Transition Toward Sustainability: Reframing Environmentally-Related Building Research

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INTRODUCTION

As the realities of resource depletion and global environmental degradation become more evident, we can anticipate a maturing and strengthening of the publicís concern and knowledge on environmental issues. This will translate into an expectation for greater environmental responsibility. As with other sectors, the building industry will be increasingly scrutinized and required to develop approaches and practices that address immediate environmental concerns and adhere to the emerging principles and dictates of sustainability.

"Life-cycle" assessment and "building environmental" assessment have emerged as prominent areas of enquiry over the past decade. Both have extended the "boundaries" of environmentally-related building research. Life cycle analysis has extended the timeframe of concern and clarified critical phases of analysis. Building environmental assessment methods have extended the range of criteria considered in the performance evaluation and offered ways of structuring them into meaningful categories for analysis. These developments are symptomatic of an emerging shift from reductive to holistic framing of environmentally-related building research, itself guided by the increasing realization of the inadequacies of our current "world view."

Western societies still exist in the Baconion belief that through knowledge, humans can assume mastery over the natural world in pursuit of their own interests. Over the past two centuries or so, we have made an uncritical investment in science and commitment to the belief that technology will free us of the limitations imposed by the natural world. (Rousseau, 1994) This "technological expansionist" model guides all human endeavours and institutions. Rees (1995) has suggested that we have reached a "unique juncture in human ecological history" and Caldwell (1990) characterizes an era when the world is "passing through a historical discontinuity." During the transition through this discontinuity, societies will have to reformulate a new "world view" and reconfigure the systems, institutions and physical fabric of human settlements. The time frame of change will certainly be measured in decades and most probably in centuries.

The contrast between the prevailing "technological expansionism" paradigm and an emerging one set within the dictates of ecology provides an instructive context for this paper. Within the former view, the economy is posited as an "independent, self-regulating, and self-sustaining system whose productivity and growth are not seriously constrained by the environment" as illustrated in Figure 1a. (Rees, 1990). By contrast, Rees describes an emerging "ecological" model that places the economy as "an inextricably integrated, completely contained, and wholly dependent subsystem of the ecosphere" (Figure 1b). While we currently assume continuous improvement in human wealth and expectations uninhibited by natural limits, the ecological view recognizes the interdependence of natural systems and processes and international economies, and that "matching" of human processes and natural limits at the global scale ultimately dictates that at all sub-levels.

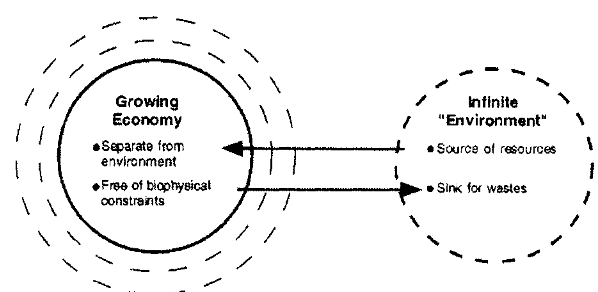


Figure 1: "Expansionist" view of Economy/Environment relationship

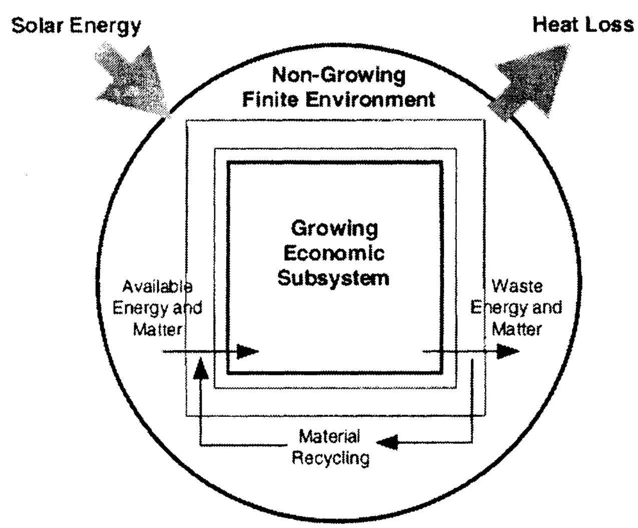


Figure 2: Ecological view (after Daly, 1992; Rees, 1990)

Continual and rapid change has become a hallmark of contemporary western society. Architects and other design professionals have, with varying degrees of success, learned to adapt to this new context. Design, as with other aspects of human thought, is shaped by and operates within the prevailing social and cultural paradigm. Many of the assumptions that guide design are seldom challenged - they are accepted as second nature. Despite this pace of recent changes, the basic assumptions that drive design have remained fairly stable. Similar argues apply to the framing of environmentally-related building research. But what are the consequences during periods of fundamental reappraisal within this "historical discontinuity?"

This paper examines the gulf between the models and theories that currently frame building environmental research and practice, with those aspired to within the notion of sustainability.

ASSESSING BUILDING ENVIRONMENTAL PERFORMANCE

During periods of relatively 'mature' design criteria, one can expect a relatively close match between the specification of design criteria by clients and their subsequent interpretation by the design team. Such criteria typically become established as accepted design norms and do not need to be made explicit. By contrast, during this current period of environmental awareness, a common knowledge base is not yet established and issues of specification, interpretation and implementation are less well defined. The overlaying of environmental considerations on the building design and construction process brings the inevitable difficulties of reassessing priorities, acquiring new skills and developing and integrating new information into an existing project delivery process. However, new emphases to design also inevitably carry with them the uncertainty of their acceptance or successful outcome. This can, to a degree, be alleviated by the use of assessment tools to establish whether new strategies are indeed effective in achieving expected levels of performance in these new areas of concern.

Life-Cycle Assessments

The notion of Life-Cycle Assessment (LCA) has been generally accepted within the environmental research community as the only legitimate basis on which to compare alternative materials, components and services. SETAC offers the most comprehensive and widely cited LCA methodology, describing it as one comprising of three distinct processes (Consoli, 1993):

- Goal Definition and Scoping: A clear statement of the primary purpose of the assessment, for whom and to what end, together with a clear definition of the functional unit - including both a description of the element and its expected life-span.
- Inventory Analysis: The calculation of the energy and raw material inputs and air emission, liquid effluents and solid waste associated with the acquisition, production, use and disposal. A clear declaration of the system boundaries is central to this stage of the process to define what is to be included or excluded from the analysis.
- Impact Assessment: The classification of the inventory data in to relevant impact categories and identification of the impacts on natural systems.

Applied to buildings, life-cycle assessment encompasses the analysis and assessment of the environmental impact of building materials, components and assemblies throughout the entire life of the building construction, use and demolition. Most of the current effort and understanding of building-related LCAs are directed at the inventory analysis stage. The theoretical basis for impact assessment and, more importantly, for interpreting and comparing the broad range of resource use and environmental impacts are currently poorly defined and will probably remain so for the foreseeable future. Although LCA methodologies continue to be clarified and refined, in practice the collection of the resource use and pollution outputs of building materials and components throughout the various stages of the life-cycle require a considerable (and often prohibitive) amount of time, effort and cost.

Figure 2 shows the primary stages of a buildingís life-cycle and emphasises the key design and construction issues. The life-cycle of buildings is more complex than that of other products in that it involves the aggregate effects of a host of life cycles of their constituent materials, components, assemblies and systems. The full life-cycle environmental impacts of building materials and components can be broken down into distinct phases: first, the detailed assessment of the acquisition and production impacts and resource use, second, the impacts and resource use throughout the

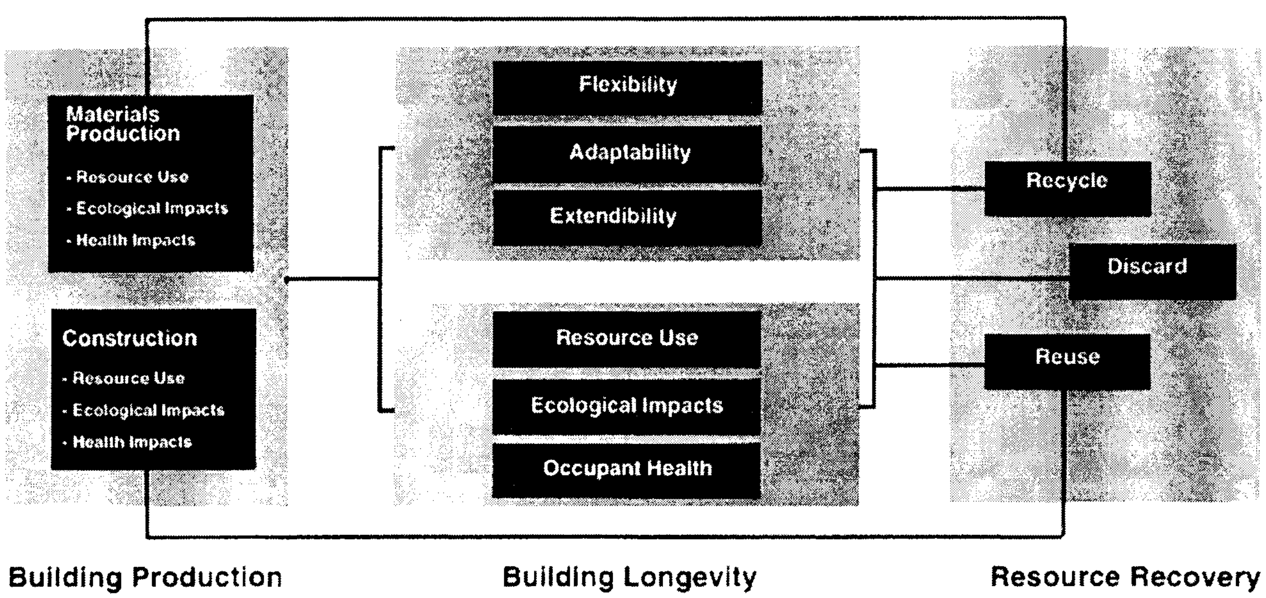


Figure 3: Life-cycle framework

useful life of the completed building and finally, the demolition and disposal impacts. Whereas the first is specific to the material or component alone, the second and third are specific to the material or component and its application within the context of a specific design. Detailed life-cycle analyses often only embrace the more general first phase and make relatively scant reference to the latter phases.

Design decisions are made at a specific point in time - with implications that can extend for decades. Similarly, the life-cycle assessment embraces a sequence of events that precede and extend past that point of decision, i.e., the life-cycle of the material or product will consist of a portion of environmental impacts incurred up to that time and those which will be incurred during the future life of the material or product in the context of the building. Each of these includes events of varying degrees of certainty. For example, many of the materials acquisition and production processes and attendant emissions can be readily determined for domestic products whereas the equivalent information on imported materials is uncertain. Similarly, an environmental analysis will typically have full knowledge of the specific circumstances of a building project including the type, quantities and specific application of materials in the initial design but is faced with all the uncertainties associated with an unknown future. Herein lies the critical concern. Since the life of buildings can be considerable, say 50 to 100+ years, the combination of current and anticipated rates of change in performance requirements, materials production techniques and efficiencies, together with those building refurbishments that will invariably be necessary to avoid environmental obsolescence, seriously diminish the confidence in the overall evaluation. As such analyses invariably combine accurately and confidently defined performance information with that which is speculative.

Building Environmental Assessment Methods

Until the release of the Building Research Establishment Environmental Assessment Method (BREEAM) in 1990 little, if any, attempt had been made to establish comprehensive means of simultaneously assessing a broad range of environmental considerations in buildings (Prior, 1990). Most environmental assessments until this time were limited to single performance issues such as operating energy use. Building environmental assessment methods have emerged as a legitimate means to evaluate the performance of buildings across a broader range of environmental considerations.

The increase in development and application of such methods has provided considerable theoretical and practical experience on their potential contribution in furthering environmentally responsible building practices. Their most significant contribution to date has clearly been to acknowledge and institutionalize the importance of assessing building across a broad range of considerations. An important indirect benefit is that the broad range of issues incorporated in environmental assessments require greater communication and interaction between members of the design team and various sectors with the building industry, i.e., it encourages greater dialogue and teamwork. Further, since assessment methods are implicitly a synthesis of current environmental knowledge related to buildings, they can play a significant role in focussing a broad range of research through a common filter (Cole and Larsson, 1998).

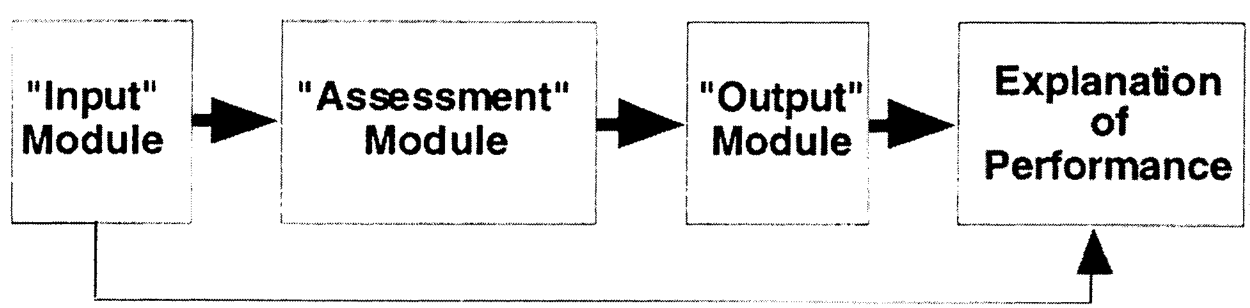
Figure 3 shows the key features that are either implicit or explicit in all existing building environmental assessment methods. The primary component is the "assessment" module in which performance scores are assigned to the various environmental criteria being scrutinized within the assessment process. The scope and structure of this module tend to form the major part of the discussion of assessment methods. A considerable amount of information about a case-study building and its context is required to facilitate an assessment. These are represented in Figure 3 by the input module. Although the input module serves the assessment module, the practicalities of data collection and quality, ultimately shape the scope and rigour of the assessment.

The results of an assessment must be summarized and communicated to the intended audience. The output forms the basis for interpreting the assessment results and should logically dictate the structuring of both the assessment and input modules. Weighting is the mechanism by which a very large number of performance criteria are reduced to a smaller and more manageable number and is a critical part of the output module. Weighting remains a controversial and theoretically complex aspect of building performance assessment—the primary concerns being the absence of an agreed theoretical and non-subjective basis for deriving weighting factors.

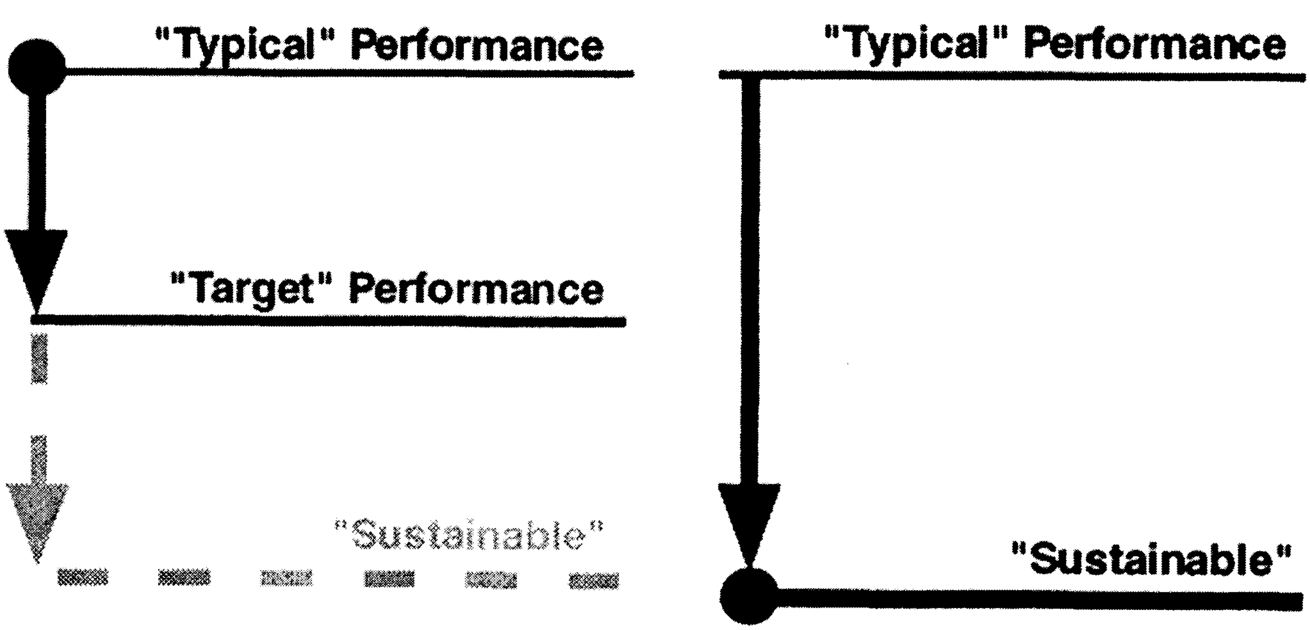
The weighting of environmental criteria is relevant at a number of scales - global, local and a project-by-project basis and there is no consensus on the factors that should appropriately be used in deriving applicable values. The range of resource use, ecological loadings and human health criteria incorporated in building assessment methods result in comparisons of quite dissimilar. Todd (1996) identifies that in deriving appropriate weightings, "the key to understanding the relative importance of environmental criteria lies in the selection of final endpoints - ones which reflect potential impacts on the environmental components of concern, not simply the changes in quality or quantity of environmental media (air, water, soil). Thus the question of importance should not be whether air pollution is more important than water pollution, for example, but instead whether air pollution or water pollution exerts a greater specific potential impact on endpoints of concern." Although this represents an appropriate direction for deriving weightings, the development of the attendant links and relationships between buildings and impacts advocated in the approach will require considerable research and data collection before it can be fully realized.

An output profile is not particularly valuable in and of itself, and must provide a:

- Link to cause: There must a means of explaining why the performance is what it is ñ good or bad. That is, the output must provide a link back to its cause or origin. Whereas some of the characteristics of the building that were collected to perform an



Figures 4: Key feature of building environmental assessment methods



Figures 5a and 5b: "Sustainable" and "Green" models of assessment methods

assessment, additional information may be required to explain the performance.

- Link to action: Since the output represents the link with action; the output must link with information that offers a basis for improving on deficient performance. It must therefore be accompanied by an explanation of what led to the achieved score. This links back to the information contained within the input module.

The output module is currently the least understood and discussed aspect of environmental assessment methods. This is itself indicative of the fact that environmental responsible building design practice is still in its infancy and there are still remains considerable uncertainty regarding what action or direction should be taken based on the results of an assessment. By moving into relatively uncharted areas, the uncertainties are also reflected in the current definitions of the goals and intentions of building environmental assessment methods.

SUSTAINABLE OR GREEN?

Although environmentally progressive building practice is currently described using a variety of different terms: "green design", "ecological design", "sustainable design," the choice seems of modest relevance to practice. Most architects who aspire to environmentally responsible design are typically more interested in "building" and less concerned with semantic differences. By contrast, the distinction between the notions of "Green" and "Sustainable" is critical in the development of building environmental methods because of the need for a clear theoretical framework.

The theoretical models held in research directly and indirectly shape actions—they frame the problems that are explored, the scope of the work the data collected and the manner in which it analysed. Holling (1998) argues that "theories that do not match the problem can at best be delusions and at worst dangerous" and illustrates the point by noting that the hole in the ozone layer was not detected initially by satellite imagery because the implicit theory presumed gradual, continuous change in atmospheric chemistry and chemical composition. Though the consequences are perhaps less acute, the general "model" within which environmental assessment methods are framed guides all the significant aspects of their structure.

Sustainable Building Practice

Sustainability has emerged as an overarching notion for the environmental discourse and must, therefore ultimately give direction to the development of environmental assessment methods and related research. Sustainability has environmental, social and economic dimensions, embraces all facets of human activity (e.g., industry, transportation, food production etc.), and spans local actions through to redressing the major inequities that exist between developed and developing nations. However, irrespective of the social and economic context, the health of the biosphere is the limiting factor for sustainability. Since the management of local and global mass and energy flows is of vital importance, physical indicators of sustainability must logically dictate the emphasis of any methodology attempting to assess sustainable approaches to human settlement and building.

Assessment implies measuring how well or poorly a building is performing, or is likely to perform, against a declared set of criteria. All assessment methods implicitly embody a scale of measurement that forms the basis for allocating performance points that are subsequently used to obtain an overall performance score. A primary emphasis of assessments is, therefore, to use the selection of the criteria to define the direction of environmental progress and to measure the degree of progress being made in improving the performance of buildings.

Figure 4a illustrates the role that an environmental assessment method would within the context of sustainability. The two defining points on the assessment scale are "typical" practice and an "environmentally sustainable" practice. Assessments are made of the extent of the progress that the building performance has made toward a declared, environmentally sustainable condition.

Assessments require an understanding of the absolute impact or stress that building design and operation place on ecological systems to ensure that it is within the productive and assimilative capabilities of the local and global ecosystems. Such an ideal would require an extensive understanding and quantification of the complex links between building decisions and ecological loadings—a goal that will not be attainable in the foreseeable future and may, in fact, never be completely possible.

The number of criteria required to judge a buildingís sustainable performance can be relatively few with the proviso that the performance indicators are carefully selected. For example, Lowe argues that most other physical and many non-physical indicators of sustainability are statistically and causally linked to carbon emissions. As such, strategies reduce carbon emissions to a sustainable level would carry a host of other improvements that would not have to be independently assessed (Lowe, 1998). Similarly, loss of biodiversity captures a host of issues related to the efficiency and effectiveness of land-use.

Physical indicators of environmental sustainability would be normalised by some measure of the total sustainable level of activity described by that indicator. Satisfying the human principle of equity would suggest that denominators represent equitable shares of the total sustainable level, e.g., per capita share of the total carbon sink capacity to normalise carbon emissions.

It is possible to define environmental sustainability goals at a global scale in terms of the relationship between resource use, assimilative capabilities of the biosphere, carbon sinks, albeit in general terms. Without reference to their wider context, it is somewhat more difficult to define specific "sustainability" goals for individual buildings. The use of "environmentally sustainable" targets such as zero fossil fuel use, zero greenhouse gas emissions, zero potable water use and zero sanitary waste entering municipal systems, implies that all future buildings should become more autonomous.

Green Building Practice

Existing building environmental assessment methods attempt to measure improvements in the environmental performance of buildings relative to current "typical practice" or requirements. Similarly, design guidelines are structured to offer direction on how to improve upon current design practices and only implicitly acknowledge sustainability. The assumption is that by continually improving the environmental performance of individual buildings, the collective reduction in resource use and ecological loadings by the building industry will be sufficient to fully address the environmental agenda. The choice of the term "green building assessment" is seen as a useful term to convey this intent.

Figure 4b illustrates the defining characteristics of a "green assessment." Within the definition of "green" offered above, the primary characteristics of a "green" building assessment method logically emerge:

- Assessments are made relative to typical practice without having to define an ultimate goal.
- To assign scores to the performance, it is necessary to declare a demanding target performance level that can be progressively increased as 'greení design matures.
- Since "green" assessment methods are invariably used as a mechanism for encouraging building owners and designers to aspire to higher building environmental performance, the range of issues is considerably larger than that necessary to assess whether it is sustainable. The selection of the range of criteria is governed more by the practicalities of performing an assessment than by any consensus of what constitutes green building.

DIMENSIONS AND BOUNDARIES

As with Life-Cycle Assessment, where the boundaries are set is important in making environmental assessment and offering design guidance. Several environmental assessment methods expand the criteria to include issues that relate to site selection, building location and proximity to public transit and amenities. Contextual issues do affect the resource use and ecological loadings associated with a specific building and are a legitimate part of its profile. Baldwin (1998) presents the life-cycle energy profiles of two UK office buildings illustrating that the magnitude of staff travel energy is similar to building construction and operating energy and that there are clearly marked differences associated with the mode of transport (See Figure 5).

Though building location and other contextual issues are important, whether or not they can be controlled by the design has created significant discussion regarding their legitimacy for inclusion in either a building assessment or design tool. This debate reveals the current gaps between modeling and assessing building environmental impacts and community environmental impacts and, more generally, between the disciplines of architecture and urban planning.

The individual building, though useful in the green building debate, is an inappropriate scale to define and discuss optimal environmental performance within a sustainability framework. Figure 6 shows a conceptual framework for building environmental assessment that includes the dimension of scale:

- The Criteria dimension references the extended set of considerations within performance assessment, distinguishing between ecological concerns (resource use, ecological loadings etc.) and human concerns (indoor environmental quality, economics etc.) Each can be further subdivided into performance issues that can more confidently be defined and assessed (shown in solid) and those that are more subjective.
- The Time dimension is that explicitly covered with Life-Cycle Assessment. Here again, both the distant past and long-term future are less clearly known and certain than the immediate past and future.
- Scale is clearly the critical dimension necessary to fully discuss building environmental performance in a comprehensive manner. Whereas a considerable strides have been made in the environmental performance and life-cycle assessment of individual materials and components as well as their aggregation to whole building performance, the links between building and community and regional scale are less developed.

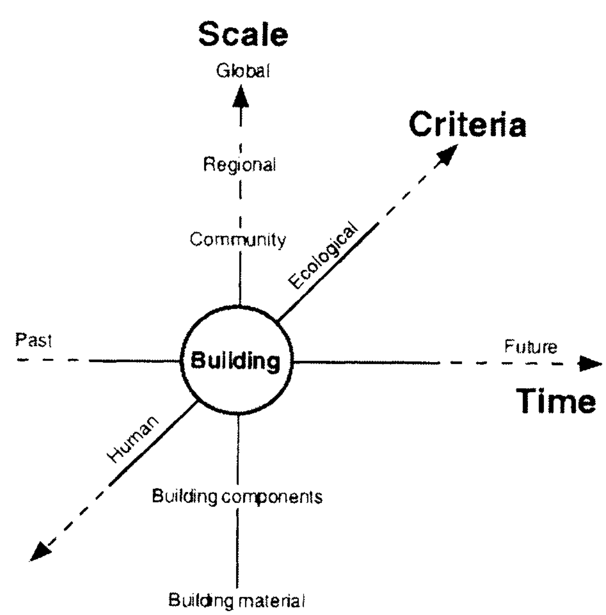


Figure 6: Three dimensions of environmental assessment—Scale, Time and Criteria

CONCLUSIONS

This paper has presented "green" and "environmentally sustainable" models for discussing environmental issues and particularly for framing building environmental assessment methods. Given the uncertainties, any assessment model based on the notion of sustainability would, by necessity, be idealistic and include features that can only currently be speculated. Assessing green performance is more fundamentally rooted in the practicalities of current building delivery and therefore more easily accepted. This is clearly both an advantage and a limitation. There is an implicit assumption in existing methods that "green design," by continually reducing resource use and ecological loadings, is charting a sustainable path. Indeed this may be the case. As long as "green design" is capable of meeting perceived needs of current practice it will not be readily revised or abandoned; and the desire to analyse and seek new principles within the sustainable model will not be a significant part of research and practice. Knowledge and associated tools will continue to be sought not for the purpose of evolving new concepts within a "sustainable" model, but rather to extend or establish more firmly those that exist.

Existing methods temper the range of assessment issues by remaining within the bounds of objective, scientifically acknowledged and verifiable issues and therefore only provide a partial view of environmental performance. Moving into performance new areas where the measures of the performance are currently poorly defined, requires more qualitative descriptions and measurement scales. Such criteria are open to wider interpretation by assessors and the scoring can vary considerably depending on those making the assessment. Although assessing sustainable performance, which is largely an issue of energy and mass flows should be described in quantitative terms, the wider range of performance issues within a comprehensive assessment of green performance currently cannot avoid using more qualitative metrics. Moreover, the issue here is not that qualitative criteria should be excluded from the assessment but to keep them distinct from the quantitative performance data that is assumed to be more objective, reproducible and therefore more reliable.

Whereas "time" has been accommodated within life-cycle assessment methods, and building environmental assessment methods have increased the range of performance criteria, significant realignment toward the more holistic "sustainable" model will not be possible until at least one more significant increase in "dimension" is accommodated. The "individual" building is a too constraining level to define sustainable practice, and it is within the links between building performance and larger scales such as community that the next significant advances in environmental assessment methods are inevitable.

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