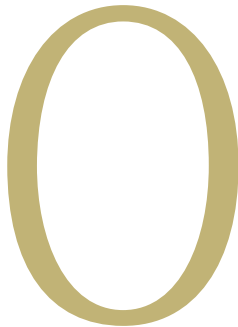




# Don't Put All Your (Green)

## Eggs in One Basket

### A l o o k a t B E E S a n d L E E D



Over the last several years, environmental advocates have successfully raised the awareness of green building design and construction benefits among architects/engineers (A/E)s and designers, as well as building owners and facility managers.

Unfortunately, there is no recognized universal standard defining precisely what constitutes a green building. Recognizing the pitfalls of leaving definitions open to individual interpretation, several organizations have set out to develop programs, specifications, or standards aimed at helping define the requirements for properly referring to any given building as environmentally friendly.

#### Certification approach

Currently, a number of groups are working on certification programs based on several criteria for determining greenness—that is, a project must meet certain objectives to receive a green label or rating. In the United States, one of the more popular programs is the Leadership in Energy and Environmental Design™ (LEED) rating system, developed and promulgated by the U.S. Green Building Council (USGBC). Another, sponsored by the World Wildlife Federation- (WWF-) Switzerland and other organizations, called Natureplus, is being promoted in seven European countries: Austria,

Belgium, Germany, Italy, Luxembourg, Netherlands, and of course, Switzerland.

Most certification programs determine greenness by either a set of requirements applying primarily to a building material's initial origins and manufacturing requirements, or assessing certification points based on certain performance criteria. This latter approach, however, can sometimes inadvertently bias the selection of certain materials regardless of their actual environmental impacts, or offer little guidance in choosing among alternate materials with 'natural' or green characteristics.

For example, natural cork floor planks might

seem to be a greener flooring material than, say, linoleum or terrazzo, based on its natural renewability, but the choice is not always as obvious or straightforward as it first appears.

Since few buildings are constructed with the luxury of a limitless budget, A/Es and owners must make practical green decisions based on both environmental and energy impact analyses and cost considerations. Moreover, because of a building's considerable life expectancy, the decision-making process should not only take into account the initial manufacturing and construction impacts, but those of replacement cycles and final disposal throughout the use phase as well.

When one analyzes the environmental and economic impact throughout the 30- to 50-year building-use phase, plus disposal, one discovers overall best performance is not always obvious. In the cork flooring example, for instance, were the importance of economics and environmental performance weighted equally (at 50 percent apiece), then linoleum and cork would score about the same in overall life-cycle performance—each having about a 20 percent advantage over terrazzo.

However, if economic performance is weighted at 25 percent importance and environmental impact at 75 percent, terrazzo has the best overall performance score, with a 20+ percent advantage over linoleum, and 50+ percent edge over natural cork. Finally, reversing importance factors to weight economics at 75 percent and environmental impact at 25 percent yields a clear advantage for linoleum, with a score about 100 percent better than either natural cork or terrazzo.

Clearly, natural materials do not always have full life-cycle advantages over synthetic ones. Material choices are affected by the value and weighting specifiers place on environmental versus economic impacts, so while life-cycle analysis (LCA) is but one part of the decision-making process, it can still help A/Es make more scientifically based green decisions.

While life-cycle analyses have historically been the purview of specialized consulting firms, the introduction of a free, publicly available life-cycle assessment tool called BEES® (Building for Environmental and Economic Sustainability) a few years ago has made LCA information available to every owner and design team.

## Life cycle considerations

With a menu-driven user interface, BEES is a Windows-based application developed by the National Institute of Standards and Technology's (NIST's) Building and Fire Research Laboratory, with support from the U.S. Environmental Protection Agency's (EPA's) Environmentally Preferable Purchasing Program. BEES is a powerful tool for helping evaluate and select cost-effective, environmentally preferable building products.

By using BEES to analyze life-cycle costs as well as environmental impacts, the A/E or owner sees tangible, meaningful comparisons in the trade-offs involved in selecting one building material over another. Although it is helpful for the user to have an understanding of how the software arrives at its conclusions, he does not necessarily have to be an engineer or mathematician. The program interface makes the complex mathematical calculations nearly transparent, allowing the user to choose initial parameters and preferences, and rendering results in overall scores and easily interpreted graphs.

BEES includes over 400 environmental flows associated with extracting, processing, manufacturing, transporting, constructing, and deconstructing total building material inventory (including manufacturing and installation waste). It analyzes the life-cycle costs and environmental impacts of a given material at every stage of its life.

LCA is a multi-faceted methodology not based solely on any one attribute that might give a particular product a green reputation (*i.e.* recycled content). LCA also measures environmental problem shifts (or burdens) from one life-cycle stage to another, or one medium (land, air, or water) to another. For example, increasing the amount of recycled content in paper products results in less solid waste being disposed, but the use of post-consumer waste requires higher energy input during the initial manufacturing process. Only by weighing all environmental impacts can users choose the necessary trade-offs for achieving maximum environmental benefits over the life of a project. The ability to perform "What if?" analyses for all trade-offs involved in a project makes LCA an excellent diagnostic tool in the evaluation and decision-making process.

Released just last fall, BEES 3.0 provides life-cycle data for an expanded list of about 200 building products, organized into 20 application categories (compared to BEES 2.0's 65 products in 15 categories). More importantly, while 2.0 included only generic, industry-average data for each product type, BEES 3.0 contains full life-cycle data for around 80 brand-specific building products.

The new version offers a number of other refinements, including an absolute performance scale (BEES 2.0 offered relative scores comparing one material choice to another, but did not reflect any absolute determinations about how environmentally benign they might be as a group).<sup>1</sup>

## Defining environmental impacts

BEES 3.0 calculates 12 separate environmental impacts for each product:

- Acidification (acid rain)
- Criteria Air Pollution (primarily a measure of particulates)
- Ecological Toxicity
- Eutrophication (unwanted mineral nutrients added to soil and water)
- Fossil Fuel Depletion
- Global Warming
- Habitat Alteration
- Human Health (cancer and non-cancer)
- Indoor Air Quality (IAQ)
- Ozone Depletion
- Smog
- Water Intake (amount used from cradle to grave)

This list adds two new categories to the 10 included in BEES 2.0: Criteria Air Pollution and Water Intake. In addition, Version 2.0's Solid Waste category has been replaced by Habitat Alteration, which NIST believes is a more accurate description of solid waste's impact on the environment. Solid waste on its own makes no environmental impact; its disposal in landfills, however, destroys habitats there and in surrounding areas.

All regional and local impacts are now scored based on new U.S.-specific methods developed by EPA. In BEES 3.0, LCA scoring includes the significance of a product's performance with respect to each impact. Thus, scores can now be compared across

most building elements (i.e. roof and floor coverings) to see which have the poorest scores and would benefit most from environmental improvement.

## Economic impacts

Like its predecessor, BEES 3.0 measures the economic performance of a product using ASTM International E 917-99, *Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems*. The economic score clearly reflects market-based costs over the life of the project rather than simple procurement costs. The ASTM model accounts for initial investment plus replacement, operation, maintenance/repair, and final disposal costs. All are calculated over a specific period of time, referred to as the 'study period,' so differences in replacement or repair frequency, for example, can be factored into the economic performance score of alternative products.

Economic performance results displayed in a BEES analysis show first costs, discounted future costs and their sum, and the life-cycle cost. In setting up each analysis, the user can specify the discount rate used to calculate future costs (the default is the value specified by the U.S. Office of Management and Budget [OMB] for most federal projects), so the economic analysis can accurately reflect current market conditions or special financial circumstances.

## Overall score

BEES not only generates an environmental impact score plus an economic performance score, it combines them to provide the user with a single aggregated score for each building product considered.<sup>2</sup>

The process begins with the user specifying the relative importance of each of the two primary study elements—environmental impact and cost—stated as a percentage. When the user sets environmental impact importance to 60 percent, then cost is automatically set to 40 percent. That ratio is then used to calculate the aggregate score for each product. Analyses can be repeated using different proportions to measure the sensitivity of each product's overall score to the importance of cost versus environmental impact.

The user can further customize the analysis by setting priorities for each environmental impact, using one of four weighting protocols:

1. user-defined
2. EPA Scientific Advisory Board
3. Harvard University
4. equal weights for all categories

(The last three are pre-defined within the BEES software.)

## Fitting into a bigger picture

### LEED basics

The U.S. Green Building Council (USGBC) is a private, non-profit organization representing a coalition of members from across the building industry. It promotes environmentally responsible, profitable, and healthy buildings. Its LEED rating system is touted as the pre-eminent methodology on the market for evaluating everything green about building products and systems. Among other things, LEED was created to:

- define 'green building' by establishing a common standard of measurement,
- promote integrated, whole-building design practices,
- recognize environmental leadership in the building industry,

- stimulate green competition,
- raise consumer awareness of green building benefits, and
- transform the building market.<sup>3</sup>

### LEED technical overview

LEED is a rating system and certification program currently covering commercial, institutional, and high-rise residential new construction and major renovations. The next generation (LEED 3.0) is expanding to cover existing buildings, multiple buildings, cores and shells, interiors, and residential construction.

LEED uses a whole-building approach, intended to encourage and guide collaborative, integrated design and construction processes, with points assigned to five categories:

- Sustainable Sites (22 percent)
- Water Efficiency (8 percent)
- Energy and Atmosphere (27 percent)
- Materials and Resources (20 percent)
- Indoor Environmental Quality (23 percent)

The total number of credits accumulated determines the LEED certification level (in descending order):

- Platinum (≥52 points)
- Gold (39–51 points)
- Silver (33–38 points)
- LEED-certified (26–32 points)

A number of resources are available, including a training workshop, reference package, professional accreditation, welcome packet, credit rulings, and a Web site ([www.leedbuilding.org](http://www.leedbuilding.org)).



## Did You Know?

Polycarbonate windows have lower thermal conductivity than glass, which can reduce heating and cooling energy needs while providing additional high-strength shatter-resistance during dangerous weather.



Plastic housewrap, foam plastic sheathing, and spray-applied plastic foams can reduce air (and by extension, moisture) infiltration by as much as 10–50 percent. The energy saved with the use of plastic housewrap surpasses the energy required for its manufacture—sometimes in less than two months after installation.

Certification recognizes quality buildings and environmental stewardship through third-party validation, helps projects qualify for state and local government incentives, and provides marketing exposure through USGBC's Web site, case studies, and media announcements.

#### BEES basics

Unlike LEED, BEES blends life-cycle costing and environmental assessment data to provide an aggregated performance score for various materials used in construction. The BEES model is based on consensus standards, including:

- ASTM E 917
- ASTM E 1557, *Standard Classification for Building Elements and Related Sitework-UniFormat II*
- ISO 14040, *Environmental management—Life cycle assessment—Principles and framework*
- ASTM E 1765

#### BEES technical overview

The data used in BEES assessments come from a number of sources, including Environmental Strategies & Solutions (an LCA small business contractor), PricewaterhouseCoopers (PwC, developers of the DEAM LCA database covering more than 6000 industrial processes gathered from actual site and literature searches from 15 countries), as well as data collected from U.S. industry, and assumptions verified through industry and trade association input.

Similarly, published economic performance data is readily available, and well-established standards exist for conducting economic performance assessments. For generic products, BEES software analyzes first-cost data taken from R.S. Means' 2000 *Building Construction Cost Data*; for brand-specific products, BEES uses first-cost data supplied by manufacturers. Most future-cost data are from Whitestone Research.<sup>4</sup> As mentioned above, life-cycle cost calculations are based on ASTM E 917.

BEES 2.0 was reviewed by an independent peer review panel chaired by the EPA, which included reviewers from the University of Tennessee, Center for Clean Products and Clean Technologies, the Swiss Federal Institute of Technology, and the California Integrated Waste Management Board. Their comments formed the basis for the modifications made to version 3.0.

#### Evaluating LEED using LCA techniques

Putting BEES head-to-head against LEED yielded some interesting results. Under contract with NIST, the University of Michigan's Center for Sustainable Systems recently evaluated the LEED certification program using LCA methods. The final report, issued in September 2002, found a number of concerns with the LEED program and identified areas where it could be improved. The report's conclusion emphasized the need for life-cycle assessment:

The lack of comparability between LEED ratings and LCA results indicates that, when considered in a life-cycle perspective, LEED does not provide a consistent, organized structure for achievement of environmental goals. Further, the disaggregation into individual credits may stimulate specific solutions, but overall building integration may be less than ideal.

Finally, the lack of balanced results may lead to so much variation in total building environmental performance that a building's rating may not align with its actual performance... Refinement of LEED should emphasize integration of life-cycle-oriented measures and standards.<sup>5</sup>

The report also notes, in terms of total environmental assessment, "LEED has provided an important cornerstone... but alone does not provide an environmental assessment tool the building industry can rely on." Meanwhile, life-cycle assessment and cost measurement tools like BEES provide a scientific method for making practical environmental decisions in current building construction.<sup>6</sup> The study shows there are numerous methodologies and techniques available for investigating and specifying green solutions. The design team should not limit the decision-making process by simply opting for the most popularized system on the market.

Those in building design and construction wishing to improve the environmental performance of their projects routinely ask the question: "What material selections offer the best opportunity to optimize environmental benefits within the limits of the project budget?" Rather than rely solely on a material's reputation or singular, high profile impact, a tool like BEES helps individuals make decisions based on scientifically sound trade-offs using LCA techniques. ○

## Notes

1. The absolute performance score is provided using the U.S. Environmental Protection Agency's (EPA's) "Tool for Reduction and Assessment of Chemical and Other Environmental Impacts" (TRACI). A detailed discussion of TRACI by J.C. Bare (et al), is available in the *Journal of Industrial Ecology*, Vol. 6, No. 3, 2002.
2. Using ASTM E 1765, *Standard Practice for Applying Analytical Hierarchy Process (AHP) to Multiattribute Decision Analysis of Investments Related to Buildings and Building Systems*.
3. Visit [www.usgbc.org](http://www.usgbc.org) and click on LEED.
4. *The Whitestone Building Maintenance and Repair Cost Reference*, 2000.
5. The full report, "Evaluation of LEED Using Life Cycle Assessment Methods," by Chris W. Scheuer and Gregory A. Keoleian, *NIST GCR 02-836*, September 2002, as well as a two-page summary, are available for free download from the NIST BEES Web site at <http://www.bfrl.nist.gov/oe/software/bees.html>. Click on What's the Buzz?
6. BEES 3.0 is available for download free of charge from [www.bfrl.nist.gov/oe/bees.html](http://www.bfrl.nist.gov/oe/bees.html). Review EPA's U.S.-specific impact methods at [www.epa.gov/ORD/NRMRL/std/sab/iam\\_traci.htm](http://www.epa.gov/ORD/NRMRL/std/sab/iam_traci.htm).

## About the Author

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