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Assessment Focus for More Sustainable Buildings

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Abstract

Proliferation and complexity of tools for assessing sustainability of buildings calls for facilitating the use of tools by different stakeholders. This consideration entails rethinking of the assessment focus and flexibility of tools. The aim of this paper is to outline how the focus on durability, adaptability and energy efficiency of buildings enables building designers and managers to assess new building designs and existing buildings by considering most significant aspects of the environmental impact of buildings. It also indicates how flexibility can be achieved by enabling changes in the assessment scope and criteria.

The paper considers a recent analysis of existing tools for assessing sustainability of buildings and draws attention to an assessment tool developed by researchers at the University of Strathclyde in 2000, which is available as software and has been used to assess new building designs and existing buildings. The transparency of the assessment criteria and flexibility of the tool regarding the assessment scope and changing performance targets in the assessment criteria enable easy adaptation of the tool for different building types, environmental/geographical context and stakeholders' needs.

The conclusions outline advantages of focusing on the most significant aspects of environmental impact of buildings, providing transparent assessment criteria and flexibility for changing performance requirements and addressing the needs of different stakeholders. This approach can also be applied in developing tools for assessing economic and social aspects in sustainability of buildings.

Keywords: durability, adaptability, energy efficiency, assessment tools, assessment focus and flexibility

Introduction

As buildings contribute about 46% of the UK's carbon dioxide emissions, require significant amounts of water (56% of water supplied is used by households), use natural resources such as timber and materials in their construction, produce construction waste and put pressure on land resources (DEFRA, 2004), design of more sustainable buildings is very important for achieving more sustainable development. Further, about 56% of the energy consumed both nationally and internationally, is used in buildings (Harvey and Ashworth, 1996), showing the opportunities and responsibilities for designing energy efficient buildings. In the construction industry energy is used for the extraction and manufacture of building materials and components, their transportation to the building site, the construction process, the running of building, maintenance, adaptations, deconstruction and disposal. Energy conservation of building pertains to all these phases of a buildings life.

Early policy documents published by the UK Government have addressed strategic development issues in documents such as *Sustainable Development: The UK Strategy* (DoE, 1994), *Opportunities for Change* (DETR, 1998a), and *A better quality of life: a strategy for sustainable development for the UK* (DETR, 1999a). Subsequent policies focused on urban planning issues in *Planning for Sustainable Development* (DETR, 1998b) which promotes the idea that planning authorities should develop a strategic vision for existing urban areas, looking 25 years ahead. The need for more sustainable urban development has been addressed in more detail in the report *Towards an Urban Renaissance* (DETR, 1999b). This report was then a basis for the Urban White Paper (DETR, 2000) which provides guidance for developing more sustainable cities.

The legislation, always the strongest tool for applying policies in practice, related to more sustainable development includes Environmental Impact Assessment (EIA) required for compliance with Town and Country Planning (Assessment of Environmental Effects) Regulations 1988, Sustainability Appraisal of Regional Planning 1999 and adopted European SEA Directive 2001/42/EC which is applied since 2004. Changes in Building Regulations have been made to ensure that new buildings will be 40% more energy efficient than those built in 2000 (ODPM, 2005). However, there is not yet legislation which comprehensively addresses sustainable building design. On 13 December 2006, the Code for Sustainable Homes (CSH) - a new national standard for sustainable design and construction of new homes was launched. This is a voluntary rating code for new homes which will demonstrate their environmental performance. Full Technical Guidance on how to comply with the Code will be published in April 2007 (DTI, 2006). There are indications that the code could become mandatory (DCLG, 2006).

The paper will compare rating systems developed in USA, Canada and Hongkong as selected for assessment in the research on *Metrics, Models and Toolkits for Whole Life Sustainable Urban Development* (BRE, 2004), some French building assessment tools, Code for Sustainable Homes (ODP, 2005) and a tool for assessing durability, adaptability and energy conservation of buildings (DAEC Tool) developed at the University of Strathclyde in 2000 (Langford et al, 2002). The BRE (2004) research has indicated a proliferation of the sustainability assessment tools (675 tools identified) which do not have a comprehensive assessment methodology. Of the identified tools, twenty five were selected to examine whether they considered the three elements required for a more sustainable development, i.e. environmental, economic and social issues. Seven of them are for sustainable urban planning; three are design tools; seven are classified as building environmental framework and rating systems; seven tools use a life cycle assessment approach; and one is classified as infrastructure tool. The BRE (2004) report indicates that of these tools the most developed are urban planning and rating systems. It also points out that the LCA tools determine particular aspects of sustainability, but are not holistic in their approach. Regarding the design tools, the BRE (2004) report conclusion is that they are generally specific to energy issues.

As the focus of this paper is on the assessment tools for a more sustainable building design, the tools for sustainable urban planning and infrastructure will not be considered. The overview of tools selected for this paper will identify what has been considered as most relevant to the design of more sustainable buildings, how the assessment criteria can be updated and how the assessment is communicated to stakeholders. The aim of the overview is to compare the scope, flexibility and usability of rating tools as these features of assessment tools could influence their acceptability by stakeholders.

Regarding the scope of an assessment tool, there is a potential conflict of interest of different stakeholders in deciding what should be assessed, e.g. a building owner/user might be more interested in durability, adaptability and energy efficiency of buildings than a developer. This paper argues that a sustainability assessment tool should protect interests of building owners/users and the society. It points out that a sustainability assessment tool should be flexible, i.e. allow for changing the assessment criteria according to building type and performance requirements. The paper indicates that the assessment process should be transparent and communicated in the way which enables all the stakeholders to understand and use the tool.

Regarding the scope, flexibility and usability of assessment tools, the paper draws attention to the assessment tool developed during the research on Sustainable Buildings: Durability, Adaptability and Energy Conservation at Strathclyde University (Langford et al, 2002). This is described in detail later in the paper. The tool enabled the assessment of new and existing projects, changes in assessment criteria to accommodate different building types, a transparent assessment process and the presentation of assessment results through charts by using dedicated software.

Overview of selected sustainability rating systems for buildings

Sustainability assessment tools selected for the comparison in this paper include seven tools selected in the BRE (2004) report (GB Tool, LEED, SPeAR, Minnesota Sustainable Design Guide, EcoCal, BREEAM and HK-BEAM), a number of French tools assessment tools (CRISP, 2001), Code for Sustainable Homes (ODP, 2005), and Durability Adaptability and Energy Conservation (DAEC) Tool (Langford et al, 2002). Assessment scope of each tool is presented in Table 1.

Table 1. Assessment scope of rating systems for sustainable building design

Name, provenance and building type	**Environmental issues**	**Economic issues**	**Social issues**
Codes for Sustainable Homes, UK, for new housing	*Energy efficiency* *Water efficiency* *Surface water management* *Site waste management* *Household waste management* *Use of materials*		
BREEAM, UK, for new housing, offices, industrial units, retail units, schools	*Energy use*: operational energy and carbon dioxide (CO_2) issues *Pollution*: air and water pollution issues *Transport:* transport-related CO_2 and location-related factors *Land use*: Greenfield and brownfield sites *Ecology*: ecological value conservation and enhancement of the site *Materials*: environmental implication of building materials, including life-cycle impacts *Water*: consumption and water efficiency *Management:* commissioning	*Management*: overall management policy, management and procedural issues	*Health and well-being*: indoor and external issues affecting health and well-being
EcoCal, UK, household lifestyle	*Transport* *Water* *House and Garden* *Energy* *Shopping* *Waste*		*Community Action*
GBTool, Canada (tested internationally, including France), for all building types	*Resource Consumption:* life-cycle energy use, land, water, materials *Environmental Loading:* GHG, COS, acidification, solid waste, effluent, site impacts	*Economics* (life cycle cost) *Pre-operation Management*	*Indoor Environmental Quality:* thermal comfort, illumination, acoustics *Quality of Service:* adaptability, controllability, maintain performance, amenity
LEED, USA, for all building types	*Sustainable site:* brownfield redevelopment, alternative fuel refuelling stations, parking capacity, protection of open space, development footprint, stormwater management, reducing heat islands *Water efficiency*: water efficient landscaping, innovative wastewater technologies, water use reduction *Energy and atmosphere:* Building systems commissioning, , minimum energy performance, CFC reduction, ozone depletion, energy monitoring, renewable energy *Materials and resources*: storage and collection of recyclables, building reuse, construction waste management, resource reuse, recycled content, local materials, rapidly renewable materials, certified wood *Innovation and design process:* exemplary recycling, rain gardens, reuse of ash, other		*Sustainable site*: above flood plains, urban redevelopment, public transportation, bicycle storage and changing rooms, light pollution reduction *Indoor environmental quality:* minimum IAQ performance, tobacco smoke control, CO_2 monitoring, ventilation, construction IAQ management plan, low-emitting materials, chemical and pollution source control, controllability of systems, thermal comfort, daylight and view

Name, provenance and building type	**Environmental issues**	**Economic issues**	**Social issues**
Minnesota Sustainable Design Guide, USA, for all building types	*Site:* Reduce sprawl due to new development, maintain and/or restore the biodiversity of natural systems, respond to microclimate and natural energy flows, restore, maintain, and/or enhance the natural character of the site, reduce energy use for transportation *Water*: Preserve site watersheds and groundwater aquifers, conserve and reuse stormwater, maintain appropriate level of water quality on the site, reduce potable water consumption, reduce off-site treatment of wastewater *Energy*: Reduce total energy consumption of buildings, reduce air pollution, global warming, and ozone depletion impacts of energy sources, slow depletion of fossil fuel reserves *Materials*: minimize consumption and depletion of material resources; minimize the life-cycle impact of materials on the environment *Waste*: minimize use of resources; minimize waste generated from construction, renovation and demolition of buildings; minimize waste generated during building occupancy; encourage better management of waste		*Water:* maintain appropriate level of water quality in the building(s) *Interior Environmental Quality*: provide an environment for occupants that is physiologically and psychologically healthy, minimize production and transmission of air pollution; provide the full range of supportive sensory conditions (olfactory, thermal, vibroacoustic, tactual, and visual) for occupants; provide needed operational control of systems to occupants; produce environments that enhance human comfort, well-being, performance, and productivity; minimize the impact of materials on indoor environmental quality
HK-BEAM, Hongkong, for all new and existing buildings (developed from BREEAM)	*Site*: land use, contaminated land, site design appraisal, ecological impact, landscaping, microclimate, vehicular access, demolition/construction management plans, pollution from construction *Materials*: building reuse, modular design, off-site fabrication, adaptability and deconstruction, envelope durability, rapidly renewable materials, sustainable forest production, recycled materials, ozone depleting substances, demolition/ construction waste, waste disposal and recycling facilities *Energy*: annual energy use, embodied energy, HVAC services, electrical and lighting systems, lifts and escalators, renewable energy production systems, energy efficient appliances, commissioning, operation, maintenance, metering and monitoring *Water*: annual water use, monitoring and control, irrigation, recycling, efficient facilities, discharge *Innovations and additions:* innovative techniques, performance enhancements		*Site*: local transport, neighbourhood amenities, cultural heritage, overshadowing and views, light pollution *Water:* water quality *Indoor environmental quality*: fire safety, electromagnetic compatibility, security, hygiene (plumbing/drainage, biological contamination, waste disposal), indoor air quality, ventilation, thermal comfort, lighting quality, acoustics and noise, amenities (accessibility for disabled people, amenity features, IT provisions)

Name, provenance and building type	**Environmental issues**	**Economic issues**	**Social issues**
High environmental quality (HQE), France	*Eco-Construction* (harmony with the immediate environment; environmentally friendly materials and products; prevention of noise and pollution at the building site) *Eco-management* (management of energy, water, waste, cleaning and maintenance)		*Indoor environmental quality:* hygrometric comfort, acoustic comfort, visual comfort, olfactory comfort, health conditions, air quality, water quality
EQUER, LCA software, France	*Environmental impact*: building products; consumption of energy, water, resources; pollution (waste, radioactivity, global warming potential, acidification, eutrophication, aquatic eco-toxicity)		*Comfort analysis:* human toxicity, summer smog, odour
ESCALE, France	*Environmental impact*: Energy, water and materials resources; Waste; Pollution (greenhouse effect, acid rains, ozone depletion, air, water, soil); Landscape integration, Respect of the site ecology, Environmental management, Maintenance *Adaptation to networks* *Adaptability*		*Architectural integration, Respect of neighbour* *Outdoor comfort* *Indoor environmental quality:* thermal, visual, acoustic, olfactory, air, water)
PAPOOSE, Computer-aided assessment tool, France	*Environmental impact*: Building products, Building processes, Structural members/elements, Resource depletion, Material and energy flow, Environmental loadings (emissions, waste...)	External costs	*Effects to the human beings*
DAEC Tool 2000, UK, for all new and existing building types	*Durability:* building elements, fittings and services (evaluation, as appropriate, of strength, physical and chemical properties, fire resistance, ease of maintenance, appearance) *Adaptability*: site expansion, interior layout and design (brief completeness, layout flexibility, grouping of functions, average main room size, design/services for disabled people), structure (strength of columns/walls, column span, floor to ceiling height, floor loading, floor structure, removability of partitions), HVAC system (plant location, plant size space wise, access for people, access for equipment, ducting access), electricity (extra load, wiring space, access for servicing), water (supply, capacity), sewage (capacity), drainage (capacity), lifts (capacity, extra space) *Energy:* design and specification - building orientation, exposure to winds, overshadowing by neighbours, building form, U values, building plan and heating adjustment/control, type of glazing, shading, solar energy use (passive and energy generation), cooling/ventilation, lighting system, lighting control, plan depth, day lighting area, energy source for lighting, energy source for heating, CO_2 emissions, NOx emissions, ozone depletion, recycling of energy and materials, embedded energy, energy consumption, metering and monitoring	*Durability*: Whole-life cost of the building elements, fittings and services *Adaptability*: Initial cost, adaptation cost *Energy:* cost of energy services	*Indoor environmental quality*: included in the performance criteria for durability and energy conservation *Design and services for disabled people*: included in adaptability performance criteria

The above overview shows that most assessment tools have considered external and internal (indoor) environmental impacts in depth. As the impacts within indoor environment affect the health of building occupants, they have been classified here as social issues. This parallel overview of assessment tools could be used as a basis for creating a comprehensive list of sub-issues which should be included in an assessment tool.

Only two of the above tools include whole-life assessment cost for each design or specification option. Developers usually aim to achieve as low as possible capital costs, but building owners/users are more interested in the whole-life costs as they have to pay for them over a long period of time. The inclusion of whole-life costs within an assessment tool facilitates decision-making on the best option for the clients and owners.

The flexibility of assessment tools is defined here as the potential for using a tool on different building types, and new and existing buildings. Flexibility of a building tool could be achieved by enabling the modification or inclusion of additional performance criteria as required for different building types or new/renovation project.

Flexibility and usability of a tool could be increased if it is presented in a format which can easily be modified and which allows quick calculations. Some tools are available in paper format as check-lists. Although they can be easy to use on a building site and to present information in a manageable way, they have to be simplified and thus not as accurate as software tools. As a decision-making process requires more accurate information which can be quickly provided in a boardroom, software tools meet these requirements better than the tools in a paper format.

Usability of software tools could be increased if the guidance for data input is provided next to each on-screen form, if the forms are clearly organised and easy to read, and if the assessment criteria are provided in full to enable transparency of the assessment.

Market penetration of assessment tools does not necessarily mean that they are “better” than other tools. DTI (2005) report on market penetration of the LEED performance assessment method in Canada and USA points out that this has been “greatly assisted by the creation and the use of the accreditation process for professionals who have excellent support in the form of guidance documentation and web resources from the US Green Building Council”. Architects and engineers in Canada and USA can attend a course in the LEED assessment method and sit an exam to obtain certification for sustainable building design. Continuous professional development and easily available sources of information/guidance for more sustainable building design assist in education of all the professionals and in achieving a significant impact across the industry.

Along with providing assessment tools for building designers, there is a need for assessment tools which could be used by building clients, owners, buyers and occupants. They could be provided in a paper format as check lists with performance criteria which could enable everyone to ask informed questions about performance of buildings.

The DAEC Tool

This tool was developed with the assistance of funding from the EPSRC. The project was entitled *Sustainability of Buildings: Durability, Adaptability and Energy Conservation*. The objectives of the project were to:

- develop the metrics for durability, adaptability and energy conservation for use in the design of buildings
- assess to what extent these characteristics of buildings are mutually contradictory
- identify design paradigms and further research in the reconciliation of the conflict.

Essentially the tool assists building design. While traditional building design has been based on the ergonomic requirements of an average, healthy adult, ignoring other human conditions, more recent architectural design aims towards '*differentiation*, not uniformity in designing the built environment' (Preiser and Vischer, 1991). Building design needs to consider the entire human lifespan, including periods of disability. It is also argued that the universal design approach – designing all products, buildings and exterior spaces to be usable by all people to the greatest extent possible – is a sensible and economical way to reconcile the integrity of a design with human needs in the environment (Mace et al, 1991).

Research Activities

Exploratory Interviews

The initial action was to interview over 20 practitioners and researchers to uncover the variables to be used in the model and to discuss the proposed research methodology. This methodology was pioneered using educational buildings of varying use (teaching, laboratory, housing, administration).

Establish metrics and associated criteria

Metrics In this context a 'metric' is means of establishing values which can be used to assess relative worth. The main approach to establishing metrics was via workshops with practitioners who were presented with drawings and data for the 11 buildings selected to be used in the research study. The task was to unfold the variables which would be important in evaluating the DAEC issues. From this information metrics were established. Where practicable the metrics were based on parameters values which can be defined on an objective basis but in some cases the parameters values can only be established on a subjective basis. The limited space available preludes listing the complete set of metrics developed. These metrics re-categorise existing knowledge.

Criteria In this context a 'criterion' is the combination of the metric and corresponding limits to values. Criteria for durability and energy conservation were mainly objective and could be found from existing sources. The criteria for energy conservation and durability were related to the specific performance targets articulated by the client in a design brief. For adaptability the criteria used were more generic and were developed with the candidate buildings used in the study. For durability 19 criteria were used and 24 in the energy conservation metric. No existing criteria for adaptability were identified and a system for assessing this had to be devised and contained 28 elements. These proved to be mainly subjective based on expert opinion and are related to building type. The development of criteria for assessing the important feature of adaptability is a major new addition to knowledge. This new knowledge was created by using workshop discussions with professionals. These were open ended discussions which were synthesised by the research team to identify the criteria for measuring adaptability.

Scoring system A scoring system based on 1 to 5 scale (5 was high). This approach was chosen because it is in common use and people appear to find the five level assessment easy to use.

Identify conflicts

The AIDA approach (Luckman 1969) was developed into a novel approach for identifying conflicts among the issues. The conflicts are described and represented graphically. The adapted AIDA approach was shown to be potentially useful in the context of sustainability assessment and its use in evaluating design options is recommended.

Develop a Design Paradigm

The proposed design paradigm is incorporated into the 'Guidelines' which accompany the DAEC software. The basis of the paradigm is:

- Define and adopt a basic design philosophy
- Prepare a building performance profile based on scores against DAEC criteria
- Develop a design for the building
- Compare the DAEC score for the building against the profile
- Identify the conflicts and assess them using the AIDA method
- Iterate

The approach is packaged as the DAEC tool. The tool uses a combination of tables and spreadsheets. A software package for this purpose called 'DAEC Tool' is available.

Validation Workshops

Three workshops were organised during the course of the research project in order to refine the DAEC tool and to examine the consistency of assessment results when the tool is used by different assessors.

1. The participants of the first workshop were built environment practitioners and academics who used the DAEC tool to assess the selected buildings. Some 36 professionals were involved and encompassed the main building disciplines – architecture, engineering, facilities management, contractors and quantity surveyors. As a result of this workshop the main improvement made was in the adaptability assessment form. The key issue addressed in this part of the work was the level of adaptability which would be attainable (e.g. were only cosmetic changes required to fit a new use or were major structural

adaptations necessary?). This level of adaptability needed was tested against special features of the building (site and layout), structure and services.

2. The second workshop aimed to examine the consistency of the assessment results obtained by asking four assessors drawn from different professions to use the DAEC too on the same building. This workshop showed that the differences in assessment results were present in the use of the assessment criteria related to ‘softer’ issues which include a degree of subjectivity in the assessment. In order to decrease the subjectivity in the assessment process, case studies about all selected buildings were prepared for the third workshop.
3. The third workshop was organised with the participation of 33 students in the final years of their studies in architecture, civil engineering and mechanical engineering. Two days before the workshop the students obtained a case study of the building each of them was going to assess. The criteria used for this assessment was based upon the issues raised in the section on metrics and criteria. The students were provided with photographs of the plans, interior and exterior of the buildings. Data such as energy use and open light area was provided. Students were also asked to visit the buildings. The assessment results showed a high degree of consistency.

The results from the workshops showed that:

- The consistency of results was greater for the students than for practitioners. This is probably due to the fact that the practitioner evaluation was carried out at an earlier stage when much less information about the buildings was available.
- The consistency of results from the students was within acceptable limits except for two of the buildings where wide differences in assessment were found. It is believed that this was due to the participants not reading the briefing information properly.
- The main difficulty in making assessment was lack of precise data.

The results from the workshops supported the view that the DAEC tool produced consistent results which underpin its validity in use.

The application of the DAEC tool to a new building design

HBG Ltd, who was the main collaborating organisation for the project, used the DAEC tool to assess the design of a new community hospital. The assessment enabled HBG to have a better insight into the proposed building design and to decide where, if needed, changes may be required. The transparency of the assessment method provides the possibility for review of the assessment and a dialogue between the client and the designers regarding building design features, possible modifications and cost implications of different specifications.

The assessment was carried out just prior to submission of the design for assessment against designs from other firms. HBG staff were of the opinion that use of the tool at earlier stages in the design (e.g. at the briefing stage) would also have been advantageous.

Outcomes

The main outcome is the DAEC Tool which assesses durability, adaptability and energy conservation of buildings. It is envisaged that the DAEC Tool will be used in the following stages of building design and building management:

- *Development of design brief and identification of achievement goals.* The client may use the proposed assessment criteria for the durability, adaptability and energy conservation to determine quality targets which need to be specified in the brief.
- *Building design.* When the achievement goals and quality targets have been built into the DAEC tool, the design team can use the DAEC tool for the assessment of different design options.
- *Client evaluation of building designs.* The evaluation tool can be used when a client needs to assess the projects submitted by different design teams. The assessors can use the evaluation tool as an aid in determining to what extent the projects meet the predefined quality targets.
- *Comparison of the whole life costs of different options for achieving the quality targets.* The evaluation tool enables comparison between the desired quality targets and the costs for their achievement. The tables for durability assessment include the whole life cycle costs of the assessed building elements. The tables for adaptability assessment offer a space for input of the initial and later costs for providing different levels of adaptability. Each design and quality option in the tables for the energy conservation assessment can also be accompanies by the related costs. Thus, the evaluation tool becomes an aid in the decision making process about the costs and related trade-offs in achieving the quality targets of a building design.
- *Assessment of the durability, adaptability and energy conservation of existing buildings.* The need for evaluations of existing buildings in relation to the durability, adaptability and energy conservation exists in the management of property estates. The assessment can be used in the decision making process on maintenance, upgrading, functional improvement, changes of use and potential savings.

The DAEC tool is flexible as it has been designed as a framework which allows for modifications of the following elements:

- *Types of building design elements and features which are assessed*, by amending the list of the assessed elements and features. The list may be longer for more complex buildings.
- *The assessment criteria*, by defining the criteria which are the most appropriate for the building type. It can be expected that the durability, adaptability and energy conservation criteria, for example, for industrial buildings will vary from those of residential buildings.
- *Achievement goals*, by defining durability, adaptability and energy conservation benchmarks according to the most recent targets.
- *Scoring system*, by selecting a different type of scoring system.
- *Weighting*, by identifying the hierarchy of achievement goals in accordance to, for example, building type, client's requirements, etc.

The tool may also be used to identify conflicts between design features which effect durability, adaptability and energy conservation. This is a contribution to new knowledge.

The DAEC tool is available free of charge from the Centre for the Built Environment, Glasgow Caledonian University, 70 Cowcaddens Road, Glasgow G4 0BA, UK.

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