Proposed Framework for Environmental Assessment of Existing Buildings

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1. BACKGROUND - WHY A FRAMEWORK IS NEEDED

For practical purposes, we regard existing buildings to include any completed building, be it recently-completed, or years or even centuries old. Environmental assessment or rating schemes for existing buildings need to address four main issues, not usually covered by systems intended to predict environmental performance of new building designs.

1. A newly constructed building, as-built, may differ significantly from the design, thus affecting the potential performance.
2. The use, equipment and management of even a new building may differ significantly from that assumed by the designers (and even the client). An as-built operating assessment offers opportunities to review design assumptions, correct deficiencies, and improve performance in operation.
3. In operation, an existing building may be usefully benchmarked against other similar buildings, using an assessment system, in order to improve operations.
4. When addition, renovations or major repairs are undertaken, an assessment system may be used to gauge the potential for improvements.

2. REVIEW OF EXISTING SYSTEMS

A variety of assessment and rating systems for existing buildings are in use around the world. Their origins and intents differ, from tools intended for use at the design stage to post occupancy evaluation tools. Very few systems make a clear distinction between environmental performance based on inherent properties of the building and performance resulting from the operation of the building. The UK's BREEAM for offices does have separate parts for the design and operation, but few links between the two. NABERS, the Australian system now in pilot stage, has different questions for the building and for the user, but does not assign separate ratings for the building and for its operation.

Table 1 Some Existing Systems

Country	System	Summary Comments
United States	LEED	Criteria-based system for existing buildings in pilot stage, language or reference standards modified to reflect operations. USGBC (2001)
United Kingdom	BREEAM	Criteria-based system for office buildings, one third of which is an optional management & operations assessment for occupied buildings.
United Kingdom	PROBE	Research project to improve building performance feedback through post-occupancy evaluations, based on occupant surveys, technical surveys, and a published energy assessment and reporting method.
Germany	EPIQR	Assessment of existing buildings for upgrade or repair purposes. Lützkendorf (2002)
Sweden	Environmental Status of Bldgs.	Criteria-based system modified on members' requirements, no LCA or weighting. Glaumann and von Platen (2002)
Denmark	BEAT	LCA method developed by SBI that treats effects on the environment from use of energy and material. Glaumann and von Platen (2002)
Norway	EcoProfile	*BREEAM*-influenced hierarchic criteria system. Two versions, one for offices and one for residences. Glaumann and von Platen (2002)
Finland	PromisE	Criteria-based system, fixed and operational in four categories; human health, natural resources, ecological consequences and environmental risk management. Aho (2002)
Canada	BREEAM Canada	Adaptations of the UK BREEAM system. Skopek (2002)
Austria	"Comprehensive Renovation"	Criteria-based environmental system for residences to stimulate comprehensive, rather than piece-meal, renovations. Geissler, 2002
Australia	NABERS	Criteria-based system for new & existing buildings, with single rating but different criteria for building and user. Ratings renewed annually. Vale et al (2001)

3. PERFORMANCE REQUIREMENTS FOR THE FRAMEWORK

Existing buildings, by definition, operate within the marketplace, so requirements must address both environmental issues and market characteristics.

General requirements applying to environmental assessment systems:

1. *Methodological transparency.* Allows access and understanding of assumptions, data and other methodological issues influencing the outcome of assessments and consequent ratings. For consumers, this allows conscious choices and meaningful comparisons. For building sector companies it means being able to improve their performance and compete more effectively.
2. *Focus on performance*. Building performance assessment methodologies should be fully performance-based for two reasons. Firstly, assessment on the basis of prescriptive technical features typically prevents buildings without those features from obtaining a good assessment result regardless of actual performance. Secondly, feature-based assessment inevitably encourages "feature-based design and maintenance" of buildings rather than design and maintenance based on performance.

Specific requirements regarding existing buildings:

1. *Life-cycle approach*. Holistic and meaningful results and recommendations require review of life-cycle environmental impacts of the building. The definition of what life-cycle actually means for buildings which might have existed for centuries or decades can be problematic, but various components of a life-cycle approach can provide useful information. These include, starting with the shortest time scale:
   - Utilities requirements to keep the facility operating (energy, transport, water, materials, services, waste).
   - Routine maintenance (painting, cleaning, consumables, routine spare parts).
   - Replacement maintenance due to wear & tear, failure and obsolescence.
   - Alteration, refit and refurbishment.

- Major interventions.

2. *Simplicity and low cost*. Costs of assessing existing buildings are typically met from the annual operation and maintenance expenses budget. This limits the amount of resources available for performance evaluation in comparison to new building (or major refurbishment) projects where the cost of assessment is low in relation to the overall project budget. Costs can be further reduced if the needs of assessment are appreciated at the time of design, refurbishment and alteration, when the design team can provide:
   - Key design information (e.g. building envelope thermal characteristics, design criteria, equipment efficiencies etc.) is recorded in a log book.
   - The results of quality assurance and system commissioning are also recorded
   - Suitable facilities to collect information relevant to ongoing assessment (e.g. utility submetering).
3. *Focus on both potential and actual performance.* Environmental assessment of a new building typically focuses on its predicted potential performance before it is built, relative to some benchmark. Assessment of existing buildings will need to examine both potential and actual performance. Even the potential performance of a newly-completed building is likely to vary from that predicted before it was built, owing to the build quality achieved and the inevitable changes in design, construction, equipment and use that will have occurred. The potential performance is the best performance that can theoretically be obtained from the building with its current levels of occupation and use and in its current condition. The actual performance will generally have more environmental impact than the potential, owing to various forms of waste which is avoidable, at least in principle (occasionally the impact may be less because standards of provision are inadequate!). Actual performance is the real basis of operating costs and resource use, and forms the starting point for analysing the cost effectiveness of the impact of different improvement measures. Figure 1 shows an example of how these might relate to each other.

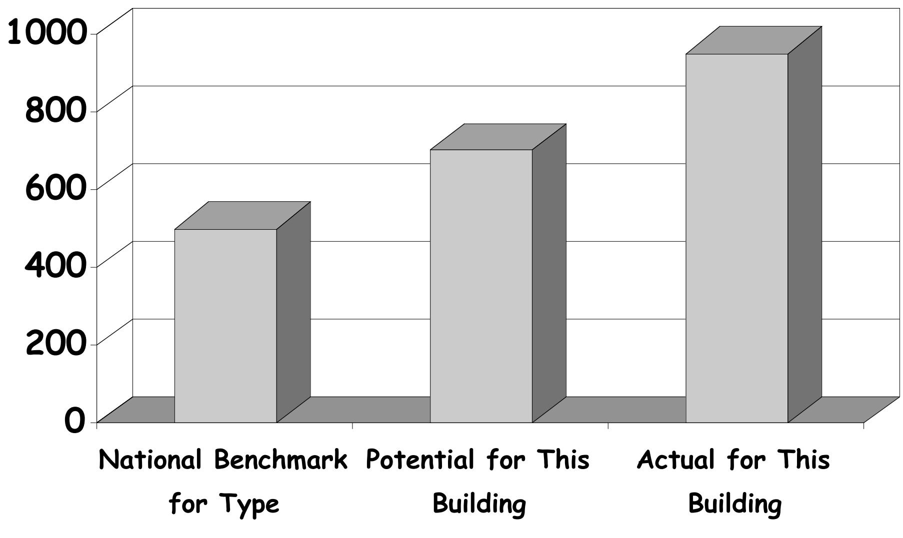

Figure 1 Relationship between benchmark, potential performance and actual

4. *Distinction between building performance and building management.* There are two aspects to the actual performance of a building, as shown in Figure 2. The first aspect is a result of the technical and design characteristics of the building (or asset) and is dependent on, or limited by, the standards to which the building has been built and the efficiency of its fabric and installations). The second is the use of the building and the effectiveness of the management practices deployed in operating and controlling it. In order to be able to

provide meaningful results and appropriate recommendations for action, an environmental assessment system for existing buildings should clearly distinguish between the impact of these two aspects on the final performance of the building.

Since there can be major differences between design predictions and in-use performance,

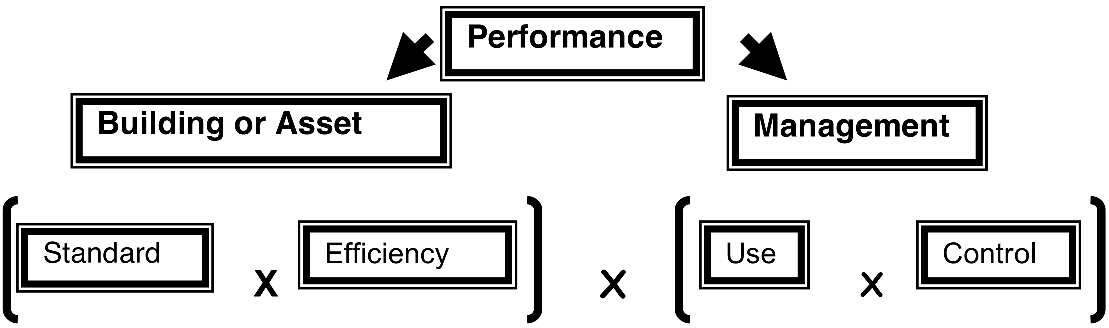

Figure 2 Two basic aspects of actual performance of existing buildings (developed from figure 4 in CIBSE (1999).

the components of performance in figure 2 should also be made explicit at the design stage and linked through to the performance of the building in use. Ideally, the designers would fill in an initial version of the in-use environmental assessment using the design data. This could then be updated with the actual results, both simplifying in-use assessment task and providing a transparent link between anticipated and actual performance. For example, the UK's CIBSE TM22 method (CIBSE, 1999) for building in-use energy assessment (as used in the Probe surveys) is also beginning to be used to record the results of design assumptions and predictions. Similar linkages could be forged between GBT predictions and in-use assessments, at least for some relevant variables.

4. A STRATEGIC APPROACH

A step by step methodology is proposed for capturing the required input information for the assessment, identifying appropriate standards for comparison, understanding the context and making the performance assessment.

1. ***Identify and quantify the inputs and waste streams.***
   Examples include energy consumption by fuel type and use, potable water use, waste water discharge, materials consumed and materials and pollutants discarded to the waste stream. Clear measurement conventions are needed.
2. ***Appreciate the context***.
   This is necessary to facilitate understanding of performance against the benchmarks, so that assessment results can be turned into meaningful recommendations. Context includes imposed variables like climate, weather and location, user factors like occupation, equipment densities and hours of use, conversion factors such as carbon intensity of fuels and other measures of extent such as floor area.
3. ***Quantify functional performance levels***
   These relate to both inputs and outputs. For example:
   - Environmental conditions: what is the illuminance level? is the temperature and humidity closely controlled? and so on.
   - Satisfaction levels: how happy are people with various aspects of the facility?
   - Output levels, e.g. perceived or measured levels of productivity.

4. ***Establish appropriate benchmarks***
   These are necessary to provide representative values, against which the building's actual performance is compared. They can be derived from a number of sources, such as typical practice or good practice levels, client requirements, design expectations, or national or local standards where these are available.
5. ***Calculate environmental performance indices***
   These are derived from the inputs, context information and benchmark categories. An example would be emissions per square metre, per person (or person-year), or per unit of production, all normalised perhaps for climate.
6. ***Compare performance indices and benchmarks to assess performance***
   This may be done with absolute numbers; or scores may be assigned derived from scales dependent on weighted values.
7. ***Come to a judgment of how the performance assessment relates to the context***
   For example water consumption for the assessed building may be good compared to the benchmark, but its components may be assessed very differently, for example:
   - on the "Asset" side of figure 2, the design might be very water-efficient (very good)
   - on the "Management" side, the user requirement for water services might be greater than normal (perhaps owing to shiftwork) - a contextual variable which justifies higher consumption; but at the same time control might be poor owing to poor maintenance and wasteful staff behaviour.

   In this example, in spite of the ostensibly good benchmarked performance, recommendations could still be made for improvements on the management side.

5. WEIGHTING

If overall scores or ratings are used, the issue of weighting needs to be addressed. The weight, or the difference in importance between variables may be explicit or implicit. Current systems use very different methods of weighting, for example:

- BREEAM in the UK uses explicitly derived weightings based on average values held by various segments of British society as determined by survey.
- LEED in the United States has weightings implicit in the distribution of credits awarded for performance in any given area. These weights were arrived at through consensus of the members of the US Green Building Council who developed the system.
- GB Tool, the system used by Green Building Challenge, makes the weights explicit and adjustable by the user in any country, region or context.

If weights are used, they need to be explicit to meet the requirement for transparency.

6. APPROPRIATE VARIABLES FOR ASSESSMENT

Starting from a base of categories in GBTool, the following are potentially suited to assessment in existing buildings:

- Operating energy, built up of:
  - Space heating, cooling and air treatment.
  - Electricity for other building services, especially lighting.
  - Water heating for normal building-related purposes.
  - In addition, energy used for other purposes needs to be identified and sometimes assessed. This will include occupier-related equipment, e.g. office equipment, process plant, catering kitchens; and energy supplied through the building but not used in it (e.g. for external lighting, signs and fountains). This user-related energy may also have knock-on effects onto the building-related energy use above.
- Recurring embodied energy in routine maintenance, replacement repairs, alterations, refits and refurbishments, and major interventions.

- Indoor environmental quality.
- Flexibility and adaptability.
- Control and controllability.
- Protection of materials
- Cleaning as it affects IEQ, materials life and loadings from use of undesirable chemicals.
- Neighbourliness (e.g. noise; night lighting; waste bin placement, smells and collection systems; traffic and parking).
- Manageability, including security.

7. NEXT STEPS

- Each of the categories of variables needs to have specific variables identified and units of measurements defined.
- More detail is required in defining the step by step methodology, and in separating the building design, user and management issues.
- Transparent linkages to design assessment methods should be developed.

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