Implications

VOL. 05 ISSUE 03 www.informedesign.umn.edu

A Newsletter by InformeDesign. A Web site for design and human behavior research.

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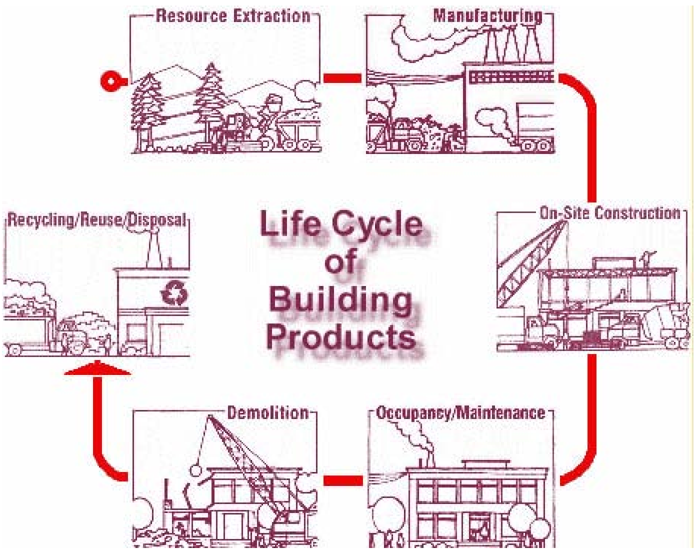
The Evolution of Sustainable Building Ratings Systems

There is no question that the building industry is in the midst of rapid change toward more sustainable design and construction. In the past 15 years, many international, national and regional sustainable building guidelines have been developed. The LEED® Rating System™ (Leadership in Energy and Environmental Development) developed by the U.S. Green Building Council (USGBC) has emerged in recent years with a high level of visibility and increasing market acceptance. Recently Green Globes™, used for many years in Canada, has been introduced into the US by the Green Building Initiative (GBI) as a sustainable building rating system and guide for commercial buildings. In the residential sector, there are many green building programs and guidelines.

The future of these rating systems is unknown, but there appear to be several driving forces that will shape their evolution. These include an emphasis on performance outcomes (such as global warming impact), the need for regional variations, the need for variations for different building types, the trend toward more requirements rather than point-based alternatives, and more focus on actual building performance during occupancy and operation. The Center for Sustainable Building Research (CSBR) at the University of Minnesota has worked with LHB, Inc. and The Weidt Group to address some of these issues in developing the State of Minnesota Sustainable Building Guidelines, now required on state-funded projects. Sustainable or green building design is still an evolving field with rapid advances in knowledge, technology, and methods of measuring outcomes. Rating systems and guidelines will continue to adapt and improve over time.

Life Cycle Assessment

A key aspect of moving toward more performance-based outcomes in sustainable design is the use of Life Cycle Assessment (LCA) to determine the embodied environmental effects of materials, rather than relying on singular material properties such as recycled content or distances traveled after the point of manufacture. LCA is a methodology for assessing the environmental performance of a product over its full life cycle. However, the LCA tools that are currently available are not widely utilized by most stakeholders, including those designing, constructing, purchasing, or occupying buildings.



According to International Standard ISO 14040, LCA is "a compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle" [Reference Number ISO 14040:1997(E)]. Environmental performance is generally measured in terms of a wide range of potential effects, such as:

- fossil fuel depletion
- other non-renewable resource use
- water use
- global warming potential
- stratospheric ozone depletion
- ground level ozone (smog) creation
- nutrification (excess nutirents)/eutrophication (oxygen deficiency) of water bodies
- acidification and acid deposition (dry and wet)
- toxic releases to air, water, and land

All of these measures are indicators of the environmental loadings that can result from the manufacture, use, and disposal of a product. The indicators do not directly address the ultimate human or ecosystem health effects, a much more difficult and uncertain task, but they do provide good measures of environmental performance, given that reducing any of these effects is a step in the right direction.

The energy required to operate a building over its life can greatly overshadow the energy attributed to the products used in its construction. However, for other embodied effects such as toxic releases to water, effects during the resource extraction and manufacturing stages greatly outweigh any releases associated with building operations. The point is to beware of the common tendency to focus only on embodied energy. The essence of LCA is to cast the net wide and capture all of the relevant effects associated with a product or process over its full life cycle. It is also important to note that the LCA of a given product should take account of the production and use of other products required for cleaning or maintenance during its use phase.

Life Cycle Assessment has its limitations. For example, LCA does not readily handle such issues as uncertainty, risk related to toxic releases, and site-specific resource extraction effects. In addition, there is greater uncertainty for projected impacts during the occupancy and demolition/disposal phases of a building's life, which may extend 50-100 years into the future. The final point to note about LCA is that it is not the same as life cycle costing. The two methodologies are complementary, but life cycle costing focuses on the dollar costs of building and maintaining a structure over its life cycle, while LCA focuses on environmental performance.

LCA Tools

Current LCA-based tools include BEES 3.0®, which is a product comparison tool including some brand-specific data, and the ATHENA® Environmental Impact Estimator (EIE) for analysis of whole buildings and assemblies. BEES 3.0 is intended for use at the specification or procurement stages of the process. Weighting factors are used to generate overall environmental and economic scores. ATHENA EIE is for use at the conceptual design stage. A range of indicators without weighting are generated to show environmental effects of changes in shape, design, or material make-up of a building.

Recently, a new tool has been developed for use with the Green Globes™ environmental assessment and rating system for commercial buildings. With funding from the Green Building Initiative, the tool was created by Morrison Hershfield Consulting Engineers in association with the University of Minnesota's Center for Sustainable Building Research and the Athena Sustainable Materials Institute. Modeled on the Building Research Establishment's (BRE) *Green Guide to Specification*, which has been used in the U.K. for over a decade, it measures the global warming potential and other environmental impacts of more than 400 common building assemblies in low- and high-rise categories.

The LCA tool and the entire Green Globes Rating System are currently going through the technical committee responsible for the Green Building Initiative's consensus process, which complies with American National Standards Institute (ANSI) standards. The Green Building Initiative has authorized the Athena Institute to make a generic version of this tool freely available for use by other green building organizations, government entities, trade associations, and universities. The generic tool should be made available by the summer of 2007. Regional versions of the tool are being developed to better reflect life cycle impacts based on local conditions. One of these regional versions is incorporated into the Minnesota Sustainable Building Guidelines. The Green Building Initiative also intends for the new software to be used in a forthcoming online version of the National Association of Home Builders' Model Green Home Building Guidelines.

The new tool allows an unbiased comparison of material assemblies across a set of five environmental indicators: embodied primary energy, which stands as a proxy for fossil fuel use; global warming potential; toxic releases to air; toxic releases to water; and solid waste. Rather than combining LCA scores across the five impact categories using some type of weighting so that each material assembly can be assigned a single score, Green Globes will attribute points to each assembly in each impact category. This approach serves a valuable educational function because it lets the design team more readily see where they're earning their points. The tool will be continually updated as new building product data or new assemblies emerge in the market. Manufacturers can contribute relevant data to the US LCI Database Project (www.nrel.gov/lci).

This same approach has been proposed for the U.S. Green Building Council's (USGBC) LEED Rating System in a report from a working group of the ad hoc "LCA into LEED" initiative that was launched in September 2004.

TABLE 1: WALL ASSEMBLY COMPARISON

ASSEMBLY TYPE	Primary Energy per SF (MJ)	GWP per SF (kg)	Solid Waste per SF (kg)	Air Pollution Index
Window system with aluminum frame Low-E silver, argon-filled glazing	622.17	32.31	17.08	10.08
CIP Concrete, brick cladding 2" extruded, 6mil PET 1/2" gypsum board, latex paint	237.93	9.79	2.81	1.63
CIP Concrete, stucco cladding 2" extruded polystyrene, 6mil PET 1/2" gypsum board, latex paint	160.23	13.22	3.29	2.39
Steel stud, stucco cladding 5/8 gypsum sheathing 3.5" fiberglass (batt), 6mil PET 1/2" gypsum board, latex paint	90.73	5.02	1.04	1.05

TABLE 2: WINDOW FRAME COMPARISON WITH CLEAR DOUBLE GLAZING

WINDOW TYPE	Primary Energy per SF (MJ)	GWP per SF (kg)	Solid Waste per SF (kg)	Air Pollution Index
Window with aluminum frame	622.17	32.31	17.08	10.08
Window with PVC-clad wood frame	387.61	27.81	2.52	7.06
Window with PVC frame	513.77	36.95	2.90	9.24
Window with wood frame	345.69	23.13	4.60	6.24

Example of LCA Applied to Building Assemblies and Materials

A series of simple material assembly comparisons using the ATHENA EIE illustrates how LCA can be used to make design decisions taking proper account of environmental performance measures throughout the life of the materials.

In Table 1, a given area of window assembly is compared to three typical solid wall assemblies in terms of primary energy use (i.e., fossil fuel use), global warming potential, solid waste, and an air pollution index. The choice of window frame type can have significant environmental impacts as indicated in Table 2. In a larger commercial office building, frame material choices are likely to be limited, but LCA can similarly be brought to bear on the more advanced glazing and façade options that may be considered. Table 1 illustrates the extent to which reducing window area has a beneficial environmental impact looking at the materials aspect in isolation, however such a decision must be examined in a whole systems context. For example, window design choices can have direct effects on building energy use if electric lighting and related cooling energy use are reduced because windows permit sufficient daylight to enter a space. Of course, they can also affect energy consumption as a result of heat loss and radiant solar heat gain. Window design decisions also have potential LCA impacts by affecting the design of many related components and systems in a building. A high performance window designed to maximize daylighting might reduce the need for light fixtures and perimeter heating in a space, as well as help reduce the size of the mechanical system. Similarly, if a particular window is chosen with a high visible transmittance glazing to enhance daylighting, glare may be increased resulting in the need for exterior or interior shading systems with related material impacts.

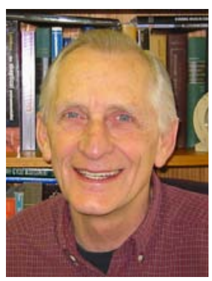
These systems implications should and can be taken into account in LCA tools, such as the ATHENA® EIE, balancing any increased environmental impacts from the materials (additional glazing layers and coatings for example) against the avoided impacts from reduced operating energy use over the life of the building. Those kinds of impacts must, of course, be balanced against other functional, cost, human comfort, and aesthetic criteria to optimize systems from all perspectives.

Conclusion

The adoption of LCA tools into Green Globes, LEED, and other regional rating systems represents a major step forward in what will likely be an ongoing integration of LCA into the sustainable design process. Over time, this process should strengthen the link between rating system scores and actual environmental benefits. The ultimate goal is to model the environmental impacts of whole buildings, so that rating systems can abandon the checklist approach and rate buildings based on a comprehensive model of their environmental performance, similar to the way energy modeling is done today.

About the Authors:

John Carmody is the director of the Center for Sustainable Building Research and a professor in the College of Design at the University of Minnesota where he teaches in the new Master of Science in Architecture program focusing on sustainable design. He has worked in building-related research for 25 years and is the author of several books on building design and construction. Most recently, Mr. Carmody was one of the leaders of a team to develop the *State of Minnesota Sustainable Building Guidelines* now required on state-funded projects. He is also the Director of the HUD-sponsored Community Outreach Partnership Center at the University addressing affordable housing issues.



Wayne Trusty holds a Masters degree in economics and has almost 40 years of experience in such diverse fields as resource industry economics and policy, water resources, transportation, energy policy and markets, and regional development. He now serves as President of the ATHENA Sustainable Materials Institute and its U.S. affiliate, Athena Institute International. In addition to involvement in other organizations, he is an adjunct associate professor on the University of Calgary's Faculty of Environmental Design, a member of the board of the Green Building Initiative, and chair of the Technical Committee.

Resources

—*Athena Environmental Impact Estimator*
Athena Sustainable Materials Institute
http://www.athenasmi.ca/
—BEES 3.0 (*Building for Environmental and Economic Sustainability*)
—National Institute of Standards and Technology
http://www.bfrl.nist.gov/oae/software/bees.html
—Green Building Initiative
http://www.thegbi.org/gbi/
—U.S. Green Building Council
http://www.usgbc.org/
—Center for Sustainable Building Research
University of Minnesota—http://www.csbr.umn.edu/
—Minnesota Sustainable Building Guidelines
http://www.csbr.umn.edu/B3/

Related Research Summaries

"Recycling Building Materials"
—*Building Research and Information*

"Fresh-Air Mechanical Ventilation"
—*Journal of Performance of Constructed Facilities*

"Economic Advantages of Sustainable Buildings"
—*Corporate Environmental Strategy*

"Design Strategies to Reduce the Effects of Global Warming"
—*Journal of the American Planning Association*

Photos Courtesy of:

John Carmody, Center for Sustainable Building Research (diagram, p. 2; p. 4)

Nathan Zook (remainder)

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