Incorporating LCA in Green Building Rating Systems

by Wayne Trusty

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Whole building assessment systems like BRE Environmental Assessment Method (BREEAM; used in the UK), Green Globes (Canada and USA), and Leadership in Energy and Environmental Design (LEED; USA) rightly place considerable emphasis on the selection of green materials or products as an important aspect of sustainability. Building design teams are clearly concerned about this topic, but are increasingly aware of the time and resources needed for, and the uncertainties associated with, the search for reliable information.

Designing, constructing, and operating environmentally friendly buildings is complex and there are few, if any, simple answers, especially when it comes to materials selection. The reality is that we are constantly forced into a balancing act, trading off a good effect here with a not-so-desirable outcome there. Life cycle assessment (LCA) has taken center stage in the past few years as a critical methodology for dealing with these complex issues, getting the focus off simple product or material attributes and onto true environmental performance measures.

As an example, some rating systems give credit for materials produced within a given distance of the structure being built. This makes sense on an intuitive level, since less energy will be required to transport the materials. But there are a tremendous number

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of factors that influence whether or not a material produced locally is better for the environment, including the source of its components, type of manufacturing process, and mode of transportation. So, in fact, using locally produced materials could either add to or detract from a building's sustainability.

Following an overview of LCA with an emphasis on its application to buildings, this article highlights tools that can be applied at different stages in the project delivery process, and then outlines the approaches for integrating LCA in Green Globes and LEED. Although the use of LCA in rating systems and standards is happening in various parts of the world, the focus here is on North America.

Life Cycle Assessment: An Overview

Put simply, LCA is a methodology for assessing the environmental performance of a product over its full life cycle. Environmental performance is measured in terms of a wide range of potential effects, such as fossil fuel depletion, global warming potential, stratospheric ozone depletion, and acidification. All of these measures are indicators of the environmental loadings that can result from the manufacture, use, and disposal of a product. These "mid-point" indicators are linked to, but do not directly address, the ultimate human or ecosystem health effects, a much more difficult and uncertain task. However, they do provide good measures of environmental performance, since reducing any of these effects benefits the environment.

In LCA, the effects associated with making, transporting, using, and disposing of products are referred to as "embodied effects," where the word embodied is not meant to imply true physical embodiment, but rather attribution or allocation in an accounting sense. In the building community, the tendency is to refer primarily to "embodied energy," but there is a wide range of embodied effects, as noted above. The energy required to operate a building over its life overshadows the energy attributed to the materials used in its construction and maintenance. However, other embodied effects generated during the resource extraction and manufacturing stages greatly outweigh any such releases associated with building operations.

For example, solid wastes are generated during the resource extraction, manufacturing and on-site construction stages of the life cycle; significant air emissions are generated during all of the intermediate transportation steps; and toxic releases to water and air are almost entirely a function of product manufacturing as opposed to building operations. Moreover, energy itself requires energy for its production and transportation, which can result in a full range of emissions (known as "precombustion effects").

To the extent possible, we should consider and balance all of these effects throughout the full life cycle of a product or building. And we should bear in mind that material choices directly influence the operating effects for a building (e.g., the thermal properties of envelope materials). When we take a full life cycle approach, we may find that accepting a penalty in one stage of the life cycle, or with regard to specific measures such as initial embodied effects, may yield overriding benefits.

It is also important to note that the LCA of a product should take account of the production and use of other products required for cleaning or maintaining the product during its use phase. For example, we should take account of the paints required to maintain some types of wood cladding, and of the cleaning products required to maintain various kinds of flooring. We must similarly take account of the repair and replacement of individual products through the building life cycle.

In LCA, we use the term "functional equivalence" when referring to the problem of ensuring that two or more products provide the same level of service and that comparisons are fair from that perspective. Ensuring functional equivalence is not as easily accomplished in building applications as might be supposed because the choice of one product may lead to, or even require, the choice of other products. For that reason, comparisons may have to be made in a building systems context rather than on a simple product-to-product basis. In general, product-to-product comparisons are more likely to be misleading when dealing with structure and envelope materials, where the systems context is key. In a similar vein, we should be careful to take account of all the components that may be required during building construction to make use of a product. Mortar and rebar go hand in hand with concrete blocks, just as fasteners, tape, and drywall compound are integral to the use of gypsum wallboard.

The final point to note about LCA is that it is not the same as life cycle costing (LCC). The two methodologies are complementary, but LCC focuses on the dollar costs of building and maintaining a structure over its life cycle, while LCA focuses on environmental performance measured in the units appropriate to each emission type or effect category. For example, global warming gases are characterized in terms of their heat trapping effects compared to the effects of carbon dioxide (CO_2), and so global warming potential is then measured in equivalent amounts of CO_2.

The LCA Toolkit

Some years ago, the Athena Institute developed a simple LCA tool classification system, which contemplates the following three main levels of tools:

- **Level 1 – Product Focus:**
  1A – For LCA practitioners
  SimaPro, GaBi, Umberto
  1B – LCA in the background
  BEES (NIST)
- **Level 2 – Assembly Focus**
  Athena EcoCalculator
- **Level 3 – Whole Building**
  Athena Impact Estimator

The Level 1A tools are designed for use by LCA practitioners, offering flexibility in terms of the data that are used and various steps in the LCA process, but requiring considerable expertise in the subject. In contrast, the Level 1B, 2, and 3 tools have the LCA in the background to make LCA more accessible to the building community; design teams can input design options at the product, assembly, or building level and get back instant LCA results to help make final choices. In North America, only the listed tools are currently available at these levels, although new tools will probably emerge. The Level 2, assembly focused tool is especially relevant here because it is the starting point for the integration of LCA in the rating systems.

The Green Building Initiative (GBI) originally commissioned development of the Level 2 Athena EcoCalculator for Assemblies by the Athena Institute, in association with the University of Minnesota and

Morrison Hershfield Consulting Engineers, for use with the Green Globes environmental assessment and rating system for commercial buildings. Recognizing its potential for more widespread application, GBI subsequently donated its share of the intellectual property so that a generic version could be made freely available on the Institute's Web site at www.athenasmi.org.

The EcoCalculator provides instant LCA results for hundreds of common building assemblies, including exterior walls, roofs, intermediate floors, interior walls, windows, and columns and beams. The information embedded in the tool is based on detailed assessments completed with its parent software, the Athena Impact Estimator for Buildings.

Integrating LCA in Building Rating Systems

There are several ways that LCA could be introduced in rating systems, ranging in level of effort from fairly easy to relatively onerous. For example,

1. Educational credits — if you use LCA, you get

points irrespective of the results or use of the results in the design process;

2. Credits that encourage manufacturers to implement LCA by giving points for the use of products that are accompanied by proof of an LCA or that have an LCA-based ISO Type III label (an Environmental Product Declaration);
3. Credits for selecting pre-studied building assemblies that are highly ranked in terms of LCA results; and
4. Credits for exceeding LCA benchmark levels at the whole building level.

The first two methods have appeal for obvious reasons, but they are not likely to advance the cause of environmental performance to a very great extent. One problem is that LCAs can vary in quality for a variety of reasons, and simply completing even a high-quality LCA has little value if the results are not brought to bear on decisions.

The third method has the merit that the LCA work can be done in the background, without requiring the use of specialized tools by design teams, but there is the problem of maintaining a sufficiently rich menu of design options from which teams can choose.

The fourth method puts the focus strictly on environmental performance measures, leaving it entirely up to the design team to decide how to achieve the required results. Moreover, this approach would allow embodied effects to be combined with operational effects so that realistic trade-offs between material use and operating performance would be handled automatically. Indeed, LCA performance criteria could entirely replace many of the credits in the operating energy section of a rating system. However, this method also puts an onus on rating system developers to study enough buildings to establish performance benchmarks at the whole building level.

In the case of the Green Globes rating system, a recommendation was made to use the assembly ranking approach (method 3 above) and GBI subsequently funded development of a credit calculator based on the now freely available EcoCalculator, as noted previously.

In the case of U.S. Green Building Council, a stakeholder meeting in September 2004 resulted in the creation of working groups, one of which was charged with establishing the goal and scope for integration of LCA in the different LEED rating system products. After considerable deliberation, that group also recommended the assembly ranking approach as a less-than-ideal but best near-term approach. Following ratification of that recommendation, efforts focused on how best to accomplish the task in terms of tools and credit language, leading eventually to a decision to use the EcoCalculator as the basis for inputs to a separate LCA credit calculator.

Both rating system organizations have a long-term objective of switching to the more ideal approach of whole building LCA (method 4 above), but benchmarks will first have to be put in place. In addition, both want to make sure there is an option for the use of tools other than just the EcoCalculator for assembly assessment; the trick is to ensure reasonable equivalence and maintain a level playing field. That, in turn, requires setting criteria with regard to data, life cycle stages that must be included, and other factors—not a trivial exercise.

Conclusions

The selection of environmentally sound or friendly (so-called "green") building materials is complex and there are no easy solutions. One has only to walk the floor at any major building materials exhibition to see the problem; few, if any, vendors fail to make the claim that their product is "green" on the booth banner and in their literature.

The reality is that most building products have both positive and negative aspects when it comes to environmental performance. The task is to balance the pros and cons, understand the trade-offs in terms of true environmental performance measures, and use materials to their best advantage, recognizing that all buildings typically incorporate a wide range of materials. LCA is no panacea, but it is the best method we have right now to shift away from simple labels and a focus on single attributes to true environmental performance measures. The integration of LCA in Green Globes and LEED is most certainly a step in the right direction, leading on a path that should and must be improved and made progressively easier to tread. **em**