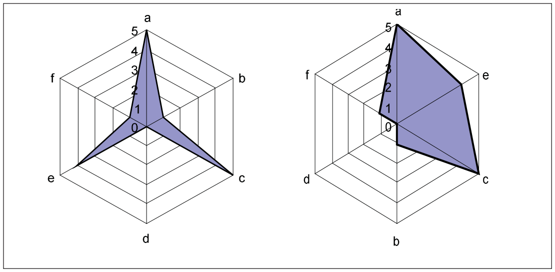

Figure 1: The Same Scores but in Different Orders Create Pictures of Different Size and Form (Source: Authors).

Conclusions

Interviews with business and incentive stakeholders revealed that a building rating tool should be flexi-ble regarding use by different stakeholders, transparent regarding choices built into the tool, include life cycle considerations, be easy to access and relatively cheap to use. It might include questionnaires for building users. The tool should be administered by an independent party and need little manpower to maintain.

An inventory of existing tools revealed that there is a wide flora of tools with very different contents and outcomes, developed mainly by building consultants and used as commercial projects, sometimes on a non-profit basis. Most tools do not include life cycle considerations. Some Swedish tools are quite narrow, focusing on e.g. the content of hazardous substances in building materials. In some of the international tools examined, much more resources have been spent on the tool, resulting in a very comprehensive content that can be difficult to grasp. No common consensus exists about content and methodology for an Environmental Rating Tool, which means that results from different tools are mostly impossible to compare.

Most tools have been developed during a long time period where alterations and additions have been successively included, therefore a systematic approach is often difficult to identify. An attempt to define a systematic approach for development of assessment tools is presented here, including proposals for the theoretical and practical properties to be considered when selecting environmental indicators.

Some of the elements generally included in assessment tools and critical for the outcome include nor-malisation, indicator types, aggregation of results and assessment scales. Normalisation is needed for comparison of buildings with different size and content. In line with LCA (Life Cycle Assessment) the normalisation basis should be closely related to the service a building offers, e.g. the number of users the building is designed for, rather than the floor area. There are differences between assessing perform-ance (e.g. energy demand), procedures (e.g. using an environmental management system) and po-tentials (e.g. individual monitoring of temperature and air flow). Most tools include such large amounts of elements that one or a few final scores have to be presented to be able to overview the result.

This requires an aggregation, but many existing tools lack a systematic weighting approach. Since weight-ing has a profound impact on the final result it is most important to describe how the weighting is made. Finally the choice of assessment scale and graphic presentation is very important for communication of results.

Since the building sector is so large and contains so many players with different interests, there are many more or less obvious contradictory demands on an assessment tool. Commercial companies want a private tool that is not transparent for competitors; building purchasers and academics want open and transparent tools facilitating comparative studies and evaluations; manufacturers want to make prod-ucts with superior properties by adding chemicals they are not ready to reveal; consumers want to avoid exposure to hazardous substances. Finally, at least in Sweden, environmental improvements most likely mean an increased market value and subsequently higher property tax, counteracting improve-ments.

The number of assessment tools to some extent reflects a real need for different tools focusing on differ-ent aspects and answering different questions. Thus the need for many tools will continue – and for im-proved tools, since even the most successful existing examples only have a market penetration of one or a few percent, perhaps because there is insufficient incentive for owners and managers to classify their buildings or because the cost is too high.

Environmental assessment of buildings is a fairly new area of research and development, making it diffi-cult to define the characteristics of a good rating tool. In a new field of research without established theoretical practices, the field is open for entrepreneurs and there is a flora of different methods with secret ingredients on the market today. It is characteristic that the first successful rating tool on the mar-ket, BREEAM, was developed by a consultant on commission from BRE (Building Research Establishment, UK).

We believe that there is a need for further development of assessment tools and that the scientific community needs to be more involved, both in developing better tools and in exploring the circum-stances in which assessment and rating tools can be successfully implemented and used. From an envi-ronmental point of view the most important thing might be to introduce a limited but solid system of continuous learning and improvement rather than look for the best tool available, because this will never be found in a field of continuous change in knowledge and opinions. The market can probably only absorb a few things at a time. The research needs to guarantee the solidity of the factual content.

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