A SUPPLEMENT TO BUILDING DESIGN & CONSTRUCTION

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Life Cycle Assessment and Sustainability

Third in a Series of Annual Reports on the Green Building Movement

Life cycle assessment, or LCA, is arguably today's most talked-about topic in the green building movement.

Architects, engineers, contractors, building owners, environmentalists, and government officials want assurance that the products and materials they are using to design and construct buildings are the most beneficial to the environment—"from cradle to grave."

Similarly, forward-looking manufacturers of green building products are searching for scientifically objective ways to distinguish the long-term environmental benefits of their products.

Interest in LCA was spurred a year ago, when the U.S. Green Building Council created an "LCA into LEED" Task Force to determine whether and how LCA could be incorporated into the next version of its LEED rating system.

Other efforts, such as the U.S. Life Cycle Inventory Database project, the National Institute of Standards & Technology's BEES program, the Green Globes rating system, and the UNEP/SETAC Life Cycle Initiative, also point to growing interest in LCA.

And surely LCA will be high on the agenda of the White House Summit on Sustainability, scheduled for January 24-25, 2006.

The editors offer this White Paper in the hope that it will inform and educate the design and construction community as to the growing importance of life cycle assessment to the built environment. We welcome your comments.

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Why LCA?

By Rita Schenck, PhD

You have probably been hearing about LCA (life cycle assessment) and wondering what the big deal is. What has biology got to do with buildings, or with manufacturing building products? Is this the latest fad in architecture? Is it just going to add cost and delays to your projects?

LCA is a measurement tool, a way to measure the environmental performance of products over their life cycle, from "cradle" (where the raw materials are extracted) to "grave" (where the product is finally disposed of). The outcome of an LCA study is called the "ecoprofile," the compiled measurements of indicators of environmental issues such as climate change, toxicity, fossil fuel depletion, and water resource depletion. An LCA of a building will tell you how much climate change was caused by the building from the point where minerals were mined to the point where the building waste is landfilled. It will do the same for about a dozen other environmental issues, including toxicity, acid rain, and resource depletion.

In the classic example comparing paper bags to plastic bags at the grocery store, plastic bags are more environmentally friendly—sometimes as much as 10 times more friendly—than plastic bags. Why? Because it takes lots of energy to make paper, and when you have used (and reused) your paper bag, it goes to a landfill where it emits methane (a potent greenhouse gas) for years.

Well, you might say, who cares? Why do we need to measure this? Anyway, don't we already know how to build green buildings?

As it turns out, lots of people care about having more environmentally friendly products. Even if you aren't one of them, your clients probably are. For building product manufacturers, if you can prove that your product is greener, you will have more market to sell it in. Similarly, Building Teams that use environmentally friendly products may find greater client acceptance. Market research has shown over and over that at least 80% of people will prefer the environmentally friendly product if it does not cost more, and 10-20% will actually pay more for a greener product. The explosion of the LEED program of the U.S. Green Building Council (USGBC) reinforces the point.

LCA is the only science-based and credible tool that is actually designed to measure the environmental impacts of a product. Because it looks at all the important environmental issues and evaluates the entire product life cycle, an LCA uncovers the whole environmental story. That way, if a product has more impacts during manufacture but saves impacts during use, you can see if it is a better environmental choice.

A good example of this is insulation. The more insulation you use, the less energy you use to heat or cool a building. It is true that by adding insulation you are adding manufacturing impacts, but the environmental benefits of insulation are so large that the more insulation you add (even with additional environmental impacts in the manufacturing stage) the fewer environmental impacts you get overall (because of the benefits in the use phase), for a net positive environmental outcome. As it turns out, adding insulation decreases the costs of operating the building, too.

One of the interesting things about LCA studies is that they can test our assumptions about what is really "green." For example, think about recycling as a way to decrease environmental impacts. We know that recycling preserves natural resources, so making recyclable products and using recycled products is a good thing, right?

Many life cycle assessments have been done on the topic of recycling and it turns out that recycling is only environmentally beneficial if it can be done close to the source of the waste stream. If you have to ship materials hundreds of miles away to a recycling facility, you probably are causing more environmental damage due to burning fossil fuels for transportation than you would if you just disposed of them in a landfill. You are using up one natural resource (petroleum) to save another. In the context of buildings, this means that onsite recycling of building wastes is a good thing and offsite recycling should be scrutinized carefully, especially for large volume materials such as waste concrete. You are trading off petroleum losses for concrete conservation. When we think about the impending depletion of oil versus the prevalence of gravel and the other components of concrete, it should give us pause.

Take another example: bio-based products. Materials made from plants are obviously better for the environment than things made from petroleum, right? Well, think again. In the classic example comparing paper bags to plastic bags at the grocery store, plastic bags are more environmentally friendly—sometimes as much as 10 times more friendly—than plastic bags. Why? Because it takes lots of energy to make paper, and when you have used (and reused) your paper bag, it goes to a landfill where it emits methane (a potent greenhouse gas) for years. In fact letting paper bags decompose in a landfill causes 20 times more climate change as burning the paper would. Plastic bags put into a landfill don't decompose. Instead they act as a carbon sink, sequestering carbon in the landfill. Moreover, it doesn't take much petroleum to make plastic bags; that's one reason they're so cheap.

All this points to the need for careful measurements if we really want to have our choices in the marketplace reduce rather than increase our environmental impacts.

In the U.S., the most common use of LCA is in the design stage of product development. Engineers try to make greener products, and they use LCA to tell them where impacts are coming from throughout the life cycle of the product. Then they can work on making things better. This design-for-environment approach has made a big difference in the products we buy.

For example, one reason cell phones are getting smaller and smaller is that designers using LCAs realized that the materials in the phones contributed lots of their ecoprofile: less material means less impact. As a bonus, less material means less cost, and consumers get these cool little phones.

Personal computers use less energy to operate than they used to, as you can see with all the Energy Star stickers you find on them. It was the outcome of LCAs performed by IBM in the 1980s that pointed out that the energy required to run a PC dominated the ecoprofile. The measured environmental impacts drove PC designers to make them more efficient. Since then, computers have become so efficient that now the manufacturing of computer chips dominates the ecoprofile. The ball is in the chip manufacturer's court now.

I used to be an environmental manager in industry, and I often made expenditures designed to decrease the emissions or use of toxic materials. Often those changes involved using more energy. In effect, I was exchanging toxicity for global warming. I was being measured on the toxics releases. If I had done an LCA, I would have been able to tell when my "pollution prevention" actions were actually making the ecoprofile better or worse.

An LCA should look at all important impacts, not just the regulated ones. In the Netherlands, LCA is used as a tool for facility permits. Rather than separate air, water, and waste permits as we do here in the U.S., the Dutch have a single facility permit based on LCA. Toxicity, climate change, and land use issues are all considered at the same time. We can only imagine the cost savings from unified permitting. Less paperwork and better environmental performance are the outcome.

In Europe, LCA is part of the policy infrastructure. The European Commission makes decisions based on life cycle considerations, and all the countries then implement those policy directives with national laws. An example is the requirement that landfill space be preserved by minimizing packaging. In Germany, you must provide reusable containers for soft drinks, unless you can prove that supplying a reusable container actually causes more environmental impacts supplying than a disposable one. For example, Red Bull, a soft drink made in Austria, has shown that the transportation impacts back and forth between Germany and Austria would create more environmental problems than would be saved by providing reusable containers.

When we are talking about LCAs of buildings and building materials, it helps to think about the whole building effects. Everything from the skin to the HVAC to the flooring can have an effect on a building's "ecoprofile," its overall environmental impact. But the issues are pretty much the same. What can we do to decrease the use of energy? Does a certain type of window help with energy conservation over the entire life of the building? How many times will the window be replaced during the lifetime of the building? Which materials are less toxic? How important is the end of life of the building? Does it make sense to design the building for "deconstruction" when it's useful life is over? Only careful LCAs can answer these questions by measuring the environmental impacts over the entire life cycle of the building.

Why LCA? The answer is simple. What gets measured gets done, and LCA measures environmental performance. Not measuring environmental performance could mean you are spending money and effort on things that don't matter. That is something no one wants.

Dr. Rita C. Schenck is executive director of the Institute for Environmental Research and Education, a not-for-profit organization dedicated to fact-based environmental decision making. Trained as an oceanographer, with expertise in ecotoxicology and biogeochemistry, she represented the U.S. in negotiating the ISO standards on life cycle assessment. She is the author of "LCA for Mere Mortals: A Primer on Environmental Life Cycle Analysis," which is available at www.iere.org. The American Center for Life Cycle Assessment is a program of IERE.

Life Cycle Assessment for Whole Buildings: Seeking the Holy Grail

By Nadav Malin

Nadav Malin is vice president of BuildingGreen, Inc., Brattleboro, Vt., editor of Environmental Building News, *and co-editor of the* GreenSpec *product directory. He chairs the Materials and Resources Technical Advisory Group for the U.S. Green Building Council's LEED rating system and is a LEED faculty member and LEED Accredited Professional. He represents BuildingGreen on the team that has been contracted by the state of California to develop an Environmentally Preferable Product Database for schools and manages the U.S. Department of Energy's High Performance Buildings Database project. He has written on environmentally preferable products for the AIA/Wiley* Handbook of Architectural Practice *and was a principal author of the Applications Reports for the AIA's* Environmental Resource Guide.

Food bought in a supermarket is labeled with a standard nutrition form that tells you the amount of nutrients, salt, and fat contained in each serving. Someday building materials may also have a label, listing each product's contribution to global warming, ozone depletion, acid rain, habitat loss, and a handful of other environmental indicators. Eventually, whole buildings might be measured based on their performance against a similar set of indicators. When that day comes, the label or rating system will be the result of an environmental life cycle assessment

While standardized labels on building products are not yet a reality (at least not in North America), the science that will make it possible is rapidly becoming more sophisticated and more widely used. While performing full LCA studies is still a job best left to the experts, building professionals are increasingly likely to encounter LCA-based data or use software tools that compile the results of studies done by others. To be effective in this setting, it is important to have a good understanding of the context in which those data and tools are created. This article describes LCA in a nutshell, presents some of the challenges faced by LCA practitioners and users today, outlines the most promising U.S. initiatives to address those challenges, and looks at the implications of this rapidly evolving field for designers and other building professionals.

In principle, LCA is simply common sense. If we are to understand the environmental impacts associated with any product, we must analyze the entire life of that product and consider the environmental burdens of each step along the way. Thus, product LCAs typically consider the extraction or harvesting of the raw materials, the refining and manufacturing processes that turn those raw materials into useful products, transportation of those products, their use, and their eventual disposal or reuse. This scope of analysis is often called "cradle-to-grave" or, including the reuse potential, "cradle-to-cradle" LCA.

Once we get into the details of this analysis, however, it gets complicated very quickly—and the closer we look, the more complicated it gets. To quantify energy and resource flows at each step in the life of a product and understand the impact of those flows, we are, in effect, trying to describe the infinitely complex real world with a bunch of categories and numbers. To make that impossible task manageable, LCA practitioners make simplifying assumptions at every step of the way, and exploit computer databases in ways that would not have been feasible a decade ago. Various international organizations are always working on guidelines and protocols to standardize the assumptions, bringing into question approaches that were common a few years earlier. Even as this is going on, academics are pointing out the shortcomings of the new standards and suggesting avenues for further improvement.

LCA is often confused with the traditional engineering practice of *life cycle costing*, but the two are very different. Where LCA is about quantifying and analyzing environmental burdens and impacts, LCC is strictly a financial tool for calculating the total cost of ownership over the useful life of an asset. The two tools are related in that they both take into account how long a particular item will serve its intended purpose and what maintenance it will need during that time. As a result, both tools give credit to items that are long-lived and durable, but LCA involves environmental accounting, while LCC only considers economic value.

Building professionals are unlikely to be in a position to carry out their own LCA studies, but those who are interested in the environmental impacts of their projects are increasingly likely to seek out, or encounter, LCA-based information. To utilize this information intelligently, it is important to know something about how such studies are carried out. Most LCA studies today adhere to the principles laid out in a series of International Organization for Standardization (ISO) documents known as the "14040 Series" within the broader ISO 14000 category on environmental management. These documents describe four general steps to be performed in any LCA:

- **Goal and scope definition,** to clarify the questions to be answered and determine how much precision, detail, and reliability are needed to answer those questions—if an LCA is to be used for comparing competing products or materials, an appropriate functional unit that defines a measure of equivalent service from each of the candidate products must be defined.
- **Inventory analysis,** in which all the energy, water,

and materials flowing into and out of every process in the subject's life cycle—including pollutants—are quantified and categorized.

- **Impact analysis,** in which the inventory of inputs and outputs is related to actual (or assumed) impacts based on a series of environmental indicators, such as global warming potential, human toxicity, and resource depletion.
- **Interpretation and conclusions.** LCA was originally developed for internal use by manufacturers considering options for product development. In fact, LCA in the U.S. got its start in the late 1960s when Coca-Cola wanted to determine the environmental impact of switching from glass to plastic bottles. William Franklin was part of a team hired to conduct the study (which found no significant reason not to switch), and he subsequently founded Franklin Associates of Prairie Village, Kan., which for years was the sole large LCA firm in the U.S.

More recently, LCA has been used for many other purposes, including some highly publicized studies, one comparing plastic and paper shopping bags, another comparing disposable to reusable diapers. In general, most LCA studies are designed to support one or more of the following goals:

- documenting environmental performance for communication and marketing purposes
- developing policy and regulations
- assessing potential liability
- evaluating environmental performance to document improvement for environmental management systems
- green labeling
- purchasing/procurement decisions.

LCAs for building materials are different from those for disposable items like packaging, for two reasons: first, building products tend to have a relatively long service life or, in LCA parlance, "use phase." As a result, any environmental impacts relating to the use of these materials, such as energy use, tend to dominate the overall life cycle profile of the product. Second, the service life of building products is highly variable, as even durable products may be replaced quickly for aesthetic or economic reasons. "Estimating the useful service life of a product or a building is very problematic for LCA," said Wayne Trusty, director of the Athena Sustainable Materials Institute, Merrickville, Ont. This factor puts a high level of uncertainty on the results of any LCA study conducted on a building material. It is clear from LCA, however, that the service life of a product is very significant in terms of that product's environmental profile. "One thing LCA tells us is that a greener building should have a long life or be made from reusable materials," said Trusty.

LCA Checklist for Green Building Designers

- Don't attempt to perform your own LCA studies unless you want to devote significant resources to making that endeavor a specialty.
- Encourage product manufacturers to perform LCAs on their products and make the results available by asking product representatives for LCA data. Refer to ISO-standard Type III Environmental Product Declarations (third-party–reviewed LCA results), the work of the Sustainable Products Purchasers Coalition, or the BEES software from NIST as mechanisms for making that data available.
- Ask key questions about any LCA data provided to assess its reliability and applicability to your decision. Examples of such questions include:

What are the sources of the data? How much is based on primary information directly from the operations, as opposed to databases of industry-average data? Is the industry-average data regionally specific (U.S. as opposed to Europe) and fully transparent to users or peer reviewers?

What assumptions are included about the functional unit and the service life of the products in question? Do these correspond to your situation?

What are the uncertainty factors in the information? No commonly used databases currently include this information, but "uncertainties of 20% or more are likely," according to Sylvatica's Greg Norris. If users ask, there will be pressure to provide an answer.

What is assumed about the products' maintenance requirements or impact on building operations?

Do the impact categories included in the results capture the important information, or might the results by skewed by leaving out key categories?

- Resist the temptation to reduce LCA results to a single score for each product. The weighting required to do this introduces assumptions that may not be appropriate, and too much information is lost. Look instead at the results across all available impact categories and make your own assessment based on those results.
- Whether or not reliable LCA results are available, always apply life cycle thinking and critically review any product information to support your choices. Resources based on life cycle thinking include *EBN* articles and *GreenSpec* product listings from BuildingGreen, as well as GreenSeal product labeling standards.
- Look at the whole building from a life cycle perspective and aim to minimize overall environmental impacts while optimizing performance. In general, such an approach suggests that addressing the ongoing impacts of building operation, including energy use, water use, and maintenance impacts, should be a higher priority than choosing materials with lower upstream environmental burdens.

THE CHALLENGES OF LCA

While LCA is simple in concept, researchers performing LCA studies or developing LCA-based tools for general use face challenges involving nearly every aspect of their work. Problems arise concerning the quality, consistency, and availability of data on products and processes; the methods used to compile inventories; and especially the assumptions and systems used to translate inputs and outputs into measures of environmental impact. Two of the more significant problems—data problems and getting from inventories to impact—are discussed here.

Issue #1: Problems with the data

LCA studies may focus on generic product types, such as linoleum flooring, or on a specific product, such as Forbo's Marmoleum. With generic products the study relies on industry-average data, which may come from a sampling of manufacturers, from trade organizations, or from pre-existing databases. Data from any of these sources will vary in accuracy depending on how it was collected and compiled and how current it is. When studying a specific product, inputs and outputs that occur at the manufacturer's own facilities can be quantified quite accurately. But for products from suppliers (unless they also participate in the study) and commodities such as electricity, fossil fuels, and raw materials, the study must rely on the same sort of industry-average data described above.

All these problems are exacerbated when one tries to compare alternatives for a specific application, whether they are competing products of the same type (linoleum from Forbo vs. Armstrong) or different products for the same application (linoleum vs. vinyl flooring). Data collection requires so many assumptions and estimates that, unless the same researchers are studying the different products, it is nearly impossible to ensure that the inventories of inputs and outputs were compiled in a consistent manner.

The availability of good life cycle inventory data is much more limited in North America than it is in Europe, where LCA is practiced and understood more widely. "There is more support in Europe, and LCA is viewed as a more legitimate academic pursuit," said researcher Joel Ann Todd, author of the Technical Reports in the AIA's *Environmental Resource Guide* (John Wiley & Sons). Even when data sets are available, they are often proprietary, so a user of the data can see the results of the LCA but not the details of what information was used to generate those results. It is difficult to ensure the accuracy of proprietary data sets, as only the developers or selected reviewers can see the actual data.

When one manufacturing process yields multiple useful products, there are differences of opinion regarding how these flows should be allocated among those products. The refining of crude oil, for example, yields acetone, gasoline, fuel oil, asphalt, and other products. In this type of situation, traditional practice in the U.S. has been to establish a physical basis, such as mass or energy, on which to divvy up the impacts. ISO lays out a series of steps that require either a demonstration of some basis for the allocation or moving toward value-based allocation as a last resort. Practitioners in the U.S. are finally reaching consensus regarding how to implement the ISO guidelines, but it has taken lengthy (at times almost hostile) debate to arrive at this consensus.

Issue #2: Getting from inventories to impacts

So far, we have discussed problems related to compiling the inventory data, but that is, in many ways, the easy part. It is not the inputs and outputs themselves that are the issue, but rather the environmental impacts of those flows. Once we have a huge table listing the life cycle inventory of a product or process, we're faced with figuring out what all that means for the environment. This process, known as *life cycle impact assessment* (LCIA), is an evolving science based on assumptions and extrapolations from the work of scientists in many fields.

The different types of environmental impacts are organized by LCA practitioners into a series of impact categories, such as global warming, ozone depletion, ecosystem toxicity, acidification, diminished human health, resource depletion, and so on. It is not uncommon for LCA studies to omit some of these impact categories from their scope, either because it is not feasible to collect the relevant inventory data or because the science for translating inventory to impacts is not considered reliable. While it makes sense to avoid generating unreliable results, there is the risk that those omitted impacts might be significant and that omitting certain categories might render the results of the entire study questionable. In the words of LCA expert Rita Schenck, "Just because you can't reliably quantify it doesn't mean it's okay to ignore it."

The methods used to translate inventories into potential impacts vary by impact category. Impacts such as global warming and ozone depletion are estimated based on internationally established methods that convert emissions of a wide range of gases to a cumulative impact measurable on a single scale. In the case of global warming, emissions of methane, CFCs, and many other gases are compared to carbon dioxide based on their contribution to global warming. The cumulative emissions of these gases are then characterized on a scale of CO_2-equivalency. Even in this relatively simple example, however, the characterization factors depend on the time frame one is using because in addition to having different potencies as greenhouse gases (radiative forcing potential), they have different life spans in the atmosphere, and so any impact assessment must clearly state the time-horizon assumed in the calculations.

An impact category like ecosystem toxicity is much more complex to quantify, and therefore the methodology used for impact assessment is less consistent. As an example, one method characterizes the effects from emissions of hundreds of substances based not on uniform effects in the atmosphere but on the likelihood that sensitive organisms will be exposed to those substances and receive doses sufficient to cause harm. To create these estimates, scientists build complex computer models of exposure and dose patterns that take into account factors such as location, topography, and ambient weather.

Even these impact categories do not describe environmental concerns directly. They are, instead, indicators or measures of the likelihood of a particular type of impact. Ozone depletion, for example, is a real change in the atmosphere, but the immediate concern is not whether the concentration of ozone in the stratosphere goes from eight parts per million to three in certain locations. Of concern to society is the increased occurrence of skin cancer, crop damage, genetic mutations, and all the other effects of the increase in ultraviolet radiation allowed by the thinning ozone layer. Impact assessment studies refer to these ultimate results as endpoint impacts, while ozone depletion is a link in the chain that leads to these problems, or a midpoint impact.

With the exception of the simplest categories, there is not, at least in North America, any consensus yet about how the impact assessment should be done or what characterization factors should be used to put different substances on the same scale within an impact category. More work has been done in Europe on these issues, according to Schenck: "In the European situation, the process was very open and transparent, and even so different countries have taken different approaches to characterization."

The ideal outcome of an impact assessment is a characterized value in each impact category for the product or process that is the subject of the LCA. These results can be compiled like a scorecard, representing the "ecoprofile" of the product. Ideally, all products would report their results in a consistent format. "It would be great if there were an agreed-upon label, like a food label, that provided the key data," said Todd. "The user could then make a decision comparable to choosing the low-fat, high-sugar item over the high-fat, low-sugar item."

Making this choice between fat and sugar is an example of "weighting": the user has to decide which impact is more important in order to compare impacts that are unrelated. Some LCA tools facilitate the weighting process, or even include default weightings, so they can boil the results down to a single score. "What everyone wants is a simple tool in which you push a button and the answer appears," said Todd. But reducing the results to a single score requires even more questionable assumptions and generalizations than impact assessment, so it is frowned upon by many LCA experts.

If all this makes you think LCA must be an impossible challenge, you're right—the perfect LCA has never been performed. But many solutions are being pursued, addressing all aspects of the problem. Some of these are making the results of LCA studies more useful and accessible today, while others are in the works for the near or not-so-near future.

One way to make LCA more feasible is to streamline and simplify the task. The most effective approach seems to be to focus intensely on the goals of the study and identify places where shortcuts can be taken without undermining those goals. If two similar products are being compared as alternatives for a specific function, for example, it may not be necessary to study all the processes and components that are the same for both products. A detailed study can focus instead on the ways in which the products differ. Economic input-output analysis can also help focus limited LCA resources on the areas that are likely to have the largest impacts. Finally, experienced LCA practitioners know from past work a great deal about the likely results of certain parts of the study and can help guide the research to the most important issues.

In situations for which LCA data and methods are simply not available—like the decisions architects, engineers, and contractors face every day—applying life cycle thinking to the options, based on the available information, is a useful first step. That approach is the basis of many articles in *Environmental Building News* and the product selection process for the *GreenSpec Directory*. "I would suggest that designers use results from LCA tools if they exist, and resources based on life cycle thinking if they do not," said Barbara Lippiatt of the National Institute of Standards & Technology.

Greater access to data

While reasonably good industry-average data sets are widely available for European industry, only one proprietary database has existed in North America—that of Franklin Associates, Ltd. More recently, the Athena Sustainable Materials Institute is coordinating the U.S. Life Cycle Inventory Database Project to create a publicly accessible resource for anyone wanting to use the data.

Robust and reliable data on generic processes is a key piece, but product manufacturers must be willing to study and report on their internal processes as well before LCA-based information becomes widely available. Many companies are now using LCA tools internally for product development and as part of an environmental management system. But companies are hesitant to publish detailed LCAs on their own products for several reasons:

- If they publish the underlying data, they may be revealing trade secrets to competitors.
- After the results are published, anything that looks negative in the study may be taken out of context and used against them by competitors or environmental activists.
- The study might show that their product is not the best choice environmentally.

To overcome this resistance from companies, the Sustainable Products Purchasers Coalition, a Portland, Ore.-based nonprofit organization, aims to create incentives for manufacturers to provide LCA results on their products. SPPC is doing this by collecting commitments from governments and companies to give preference to those products for which LCA data is available. In addition, SPPC is working to develop standard formats for companies to use in reporting on their LCAs. ISO has also published a Technical Report (ISO/WD/TR 14025) on Environmental Labels and Declarations (also called "Type III Environmental Declarations") that provides guidance on reporting the results of LCA studies.

With its "BEES Please" program, NIST provides a user-friendly interface for comparing LCA data on building materials. The BEES software protects proprietary information by publishing only the aggregated LCA inventory data while keeping the details on specific products hidden. To have their products included, manufacturers pay a fee and fill out a questionnaire on the inputs and outputs for the processes that take place within their own gates, and NIST's contractor uses its proprietary database of industry-average data to complete the life cycle inventory.

For now, much of the LCA-based information in the U.S. is still based on European data and leaves out some categories that are difficult to measure. If initiatives such as the ones listed here are successful, however, the consistency and reliability of product-specific LCAs will improve significantly, and LCAs performed on competing products can be considered comparable. Then initiatives like the U.S. Green Building Council's LEED rating system will likely begin referencing LCA results as the basis for materials selection credits, and the pressure on companies to deliver LCA-based information will increase greatly.

As LCA becomes more widely applied in the buildings arena, some nagging issues that have largely been ignored until now are likely to become unavoidable. Key among these is the question of how to respond when LCA results fly in the face of conventional wisdom. For example, Americans have a lot invested in promoting recycling and the use of recycled-content products for environmental reasons, but LCA studies show that recycled products do not always have the lowest overall impacts.

We can shoot the messenger (as an LCA expert at one large company put it, "They don't like me at my company"), but a more constructive approach is to research the issue further and even use LCA to figure out where the environmental burdens associated with the recycled products are coming from. We may learn that, for some products, recycling really isn't the best choice, or we might discover that some methods of recycling are inappropriate and should be reinvented. "Recycling is a new industry, and it hasn't yet been made efficient by decades of cost pressures," said Alyssa Tippens of Interface Research Corporation. As a society we could also decide that recycling is a public policy worth supporting even if it isn't the best environmental choice right now, because we're still developing the infrastructure and scale that will make it more sensible in the future.

There are also types of environmental hazards for which LCA might not be the most appropriate tool, although endorsing LCA results in some areas and rejecting them in others can become a slippery slope for policy makers. One problematic example is in the area of endocrine disrupters, in which the effect of toxins on the system may not correlate with the size of the dose, and the science in general is not well enough established to support robust impact-assessment methods. In addition, with substances that are highly toxic in tiny quantities, such as dioxin, a small degree of uncertainty in the amount of the release can lead to a large degree of uncertainty in the results of the study.

Finally, the rules will keep changing. While LCA is fairly straightforward in principle, the details in practice are so complex that researchers are constantly coming up with ways to enhance accuracy and applicability. As new approaches are adopted, they may make data collected or analyzed with older systems obsolete. It is important to remember that, even as LCA is finally becoming accessible for use by building designers and other nonscientists, the science behind it is still very new and will continue to evolve.

The Holy Grail—LCAs for Whole Buildings

One day, it might be possible to model the environmental impacts of whole buildings, so that rating systems such as LEED could 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.

That goal is still far off, but the pieces that will make it possible are coming together. The Athena LCA software tool has always focused on whole buildings and building assemblies. "For most materials, the real answers ultimately have to be at the level of the building," said Athena's Wayne Trusty. "The real functional unit is a piece of space to fill a certain need. That's the level on which we should ultimately compare." Trusty points out that simply comparing one floor covering material to another may not be fair if one of the products requires a more substantial substrate. Similarly, we at EBN have argued that comparing wood and steel as light-gauge framing materials only works if we also include rigid foam insulation in the steel assembly to provide comparable thermal performance.

Version 2.0 of Athena includes an option to input the building's annual energy use by fuel type (based on modeling done elsewhere) and then Athena will include the life cycle impacts of that fuel in the results for the building. The Envest LCA tool from the Building Research Establishment in the U.K. takes a simpler approach: it assumes a certain energy use based on the shape of the building and includes that figure in its results. Nigel Howard was a developer of Envest and is currently chief technology officer of the U.S. Green Building Council overseeing the LEED Rating System. Howard has argued that "nearly all of the most significant decisions about a new design are made in the first 10 minutes of the first design meeting," so immediate feedback on energy use, however crude, is still valuable. "The biggest lesson learned from using Envest is that there are very significant tradeoffs between materials and specification choices and the operational performance of buildings," Howard said. To date, we know of no tools that attempt to integrate additional resource flows, such as water use, solid waste creation, or the impact of maintenance operations into a whole-building LCA.

Whether at the scale of product-to-product comparisons, design of building assemblies, or whole-building assessment, LCA-based information is a valuable resource for building designers. The checklist on page 7 provides some pointers on how to take advantage of the power of LCA and what to look out for in the process.

LCA Tools Around the World

By Wayne Trusty, MA, and Scot Horst

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Scot Horst is vice president of Athena Institute International, Kutztown, Pa., and Athena International manager of the U.S. Life Cycle Inventory Database project. An advisor to the Governor's Green Government Council in Pennsylvania and a LEED 2.0 Accredited Professional, he has served as a member of the U.S. Green Building Council's Materials and Resources Technical Advisory Group and the LEED Commercial Interiors steering committee. He holds a bachelor's in philosophy from Oberlin College and a BA in music from Oberlin Conservatory of Music.

When choosing materials and designing buildings to achieve sustainability, our decisions are seldom as clear-cut as we'd like. We'd all love to have a simple list of all the products that are truly green. Unfortunately, the natural world and our interaction with it are too complex to yield such a list. The challenge is to understand our product choices within the context of this complexity: otherwise we can't possibly know how to design buildings that function sustainably with nature.

Once we see that there is no green "absolute," that all activity has some sort of impact, then we can begin to make decisions of the basis of choosing materials that have lower impacts relative to alternatives. Each decision becomes a process of seeking to optimize an alignment with nature.

To do this we need to measure what is occurring in the environment through the life cycle of each material; hence, life cycle assessment. Because LCA attempts to track a complex world, it remains a complex methodology. To simplify LCA and make it easier to understand, experts around the world have developed (and continue to develop) LCA tools to fit into the green building toolkit. The focus in this discussion is on North America, but we'll also look at the kinds of tools available internationally.

Defining a Tool Classification System

To give order to what may seem to be a confusing scene, let's make use of the Athena Institute's simple tool classification system. The system suggests three main levels of tools, describing the spectrum from individual product assessments through to whole building assessment and rating systems.

Level 1 tools focus on individual products or simple assemblies (e.g., floor coverings or window assemblies) and are used to make comparisons in terms of environmental or economic criteria (or both), especially at the specification stage of project delivery. Level 1 tools can be further grouped into those intended for use by LCA practitioners (Level 1A) and those intended for those who simply want the results, with the detailed LCA work done in the background (Level 1B). Some Level 1B tools, such as the *GreenSpec Directory*, are not LCA focused and are therefore not included here.

Level 2 tools focus on the whole building, or on complete building assemblies or elements, with each tool typically providing decision support with regard to specific areas of concern, such as operating energy, lighting, life cycle costing, and life cycle environmental effects. These tools tend to be data-oriented and objective, and apply from the early conceptual through detailed design stages. Again, the emphasis here is on the LCA tools.

Level 3 tools are the more familiar whole building assessment frameworks or systems that encompass a broader range of environmental, economic, and social concerns relevant to sustainability. They use a mix of objective and subjective inputs, leaning on Level 2 tools for much of the objective data—energy simulation results, for example. All use subjective scoring or weighting systems to distill the information and provide overall measures, and all can be used to inform or guide the design process. Only those that explicitly incorporate LCA are considered here.

We urge Building Teams to take advantage of the complementarities among tools, even those in the same classification level. Too often we see comparisons based on the implicit assumption that all LCA tools are competitive, without regard for their intended function or where they fit in the decision process. The reality is that seemingly similar tools in the same level can complement each other. Pliers and vice grips may appear to do essentially the same job, but each has it own special function, and a well-stocked toolkit will hold both. The same is true of tools for green building.

The accompanying table shows a sample of tools that are either devoted to LCA or that incorporate LCA to a significant extent.

One could argue that so-called "labeling systems," such as Green Seal, the Environmental Choice program, and various forest certification systems, should be included in Level 1 tools. We would caution, however, that most labeling programs focus on single attributes or performance measures (energy use or recycled content, for example). The product in question may be excellent in terms of the criteria selected for evaluation, but that does not necessarily mean it would score well in a system that takes multiple attributes into account. Fully LCA-based labels or environmental product declarations are in a different category, but are not considered tools for our purposes here because users can only make decisions by comparing one label to another.

Although Level 1A tools are conceptually able to work at the whole building level (and might therefore be put into Level 2), they are not designed for such complex systems and would require considerable effort on the part of users, whereas a Level 2 tool such as the Athena Environmental Impact Estimator performs the LCA work in the background, freeing users to concentrate on the effects of design changes.

From time to time we see efforts to develop tools that supposedly streamline LCA. The basic premise is that once you understand a product group or category as a result of a full LCA of one or more specific products within the group, then you can assess all others in the group without having to collect as much data—the idea of estimating 80% of the impacts with 20% of the information.

The reality, however, is that products within a category (carpeting, for example) are often not as uniform as might be supposed. Also, since there has to be a full LCA at some stage, it can be more cost-effective and more accurate to capture the range of variation within a category through study design and the use of specialized scripting tools or wizards.[1]

Turning to Level 2, all of the tools cited (except the UK Green Guide to Specifications) work at the whole building level of design, with some such as the Athena EIE also allowing comparisons at the assembly level (for example, wall assemblies). The Green Guide works only at the assembly level, but has the advantage that assemblies are pre-ranked based on detailed LCA: users need only select those that are highly ranked.

The Australian LCADesign tool is cited, even though it is still under development, because it represents the latest in a continuing effort to link LCA directly to a 3-D CAD program, as is the case with energy simulation and costing tools. This is an important objective if LCA is to be more readily used by design teams and more fully incorporated in Level 3 tools. However, repeated efforts in various countries have demonstrated that it is not easily achieved, partly because of the different types of detailed data needed for a whole building LCA compared, for example, to an energy simulation. There is also the problem that 3-D CAD does not seem to be widely used at the early design stage when LCA should be brought to bear on critical decisions. Nevertheless, this is critical area of development that should be continued and supported.

As shown in the table, the Level 2 tools use data and typically incorporate building systems specific to the region for which they are built. Conceptually, they can be modified or adapted for use in other regions, but only with care. Considerable caution is advised when using a Level 2 LCA tool from another country. It should also be noted that all of these tools are not developed to the same level. Some provide sophisticated interfaces, others don't. Some are supported by robust life cycle inventory data, others are not. Some consider all life cycle stages, others only one or two. Any tool is only as good as the data that supports it.

Currently, available Level 3 tools may apply to new projects, to existing buildings, and to major renovations or retrofits, a wide range of building types. Some require external auditors. Most yield certificates or labels indicating a building's performance.

LEED is notably absent from the Level 3 list because the USGBC is in the process of investigating how LCA can best be incorporated in future versions of the rating system, whereas LCA is already incorpo-

LCA Tools and What They Do

	Country	Comments
Level 1A Tools		
SimaPro	Netherlands	While the countries of origin vary, these tools can be used in different regions by selecting or incorporating the appropriate data. But the task is best done by LCA practitioners for whom the tools are intended.
GaBi	Germany	
Umberto	Germany	
TEAM	France	
Level 1B Tools		
BEES	USA	Combines LCA and life cycle costing. Includes both brand-specific and generic data.
LCAiT	Sweden	Streamlined LCA tool for product designers and manufacturers.
TAKE-LCA	Finland	LCA tool for comparison of HVAC products, including energy content of the product and energy consumption.
Level 2 Tools		
Athena Environmental Impact Estimator (EIE)	Canada/USA	All of these tools use data and incorporate building systems that are specific to the country or regions for which they were designed.
BRI LCA (energy and CO2)	Japan	
EcoQuantum	Netherlands	
Envest	United Kingdom	
Green Guide to Specifications	United Kingdom	
LISA	Australia	
LCADesign (under development)	Australia	
Level 3 Tools		
BREEAM	United Kingdom	Uses LCA results from the Level 2 Green Guide.
GBTool	International	Experimental platform that accepts LCA results or performs a rudimentary LCA calculation using built-in calculators.
Green Globes	Canada/USA	Assigns a high percentage of resource use credits based on evidence that a design team has conducted LCA using a recognized Level 1 or 2 tool.

[1] *Evaluation of August 2002 Proposed Method for Streamlined Life Cycle Review of Products and Services for EPP. Greg Norris, PhD, July 2004.*

rated in one way or another in the listed systems.

We want to emphasize that the accompanying table is not a comprehensive listing. In the Level 2 and 3 categories, in particular, work is going on throughout the world and new systems are steadily being introduced, while older systems are being modified, melded, or abandoned.

NORTH AMERICAN LCA SYSTEMS

All of the Level 1A tools can be used by LCA practitioners in North America. North American data is included to some extent in at least some of the tools, and new data can generally be added. In Levels 1B and 2, however, there are only two tools that have been designed for use in North America: BEES and the Athena EIE.

BEES: Providing Direct Comparisons

BEES—Building for Environmental and Economic Sustainability–is an LCA-based software tool developed by the National Institute of Standards & Technology, with support from the U.S. EPA Environmentally Preferable Purchasing Program. The NIST Building and Fire Research Laboratory developed the software to provide the building community with access to the data necessary for selecting cost-effective, environmentally preferable building products. BEES does this by allowing product-to-product comparisons based on LCA and life cycle costing data, with the LCA data covering a full range of environmental flows, from raw material acquisition through product disposal.

An especially valuable feature of BEES is its ability to provide users with direct comparisons between environmental performance and life cycle costs, thereby making tradeoffs explicit. The direct economic versus environmental comparison is just one of many ways in which users can view side-by-side comparative results for different products. Results can also be viewed by life stage and environmental flow—for example, acidification flows include such substances as ammonia, hydrogen chloride, and sulfur oxides—for a list of 12 performance measures, which includes indoor air quality, ecological toxicity, and human health.

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All regional and local impacts are scored based on new U.S.-specific methods developed by the U.S. EPA. The significance of a product's performance with respect to each impact is also included in the scoring, using new U.S. EPA data that serves as a yardstick against which each impact can be scored. Thus, BEES can compare scores across most building elements (e.g., roof coverings and floor coverings) to see which elements get the poorest scores and thus would benefit most from environmental improvement.

BEES uses importance weights to combine environmental and economic performance measures in a single performance score, although users can select a "no weighting" option. If weighting is selected, users must first decide how to weight environmental versus economic performance—50/50? or 40/60?—and then select from among four alternative weighting systems for the environmental performance measures. The four alternatives include a user-defined option and equal weighting as well as two systems developed by scientific panels. Users can also change the default discount rate used for calculating the present value of life cycle costs.

BEES 3.0 includes approximately 200 building products or variations on products, including about 80 brand-specific products. For example, in the "slab on grade" product category, there are 10 generic product variations and six brand-specific variations. In the case of floor coverings, there are 17 distinct generic products and 18 brand-specific products. The generic data covers the most representative production technology or an aggregated result based on U.S. average technology for the relevant industry. Brand-specific data was provided through the participation of a number of manufacturers in the "BEES Please" data program.

BEES can be downloaded free of charge from *www.bfrl.nist.gov/oae/software/bees.html*.

Athena EIE: A Whole Building Approach

The Athena Environmental Impact Estimator software was developed by the nonprofit Athena Institute to make it possible for architects, engineers, and researchers to assess the environmental implications of industrial, institutional, office, and residential building designs at an early stage in the project delivery process. As an LCA-based decision support tool working at the level of whole buildings or complete building assemblies, the EIE captures the systems implications of product selections related to a building's structure and envelope; it therefore ensures that products are implicitly compared on a fully functional equivalence basis (see sidebar).

The tool currently covers eight specific regions for Canada, four for the U.S., and a U.S. average. It allows users to take account of the embodied effects of material maintenance and replacement over an assumed building life, distinguishing between owner-occupied and rental facilities where relevant. The building life is selected by the user and can be varied to assess relative service life effects.

If an energy simulation has been completed for a design, the estimated annual operating energy use by type can be entered through a simple dialogue; the EIE will then take account of operating energy emissions and pre-combustion effects (i.e., the energy and emissions associated with making and moving energy). It will also let users compare life cycle embodied energy use to operating energy use.

The Estimator incorporates the institute's life cycle inventory databases for generic products, covering more than 90 structural and envelope materials. It simulates over 1,000 different assembly combinations and is capable of modeling the structure and envelope systems for about 95% of the building stock in North America.

A conceptual building design is entered in the EIE using preset building assembly dialogues. The user can then instantly see the cradle-to-grave, region-specific implications of a design in terms of a detailed list of flows from and to nature (inventory results), as well as summary measures, at the whole building or assembly level, or by life cycle stage. A comparison dialogue can be used to make side-by-side comparisons of as many as five alternative designs, for any one or all of the summary measures. The comparisons can be among variations on a base case, or can include completely different projects. Similar projects with different floor areas can be compared on a unit floor area basis.

For more information, go to: *www.athenaSMI.ca*.

It is important to establish some clear and important distinctions when delving into the green building toolkit. Does a tool work at the level of whole buildings, or is it focused more on individual products or components? Does it deal with a specific topic or concern, like energy use, or does it cover a broad spectrum of sustainability issues? Is the tool quantitative, or does it include subjective or qualitative elements? Too often these distinctions are ignored and comparisons are made between tools that are intended for entirely different purposes. For example, BEES and the Athena EIE are complementary tools, intended to meet different needs at different stages in the project delivery process, not competitive tools between which one must choose.

In LCA, the effects associated with making, transporting, using, and disposing of products are referred to as "embodied effects," where the word *embodied* refers to attribution or allocation in an accounting sense as opposed to true physical embodiment. In the building community, the tendency is to refer primarily to "embodied energy," but all of the extractions from and releases to nature—to water, for example—are embodied effects. There are also embodied effects (known as pre-combustion effects) associated with the production and transportation of energy itself.

In the case of buildings, the energy required to operate a building over its life greatly overshadows 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. The tools can help.

Comparing building products for functional equivalence

Ensuring functional equivalence in building product comparisons is not as easy as it may seem. The choice of one product may lead to, or even require, the choice of other products. Consider the following examples:

- The choice of wood, steel, or concrete structural systems will likely influence, or even dictate, the choice of insulation materials;
- An above-grade structure using high-mass materials may require more concrete in footings than a lighter structural system;
- A rigid floor covering may require a different substrate than a flexible floor covering.

As these examples illustrate, product comparisons must take into account material-use implications of the alternatives. In other words, comparisons should be made in the context of building systems, rather than on a simple product-to-product basis, whenever there are systems implications, especially for building structures and building envelopes. Even though two products may appear to be equivalent in terms of specific criteria like load-bearing capacity, they may not be at all equivalent in the sense of true functional equivalence.

In a similar vein, we should be cautious 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.

Can ISO Life Cycle Assessment Standards Provide Credibility for LCA?

By James A. Fava, PhD

In the late 1980s a number of "dueling" life cycle assessment studies attempted to illustrate the superiority of one product over another. As these studies gained visibility, issues associated with boundary conditions, sources of data, and functional unit were revealed. In response to these issues, as well as to concerns by industry, government, and the public about the proliferation of local and national environmental standards, ISO—the International Organization for Standardization, based in Geneva—established a technical committee (TC-207) to develop environmental management tools (including LCA) that would be applicable worldwide.

To get a sense of the ISO LCA standards and their application to building products and the construction industry, let's consider LCA and ISO in context.

In 1990, the Society of Environmental Toxicology and Chemistry (SETAC) sponsored an international workshop which resulted in "A Technical Framework for Life Cycle Assessments."[1] Although LCA had been used by a few practitioners in the U.S. and Europe under various names (such as REPA, or "Resource and Environmental Profile Analysis),"[2] SETAC established the terminology and framework for LCA development worldwide. In North America and Europe, SETAC set up LCA advisory groups whose mission has remained to advance the science, practice, and application of LCA.[3] SETAC has partnered with the United Nations Environmental Programme (UNEP) to establish the UNEP/SETAC Life Cycle Initiative to develop practical tools for evaluating products and services over their entire life cycle to achieve sustainable development.[4]

In 2004, the UNEP/SETAC Life Cycle Initiative held a forum to discuss current LCA and green building programs.[5] When asked for a vision of LCA in 2010, the group foresaw a number of exciting possibilities: LCA tools and data being as readily available as geographical information systems are today; LCA as an integral part of design and permitting; readily available Web-enabled access to LCA tools and databases; and a widespread understanding and use of LCA. In addition, they saw product information carrying not only information on product features and benefits, but also life cycle information.[6] In five years, the group agreed, LCA would be seen as a means to improve decision making, not an end in itself.

Two issues requiring further examination also surfaced: 1) the definition of a "functional unit" for buildings and 2) the pros and cons of performance- or continuous-improvement-based approaches to using LCA. LCA can be used at two levels, at the level of the building as a whole and at the level of building materials or products. Experience shows that the latter is easier to achieve than the former, although applications at the building level can also produce useful results.[7]

The characteristics of LCA tools that are required to implement this vision were also identified: ready access to databases, easy-to-use LCA tools, relevant impact categories, and a methodology that is trusted, comprehensive, robust, accepted, invisible, reproducible, simple, transparent, credible, and accountable. It was agreed that the ISO 14040 family of LCA standards should be used as a starting point for further development of LCA methodology within building industry sector.

The Guiding Role of the ISO

It is important to understand that SETAC's role is not to standardize methodology, but to improve the science and practice of LCA. Primary responsibility for standardization lies with ISO, which performs this function worldwide in an effort to standardize and streamline the international marketplace for industry. Among the tools developed are environmental management systems, auditing, environmental performance evaluation, life cycle assessment, and eco-labeling. More than 30 countries have participated in the development of the ISO 14000 series. More than 20 specific standards have been completed, with more in development (see www.iso.org).

Within ISO, TC-207 has responsibility for the development of environmental management standards, including those dealing with LCA. The accompanying table (Table 1, next page) describes the extant ISO LCA standards and technical reports. Note that ISO is combining ISO 14040, 14041, 14042, and 14043 into two standards: ISO/DIS 14040 (Environmental management—Life cycle

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[1] *Fava, J., R. Denison, B. Jones, M. Curran, B. Vigon, S. Selke, and J. Barnum (eds.) 1991. A Technical Framework for Life-Cycle Assessment. SETAC: Pensacola, Fla.*

[2] *Hunt, R; Franklin, W. (1996): LCA - How it Came About. Personal Reflections on the Origin and the Development of LCA in the USA. Int J LCA 1, 4-7*

[3] *One product of this effort is a recent book,* LCA in Building and Construction. *See www.SETAC.org for additional information on SETAC's LCA program.*

[4] *See www.uneptie.org/pc/sustain/lcinitiative/home.htm.*

[5] *For a summary of the workshop, see http://unep.greenriver.org/other/LCA buildings.html.*

assessment—Principles and framework) and ISO/DIS 14044 (Environmental management—Life cycle assessment—Requirements and guidelines). They are expected to be published in 2006.

For additional ISO standards related to LCA, see Table 2.

Examining the Value of ISO LCA in the Building Sector

ISO standards provide excellent resources for understanding the basic elements and requirements for LCA studies. They also provide insights into factors to consider when evaluating the results of an LCA study. Critical portions of the ISO standards relevant to the building sector are summarized in the next section.

Life cycle assessment is a systematic approach used to manage the potential environmental impacts of product and service systems. It is applied methodologically to build a quantitative inventory of environmental burdens or releases, evaluate their potential impacts, and consider alternatives to interpret the results or improve environmental performance. LCA can be used to identify critical life cycle stages or burdens for which additional environmental assessment tools (such as risk assessment) may be applied to fully understand the potential impacts and risks.

In any application, LCA considers the potential environmental impacts along the continuum of a product's life (i.e., cradle to grave or cradle to cradle), from raw materials acquisition to production, use, and disposal or recovery. The potential environmental impacts to consider include resource depletion, human health, and ecological health.

LCA consists of four iterative phases:

1) *Goal and Scope Definition*: Defining the aims, product system, and reach of the study.

2) *Inventory Analysis*: In which extractions and emissions related to the product system are quantified and related to the product function.

3) *Impact Assessment*: In which the outcome of the inventory is analyzed with respect to their environmental relevance and is aggregated within a smaller number of relevant environmental issues.

4) *Interpretation*: In which the results are compared with the goal of the study.

Identifying Tradeoffs and Opportunities

Many approaches to environmental protection continue to be based on "end-of-pipe" solutions, focused on a single medium (air, water, soil), a single stage in the product's life cycle (production, use, disposal), or a single issue (e.g., individual chemical limits). These strategies do not always lead to an overall reduction in environmental impacts. Pollution control resources are spent on activities required by laws and regulations, but which do not always provide the most efficient use of those resources in terms of reducing impacts.

This has often allowed unexpected environmental "impacts" to occur, by, for example, allowing one environmental problem to be solved while generating other, often unexpected, problems. Because they are not designed to address a full understanding of the tradeoffs and their implications in a systematic fashion, single-issue approaches often diminish opportunities for achieving net environmental improvements.

The result of an LCA study helps identifies both opportunities and risks of a product or technology, all the way from raw materials to final disposition. An LCA helps us recognize how our choices influence each of these stages, so we can choose to make positive impacts on the economy, the environment, and society. LCA helps us recognize that our choices are not isolated, but are connected to a larger system.

Life cycle assessment is not necessarily about making right or wrong decisions. It simply helps us make decisions in the context of all stages of the life cycle. It helps us identify unintentional impacts of our actions and take responsibility for those impacts, and it helps us avoid decisions that fix one environmental problem at the expense of another environmental issue.

LCA can assist in:

- Identifying opportunities to improve the environ-

[6] *"Products" refers to products, services, and technology, with a cradle-to-grave or cradle-to-cradle perspective.*

[7] *These are the types of issues the USGBC LCA into LEED program is addressing.*

Table 1. ISO LCA Standards and Technical Reports	Description
ISO 14040 - General Principles and Framework	Provides the basic description and framework for LCA from which the remaining LCA standards are based. This standard also defines the "comparative assertion" requirements, including critical review.
ISO 14041 - Goal and Scope Definition and Inventory Analysis	Establishes at the outset the goals, purpose, audience, scope, and stakeholders that will be impacted or influenced by the results. This information influences the actual conduct of the LCA study. The inventory analysis portion is where the resources and emissions related to the product system are quantified
ISO 14042 - Life Cycle Impact Assessment (LCIA)	The phase of life cycle assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts of a product system.
ISO 14043 - Life Cycle Interpretation	The interpretation phase of an LCA, where the significance and relative contributions of the results are broken down and analyzed.
ISO 14047 -Technical Report	Provides illustrative examples on how to apply life cycle impact assessment.
ISO 14048 - LCA Data Documentation Format	Provides guidance on factors to consider when documenting LCA data.
ISO 14049 - Technical Report	Provides illustrative examples on how to apply goal and scope definition and inventory analysis.

mental aspects of products at various points in their life cycle.

- Decision making in industry, government, or non-governmental organizations (e.g. building design, material and product selection).
- Selection of relevant indicators of environmental performance, including measurement techniques.
- Marketing (e.g., environmental claims, eco-labeling or environmental product declarations).

Core LCA Principles

As stated in the new ISO/DIS 14040, a number of principles have been added:

- Life cycle perspective - LCA considers the entire life cycle of a product, from raw material extraction and acquisition, through energy and material production and manufacturing, to use and end of life treatment and final disposal. Through such a systematic overview and perspective, the shifting of a potential environmental burden between life cycle stages or individual processes can be identified and possibly avoided.
- Environmental focus - LCA addresses the environmental aspects and impacts of a product system. Economic and social aspects and impacts are, typically, outside the scope of the LCA. Other tools may be combined with LCA for more extensive assessments.
- Relative approach and functional unit - LCA is a relative approach, which is structured around a functional unit. This functional unit defines what is being studied. All subsequent analyses are then relative to that functional unit as all inputs and outputs in the LCI and consequently the LCIA profile is related to the functional unit.
- Iterative approach - LCA is an iterative technique. The individual phases of an LCA use results of the other phases. The iterative approach within and between the phases contributes to the comprehensiveness and consistency of the study and the reported results.
- Transparency - Due to the inherent complexity in LCA, transparency is an important guiding principle in executing LCAs, in order to ensure a proper interpretation of the results.
- Comprehensiveness - LCA considers all attributes or aspects of natural environment, human health, and resources. By considering all attributes and aspects within one study in a cross-media perspective, potential tradeoffs can be identified and assessed.
- Priority of scientific approach - Decisions within an LCA are preferably based on natural science. If this is not possible, other scientific approaches (e.g., from social or economic sciences) can be used or international conventions can be referred to. If neither a scientific basis exists nor a justification based on other scientific approaches or international conventions is possible, then, as appropriate, decisions may be based on value choices.

Table 2. Additional ISO Standards and Technical Reports	Description
ISO 14025 - Environmental Labeling and Declarations - Type III Environmental Declarations - Principles and Procedures	Establishes the use of the ISO 14040 series of standards in the development of Type III environmental declaration programs and Type III environmental declarations. The declarations covered by this standard are primarily intended for use in business-to-business communication, but their use from business to consumers is not precluded.
ISO 14062 - Environmental Management- Guidelines to Integrating Environmental Aspects in Product Development	A technical report intended for use by those involved in the design and development of products (such as building products).
Guide 64 - Guide for the Inclusion of Environmental Aspects in Product Standards	A guide intended for product standard writers, to raise awareness that provisions in product standards can affect the environment (both negatively and positively) and recommending the use of life cycle thinking and recognized scientific techniques when addressing environmental aspects of a product being standardized.

ISO and 'Comparative Assertions'

Users of LCA results sometimes seek to make environmental claims regarding the superiority or equivalence of their product versus a similar competing product—for example, how one manufacturer's low-e glass is superior to another's on the basis of LCA. Although the LCA standards have been written to ensure flexibility in their use within an organization—say, for research purposes—when the ISO 14040 series is used to support a publicly stated environmental claim of superiority or equivalence—which within ISO is referred to as a "comparative assertion"—additional requirements must be met, including:

- The data quality requirements shall address time-related coverage, geographical coverage, technology coverage, precision, completeness and representativeness of the data, consistency and reproducibility of the methods used throughout the LCA, sources of the data and their representativeness, and the uncertainty of the information.
- The LCA study shall be peer reviewed in accordance with the critical review process of Section 7.3.3.
- An impact assessment shall be performed. The category indicators of the impact assessment used to support the comparative assertion must be sufficiently comprehensive, internationally accepted, scientifically and technically valid, and environmentally relevant. Weighting may not be used.

- Systems shall be compared using the same functional unit and equivalent methodological considerations, such as performance, system boundaries, data quality, allocation procedures, decision rules on evaluating inputs and outputs, and impact assessment. Any differences between systems regarding these parameters must be identified and reported.

Additional information on how LCA results can be used to making claims can be found in ISO/DIS 14025. In addition, the U.S. Federal Trade Commission has developed "Guides for the Use of Environmental Marketing Claims," which prohibit unfair or deceptive advertising claims.

Eight Lessons Learned from LCA Application

What have we learned from the application of life cycle assessment based on the ISO LCA standards? Some thoughts from my experience as an LCA practitioner working with building products and materials manufacturers:

1. The ISO LCA standards have established a consistent methodology for conducting LCA studies and reporting their results. They represent a serious "stake in the ground" on LCA practice.

2. The ISO LCA peer review and criteria review process provides a system of checks and balances to ensure that LCA studies used for external policy and decision making undergo additional review by independent and interested parties.

3. Practitioners should be able to demonstrate their knowledge of the requirements of the ISO LCA standards and that they have applied those requirements.

4. There is a learning curve in completing LCAs. A company's first LCA study (either one done internally using LCA software tools such as GaBi, or one done by consultants) often takes more time and resources than expected, but subsequent studies usually become easier to complete.

5. Within the LCA standards sufficient flexibility exists to ensure that LCA studies can be completed on a number of applications, ranging from answer to question on a select list of impact categories and/or life cycle stages, to comprehensive studies supporting environmental claims.

6. Any LCA methodology used in the public context must have transparency, be publicly available, and must have undergone appropriate peer review.

7. Application internally within an organization to drive continuous improvement and innovation can achieve meaningful results, but it must be consistently applied.

8. LCA studies can provide information on tradeoffs and opportunities to improve a product performance over its life cycle. However, complementary assessments, in particular those related to site-specific environmental issues, are often necessary to provide a fuller understanding of absolute risks and opportunities.

In conclusion, the ISO LCA standards have established a worldwide set of rules to ensure that LCA studies are conducted in a consistent, reproducible fashion. The standards define what should be considered in setting the goal and scope of the study, what data are needed, how to evaluate the quality of the data, what impact assessment categories will be used (and why), how the results can be interpreted for improvement, what information should be included, and when different levels of review are necessary.

Over the next few years, LCA will, in my opinion, move even further toward becoming a practical tool for design and development, marketing, material selection, design tradeoffs, and environmental and business improvements.

Life Cycle Impact Assessment for the Building Design and Construction Industry

By Jane Bare and Thomas Gloria, PhD

Jane C. Bare is with the U.S. Environmental Protection Agency's National Risk Management Research Laboratory in Cincinnati. She has been involved in life cycle impact assessment and the development of TRACI for the last 11 years and was involved in the development of ISO Standard 14042—LCIA. She is one of 14 international experts on the International Life Cycle Panel of the UNEP/SETAC Life Cycle Initiative. She holds a BS in chemical engineering from Ohio University.

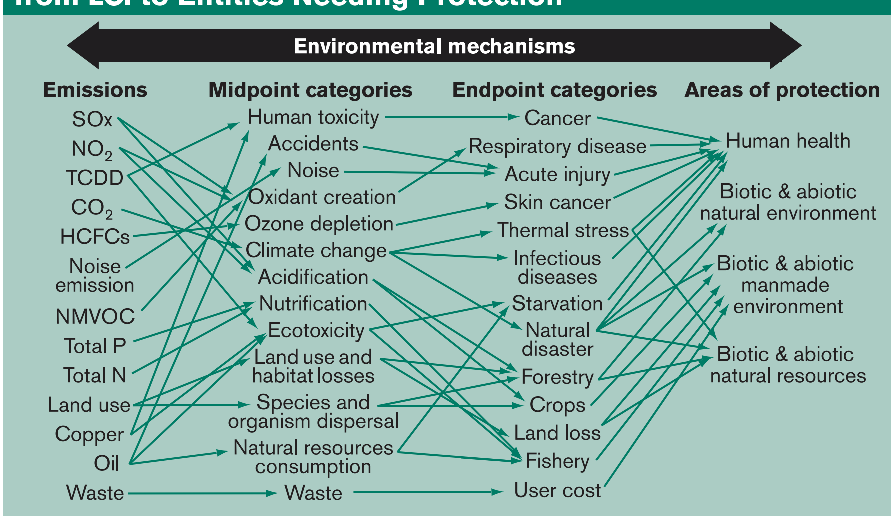
Dr. Thomas P. Gloria, a senior consultant with Five Winds International, is a task force leader for the UNEP/SETAC Life Cycle Initiative on Life Cycle Impact Assessment. He has supported the U.S. EPA's LCIA methodology, TRACI, and is participating in the USGBC's LCA into LEED initiative. Gloria holds a PhD and MS in civil and environmental engineering from Tufts University and a BSc in electrical and computer science engineering from the University of Connecticut.

You can measure chemical emissions and construction wastes by the ton, but weight alone won't tell you how or where the emissions and waste may harm humans or the environment. If you can apply the metrics of life cycle impact assessment, however, you can understand a great deal more about how much harm might come to humans and the environment from the emissions or waste—harm in the form of global climate change, reduction in the ozone layer, increased risk of cancer in humans, and the depletion of finite resources such as fossil fuels.

The most effective way to assess the potential for long-term improvements for human health and the environment is through the use of consistent metrics within a comprehensive decision-making framework. Life cycle assessment is the framework embraced by many leading sustainability professionals. LCA can be used to evaluate the potential for impacts at all of the points along the process of design, construction, maintenance, use, and disassembly. Within life cycle assessment, life cycle impact assessment represents the consistent metrics.

Life cycle impact assessment is the tool that life cycle practitioners use to see which chemical emissions have the greatest potential to cause harm and in what form that harm may occur. Without this tool, releasing a pound of mercury to the environment would look just like releasing a pound of sand. Many aspects of this tool were formed as little as a decade ago. Although there is still room for improvement, LCIA can now distinguish a full spectrum of areas of concern.

Impact Assessment: Making the Connection from LCI to Entities Needing Protection



Source: Jolliott O et al. (2004): "The LCIA midpoint-damage framework of the UNEP-SETAC life cycle initiative," Int J of LCA 9 (6) 394-404.

The Basics of LCIA

Life cycle impact assessment creates the connection between the life cycle inventory (the emissions and materials used) and the components of our society that we wish most dearly to protect—human health, the natural environment, the man-made environment (not just buildings and homes, but also things like crops), and natural resources. As shown in the accompanying figure, LCIA attempts to capture the continuum of all environmental mechanisms. The arrows in this figure should not be construed as describing environmental mechanisms with absolute certainty, but they do indicate that, at minimum, there is some quantitative evidence and qualitative understanding of the links shown.

Across this continuum there are two general approaches to categorize life cycle impacts—a midpoint approach and an endpoint approach.

The midpoint approach starts from the emissions identified by a life cycle inventory and takes these as input to models that bring us further along the environmental mechanism of accepted impact categories. One of the most well-known midpoint indicators is global warming potential, a measure of a chemical's potential to affect the world's climate. Global warming potential is typically expressed in terms relative to carbon dioxide's contribution to climate change, usually referred to as "CO_2 equivalents." The LCIA results expressed in terms of midpoint variables are typically used to support decision making, as they are readily understood and their scientific basis is well established.

In contrast, endpoint (or "damage assessment") models link emissions and resources used to endpoint indicators. Endpoint models typically have a higher level of uncertainty, since they include more assumptions to quantify the impacts. Damage assessments also attempt to represent many more links across the network of environmental mechanisms, and in the absence of data to support these calculations, damage assessments tend to be less comprehensive—those endpoints which are difficult to calculate simply drop out.

In addition to the impacts related to chemical emissions, LCA typically keeps track of resource depletion. Resource depletion impact assessment includes an accounting of the amount of a material used and the amount of material which remains, while also considering quality and the potential for substitution. Typical resource depletion categories include fossil fuel use, land use, water use, and mineral use. Some LCA experts also choose to keep track of the energy consumed within the individual life cycle stages. Other methodologies make a distinction between sources of energy (e.g., wind, fossil fuels), thus recognizing the scarcity of some fuel sources.

In more formal terms, LCIA is one of the four iterative steps of LCA as outlined by the ISO standards:

1) Goal and Scope
2) Life Cycle Inventory
3) Impact Assessment
4) Interpretation

Within the Impact Assessment step, there are seven generally accepted elements (see chart) pertaining to the process of conducting a life cycle impact assessment.

The first three elements of LCIA—selection, classification, and characterization—are mandatory.

Selection pertains to the identification of relevant impact categories. The impact categories selected should be consistent with the goal and scope and reflect a comprehensive set of environmental issues related to the product system being studied. Although broken out as part of the impact assessment phase of an LCA study, the selection of impact categories is decided at the very beginning, when the goal and scope of the study are being determined and before the collection of the supporting data begins. Selection of impact categories determines to a great extent data collection needs and the boundary of the conclusions that can be made.

Classification involves assigning the emissions and resources identified by the LCIA to specific impact categories (global warming, ozone depletion, ecological toxicity, etc.) In practice, the characterization method selected determines the classification. This is an area that requires particular attention by the LCA consultant, as naming conventions can cause classification mismatches or may cause some chemicals to drop out.

Characterization is where impact assessment results are calculated. The actual calculation of impact involves multiplying each environmental intervention (emissions in mass) by the corresponding characterization factor (effect per unit of emission), and summing the results within each impact category. Characterization factors are essentially a rank measure of potential harm by a chemical within an impact category.

For example, carbon dioxide has a global warming potential (GWP) of 1, while methane has a GWP of 23. This means that one molecule of methane has the potential to affect climate change with a potency 23 times that of carbon dioxide. Characterization factors are based on underlying characterization models set to specific conditions—climate, soil type, time frame, etc.

The remaining four elements—normalization, grouping, weighting, and data quality—while optional in an LCIA, can provide valuable insights.

Normalization involves the calculation of relative contribution to impact to a reference boundary, typically a region or country. For example, results obtained for GWP are normalized to all emissions that occur in the U.S. on a per capita basis. Normalization is typically done to obtain congruent (i.e., equal) representation of impact categories when proceeding with further grouping or weighting of results.

Grouping is simply the assignment of impact categories to groups of similar impacts or ranking categories in a given hierarchy—high, medium, and low priority.

Weighting is a more formalized process of grouping that involves the assignment of relative values or weights to different impacts, allowing integration across all impact categories. The "weights" in the weighting step are typically determined by a panel of experts or stakeholders.

Data quality analysis is done to better understand the significance, uncertainty, and sensitivity of LCIA results.

Detailed Elements of Life Cycle Impact Assessment (ISO 14042)

Selection Determination of relevant impact categories, category indicators, and characterization models

Classification Assignment of life cycle inventory results

Characterization Calculation of category indicator results

Normalization Calculation of the magnitude of category indicator results relative to reference

Grouping Assignment of impact categories to groups of similar impacts

Weighting Assignment of relative values or weights to different impacts, allowing integration across all categories

Data quality check Analysis of the significance, uncertainty, and sensitivity of LCIA results

Source: ISO 14042 (2000) Environmental Management – Life cycle assessment – Life cycle impact assessment, International Organization of Standardization, Geneva, Switzerland.

Impact Categories in TRACI

1. Acidification
2. Ecotoxicty
3. Eutrophication
4. Fossil fuel depletion
5. Global warming
6. Human health cancer
7. Human health criteria
8. Human health noncancer
9. Ozone depletion
10. Smog formation

Midpoint Methods

EDIP97/2003
http://ipt.dtu.dk/~mic/Projects.htm

Dutch LCA Handbook
www.leidenuniv.nl/cml/ssp/projects/lca2/lca2.html

USEPA TRACI method
www.epa.gov/ORD/NRMRL/std/sab/iam_traci.htm

Endpoint Methods

Eco-indicator 99
www.pre.nl/eco-indicator99/

EPS 2000d
http://eps.esa.chalmers.se/

A Look at the U.S. EPA's TRACI

For the past 10 years, the US EPA has focused on developing the best possible impact assessment tool for life cycle impact assessment, pollution prevention (known as P2), and sustainability metrics for the U.S. This research effort is called TRACI, which stands for the Tool for the Reduction and Assessment of Chemical and other Environmental Impacts.

The impact categories in TRACI (see list) were selected based on their level of commonality with existing literature in this area, their consistency with EPA regulations and policies, their current state of development, and their perceived societal value. The traditional pollution categories of ozone depletion, global warming, human toxicology, ecological toxicology (ecotoxicity), smog formation, acidification, and eutrophication were included within TRACI because EPA programs and regulations recognize the value of minimizing effects from these categories. Criteria pollutants were preserved as a separate human health impact category to allow a modeling approach that could take advantage of the extensive epidemiological data associated with the impacts of criteria pollutants.

The TRACI software allows the storage of inventory data, classification of stressors into 10 impact categories, and characterization for the listed impact categories.

Consistency with previous modeling assumptions (especially within the EPA) was important in the development of the impact assessment characterization underlying every category. The human health cancer and noncancer categories were heavily based on the assumptions made for the US EPA Risk Assessment Guidance for Superfund. The EPA's Exposure Factors Handbook was utilized to make decisions related to the various input parameters for both of these categories as well. Another example of consistency with EPA modeling assumptions includes the use of the 100-year time frame reference for global warming potentials.

The EPA decided that TRACI should be primarily a midpoint model because this is the level that enjoys the greatest consensus. With endpoint modeling, moreover, some of the endpoints are lost when extrapolating to damages, since they cannot be calculated.

LCIA in Building Design and Construction

Life cycle impact assessment is already being used by the green building community. In the United Kingdom, the Building Research Establishment has developed a product rating system, the Green Guide to Industry, using the Dutch Handbook (CML) Method. In the U.S., TRACI is embedded in the National Institute of Standards & Technology's Building for Environmental and Economic Sustainability (BEES 3.0) method.

More recently, the U.S. Green Building Council has initiated an investigation of applying LCA into the Leadership in Energy and Environmental Design (LEED) rating system. Workgroup B of the task force was charged with selecting the most appropriate LCIA methodology for inclusion within LEED. Criteria deemed important by the task force included:

- Relevance to building product systems
- Availablity of U.S. characterization factors (not including GWP and ozone depletion potential)
- Site specificity selection (e.g., bioregions)
- General scientific validity of the method
- Relevance to the green building community
- Comprehensive set of environmentally important impact categories
- Identifies endpoints of concern and considers linkages with inventory results
- Contains U.S. normalization database

Based on its evaluation of the above criteria, Workgroup B recommended to the LEED task force that TRACI be used as the impact assessment methodology of choice. By consensus vote, the task force adopted the use of TRACI within LEED.

As we have seen, life cycle impact assessment is the tool that life cycle practitioners use to see which chemical emissions and resource uses have the greatest potential to cause harm. With this perspective, LCIA methods are able to assist decision makers to appropriately prioritize the most beneficial options to reduce burden to humans and the environment. The green building community has already started using LCIA methods to measure product performance and this use of LCIA is likely to increase. Tools like the U.S. EPA's TRACI can be used to do an LCIA for individual building materials or for whole buildings.

The U.S. LCI Database Project and Its Role in Life Cycle Assessment

By Wayne Trusty, MA, and Michael Deru, PhD

We are experiencing a fundamental change that affects not only how building products are developed, but how they are perceived, especially by governments and other high-volume purchasers and by members of extended supply chains. We're referring, of course, to the evolving environmental movement that has, over the past several decades, come to encompass more of the issues and activities that had previously been approached in an isolated fashion, including biodiversity, water use, transportation, and fossil fuel depletion. The 1972 Club of Rome "Limits to Growth" report, the 1987 Bruntland Report ("Our Common Future"), the Rio Accords of 1992, and the Kyoto Protocol of 1997 are all notable milestones in this movement.

Because of their breadth, LCAs require large amounts of information. LCA practitioners, industry, and government have to work together to make available the best information possible; that means starting with high-quality raw data cataloguing flows from and to nature. We call this life cycle inventory data.

At some point in the late 1960s and early '70s, a less well-known phenomenon began to emerge. Two researchers at the Midwest Research Institute, William Franklin and Robert Hunt, began working on a technique for quantifying energy and resource use as well as the environmental emissions from the manufacture and use of products. Others in Europe were following parallel lines, and the result was what we now call life cycle assessment.

As environmental concerns have steadily moved from the periphery to center stage, transportation, energy, water supply, and related resource issues have become focal points on the environmental agenda. And that, of course, is a big part of what LCA is all about—casting the net wide to capture the full spectrum of environmental concerns.

Because of their breadth, LCAs require large amounts of information. LCA practitioners, industry, and government have to work together to make available the best information possible; that means starting with high-quality raw data cataloguing flows from and to nature. We call this life cycle inventory data. Too often the tendency is to focus on the development of attractive software without at least comparable time and effort being spent on the data side. But the quality of any LCA can never exceed the quality of the underlying LCI data on which such tools depend.

In a growing number of countries, there are national projects planned, under way, or completed, whose purpose is to develop publicly available LCI data for common materials, energy carriers, energy use, and electricity generation. Such projects exist in Australia, Canada, China, Germany, India, Italy, Japan, Korea, Switzerland, and Taiwan. This article focuses on a similar project in the United States—the U.S. LCI Database Project, owned and managed by the National Renewable Energy Laboratory (NREL).

The U.S. LCI Database Project is a public/private research partnership to develop a publicly available life cycle inventory database for commonly used materials, products, and processes. The database provides LCI data to support public, private, and nonprofit sector efforts to develop product life cycle assessments and environmentally oriented decision-support systems and tools.

The project was conceived by the Athena Institute and initially funded by the U.S. Department of Energy and the General Services Administration in response to the lack of transparent LCI data in North America. Prior to the release of data through this project, LCI databases in the U.S. had restricted access or data that was not verifiable. The U.S. LCI Database Project began in May 2001 with an intensive initiation and planning phase. Phase II (October 2002 to October 2004) was a period of basic data collection, analysis, and review. Phase III, now under way, encompasses long-term data dissemination, database expansion, and maintenance.

The objective of the project is to provide LCI data for commonly used materials, products, and processes following a single data development protocol consistent with international standards. The resulting consistent and coherent LCI datasets for basic processes make it easier to perform LCAs and increase the credibility and acceptance of the results. Assured data quality and user-friendly access to the database are prerequisites to establishing LCA as a reliable tool for environmental assessment that will support decision making in the public and private arenas.

To date, data modules have been developed in accordance with the following priorities established in Phase I by stakeholders:

1. Fuels, energy, and transportation
2. Products and materials
    - Building and construction
    - Automotive and durable goods
    - Commodity chemicals and materials
3. Common industrial transformation processes, such as casting and painting.

Seventy-three data modules have now been posted to the project web site (www.nrel.gov/lci). Future data collection efforts will provide additional modules in these categories as well as other identified priorities. Construction materials such as cement and concrete products have been identified as one of the priorities for the next round of data development in order to support the "LCA into LEED" initiative. A major study funded by the American Plastics Council is under way to develop data on basic polymers.

The data format for providing and accessing data modules is a streamlined version of a format called EcoSpold adopted for the Swiss "ecoinvent" project, a major European database development. Data provided in the streamlined format can be readily converted by NREL to the full EcoSpold format, which allows data sharing with the Swiss project and any other national databases that adopt the same formatting. In addition, major LCA software suppliers support the EcoSpold format, which provides an easy way to import the U.S. LCI data.

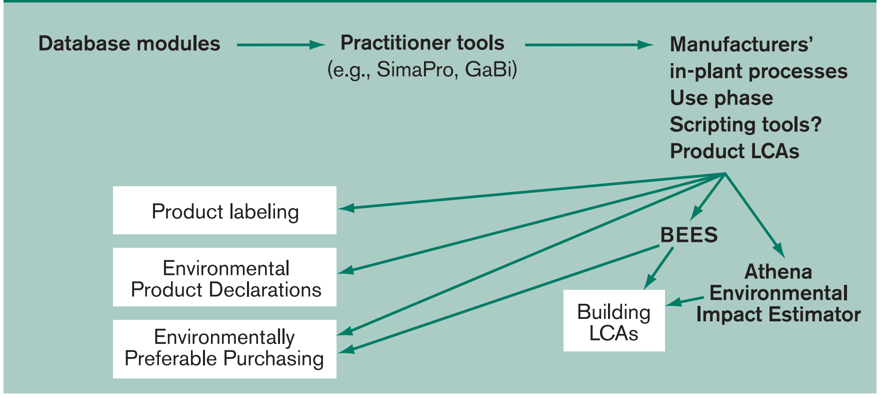
Although the data modules are publicly available, they are not intended for use by the general public in the way that full product LCAs might be used. The modules represent unit processes and will typically be used in combination with each other and with other data, by users such as:

- Manufacturers, researchers, policy analysts, and others undertaking LCAs of specific products or processes
- Developers and users of tools for LCA practitioners
- Developers of tools for nonpractitioners which typically do not allow the user to modify embedded databases
- Organizations or individuals engaged in product assessment and labeling at various levels of system complexity, from relatively simple consumer products to complex systems like buildings and automobiles.

The use of common data modules allows those doing LCAs of specific products to focus on the elements that are unique to a specific manufacturing plant or process.

The accompanying figure illustrates the many ways in which the database serves a variety of user needs.

How the US LCI Database Serves User Needs



The following are examples of how the LCI database is being used:

- The National Institute of Standards & Technology (NIST) is switching to U.S. LCI Database Project modules for energy combustion, pre-combustion, transportation, and other common processes used in its BEES software tool. BEES (Building for Environmental and Economics Sustainability) is used for making product-to-product comparisons in terms of both LCA and life cycle costing measures.
- The Athena Institute is making similar changes for the U.S. regions in its Environmental Impact Estimator software for LCAs of whole buildings at the conceptual design stage. This will help bring NIST and Athena data more into line, thereby strengthening the concept of a suite of building assessment tools that can be used for different purposes at different stages in the project delivery process.
- The USGBC has stated that the U.S. LCI Database Project will "serve as a fundamental resource" in its initiative to integrate LCA in the LEED building rating system.
- Other work is under way to develop scripting tools that will make it much easier for manufacturers to prepare brand-specific LCA information. The U.S. LCI Database is cited as a fundamental

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Michael Deru is a senior engineer with the Center for Buildings and Thermal Systems at the U.S. Department of Energy's National Renewable Energy Laboratory, Golden, Colo., where he is project leader for the development of the U.S. Life Cycle Inventory Database and DOE's Performance Metrics Project. He holds PhD and MS degrees in mechanical engineering from Colorado State University and a BS in mechanical engineering from the University of Wyoming.

resource for such tools.

In terms of operations, the Database Project is owned and managed by NREL on behalf of the federal government, with funding from various departments and agencies. NREL also maintains the Web site and has ultimate responsibility for data quality and ongoing data dissemination. The Athena Institute, a subcontractor to NREL, provides management assistance and also undertakes certain data development tasks separately funded by public- and private-sector sources. As of last year, private-sector contributions by the Vehicle Recycling Partnership (Ford, General Motors, and DaimlerChrysler), the Consortium on Research on Renewable Industrial Materials (CORRIM), and the American Plastics Council exceeded public sector funding. An advisory board is being formed with representatives of stakeholder groups, including direct data users, tool developers, ultimate users of information based on the data, data providers, the LCA methodology development community, and public- and private-sector funders.

The project web site (*www.nrel.gov/lci*) has ensured transparency from the outset. All key working documents, the research protocol, and the final Phase I and II reports have been posted to that site, which also has provision for receiving comments on specific documents or the process in general.

The LCI Database Project is crucial to the overall success of LCAs. Without high-quality, transparent LCI data, there can be no high-quality, transparent LCAs. A major driver of the cost of LCAs is data collection, and public LCI databases addressing basic, commonly occurring processes in life cycles go a long way toward reducing the cost of all LCAs. Their use also increases the consistency among LCAs and LCA-based comparisons, and their increased availability reduces the barrier to entry into LCA.

One particularly important use of an LCI database is in Environmental Product Declarations. EPDs, also known as ISO Type III Environmental Declarations, are intended to provide easily accessible, quality-assured, and comparable information regarding the environmental performance of products and services. They are used in a growing number of countries, and the European Commission is considering the development of a pan-Europe Type III EPD framework. Already, some countries require that an EPD accompany imported products, and we can expect to eventually see a more widespread adoption of that policy. As a result, countries that fail to develop national databases, and to thereby support the individual data development efforts of their export industries (including building products), may find it difficult and costly to catch up.

The use of LCI data for the development of design or decision-support tools such as BEES needs no further elaboration. In the building field, in solid-waste management, and in product improvement programs, the challenge is to develop field-specific design tools that make LCA data readily usable by non-LCA specialists.

The central theme in all this is information—the development of the best possible data and disseminating it to those who make or influence decisions about design, purchasing, or environmental policies. Good data also allows manufacturers to exercise a greater degree of control over their processes, and it allows governments to assess and understand environmental issues and to develop appropriate policy responses. In the future, data in the form of environmental declarations or labels may be an essential part of an export package, and those who fail to lay the groundwork early will be at a serious competitive disadvantage.

Overarching all of this is the fact that "sustainability"—however you define that word—is becoming embedded in how we think about our world. Nowhere is this truer than in the case of the built environment. Political shifts may alter the priorities, and may even temporarily suppress the sustainability movement in some countries.

Humankind, however, is not going to back away from a fundamental concern for the environment, or fail to do whatever is necessary to solve, or at least redress, critical environmental problems like climate change. Our future, and the future of our children, must rest on a firm and stable tripod of economic, social, and environmental consciousness.

The Role of Life Cycle Assessment in Sustainable Product Certification

By Kirsten Ritchie, PE

Kirsten Ritchie is director of the SCS Environmental Claims Certification Program, the nation's first scientific program for independently verifying the accuracy of environmental claims of products, at Scientific Certification Systems, Emeryville, Calif. She serves as lead researcher and developer of environmentally preferable product specifications for SCS, chairs the ASTM Task Force on Environmentally Preferable Products, and is vice chair of the U.S. Green Building Council's Material and Resources Technical Advisory Group. A licensed civil engineer with more than 20 years' experience, Ritchie holds a BS in civil engineering from the University of California, Berkeley, and an MS in civil engineering from California State University, San Jose.

Product certification programs—with their necessary partner, voluntary consensus standards—are a key component in the design and construction of buildings. The work of today's architects, engineers, and contractors has been streamlined significantly by independent standards and certification programs, such as Underwriters Laboratories' electrical and safety standards, NSF International's drinking water piping and filtration programs, and ASTM's performance and grading systems for steel, wood, and cement.

While providing practical, easy-to-specify tools for building professionals, these standards and certification programs also give product designers and manufacturers something of a road map for the design process. They know what targets are expected of them—how much weight an I-beam must support or how much heat a carpet must withstand before it melts.

While we have come a long way in developing assessment systems for product performance and safety, there is still much to be done to drive the development and use of products that can be considered sustainable or environmentally preferable. To date, we have focused on those particular environmental attributes which we believe to be of importance—for example, wood that comes from well-managed forests, energy derived from renewable resources, and products made from post-consumer recycled materials.

But have the criteria and standards that serve as cornerstones of these "green" product certification programs kept up with the latest advances in our understanding of the environmental impacts? Are they providing the right road map to product designers and manufacturers to deliver environmentally preferable and sustainable products to the marketplace, as well as to enable Building Teams to design and construct more sustainable buildings?

LCA—A Scientific Approach to Environmental Impact/Benefit Analysis

The missing link in understanding the actual rather than the perceived environmental benefits from specific actions is a rigorous quantitative analysis for the systems of concern. Typically, the environmental impacts associated with a specific industrial system have to do with either the consumption of resources necessary to run the system (raw materials, land, and energy) or the release of pollution created by the system (air emissions, water effluents, and solid wastes). Common sense tells us that there should be some way to measure all these parameters to see if proposed changes in the system, such as requiring the use of more renewable energy, recycled content materials, or noncarcinogenic chemicals, actually provide the benefits sought.

Life cycle analysis, standardized in the ISO 14040 series, begins to satisfy this need. LCA is, by design, a system-based data integration and analysis approach. It is a quantitative analysis that measures energy use, raw materials consumption, air emissions, water effluents, and solid wastes along the entire life cycle of a production system, from the initial extraction of natural resources to the final disposal of wastes. Thus, LCA methods can be used to allow users to see where environmental burdens are high, and if proposed solutions provide real reductions.

As the basis for determining "greenness," LCA has strong support internationally from a wide range of interest groups: the UN Office of Environmental and Community Development, the U.S. Environmental Protection Agency, the U.S. Department of Energy's National Renewable Energy Laboratory, the Swedish Environmental Management Agency, the Canadian Electricity Association, the National Institute of Standards & Technology, and the Associated Plastics Manufacturers of Europe, to name a few.

Interest in LCA runs high for a variety of reasons. When considering just the context of driving environmental improvement, facilitating product certification, and conforming to the rules of international commerce, LCA satisfies several key objectives, because it is:

- Technology neutral—All forms of production can be evaluated equally on a factual, scientific basis with available data rather than relying on assumptions of inherent "greenness" derived from value-based judgments.
- Transparent—Assumptions and methods are open for all to see.
- Flexible—The analysis avoids prescriptive meas-

ures while providing maximum flexibility to determine which improvements should be made based on production expertise, site location, and business realities.

- Nonproprietary—The methodology can be applied by any competent researcher, policy analyst, or certification practitioner.
- Thorough—The process can address the full spectrum of relevant environmental impacts: resource depletion, ecosystem disruption, greenhouse gas emissions, stratospheric ozone depletion, toxic water effluents, etc.
- Actionable—Once a mechanism is in place to measure an activity, such as greenhouse gas emissions or embodied energy, it is now possible to both manage the activity and improve it.

Without a doubt, the main advantage of LCA is in enabling informed decision making with scientific data and competence. However, LCA in and of itself does not tell manufacturers where to make changes or improvements, nor does it inform Building Teams as to what they should specify to produce buildings of superior environmental performance. For that we must take the next step: establishing what is important and quantifying the performance levels expected.

From LCA to Product Certification

The overall consensus goals for environmental declarations and product certification are:

1) To communicate comprehensive, verifiable, and accurate information—data that is not misleading in any way—regarding the environmental aspects of products and services.

2) To encourage the demand for and supply of products and services that produce less stress on the environment.

3) To stimulate the potential for market-driven, continuous environmental improvement.

Clearly, LCA can and should play a central role as the methodology of choice in supporting the claims that are made. However, it is important to recognize the different degrees and associated nuances that exist in the world of environmental labeling and product certification.

According to the standards of the ISO 14020 series, environmental labels and declarations are divided into three principal types:

- ISO 14024, Type I environmental labeling–Principles and procedures
- ISO 14021, Self-declared environmental claims (Type II environmental labeling)
- ISO/TR 14025, Type III environmental declarations

Type I Certified Products (Seal of Approval)

Type I describes environmental labeling programs which award their environmental label to products that meet a set of predetermined requirements. The standard provides a mechanism by which a third party can authorize the use of environmental labels on products indicating overall environmental preferability of a product within a particular product category based on life cycle considerations. The standard requires the use of multiple criteria in the assessment. A Type I label cannot be awarded on the basis of a single attribute, such as recycled content or energy efficiency.

ISO 14024 establishes the principles and procedures for developing Type I environmental labeling programs, including the selection of product categories, product environmental criteria, and product function characteristics, and for assessing and demonstrating compliance. The standard requires the life cycle stages to be taken into account when developing the product environmental criteria to include: extraction of resources, manufacturing, distribution, use, and disposal relating to relevant cross-media environmental indicators. Any departure from this comprehensive approach or selective use of restricted environmental issues must be justified. In addition, the development and selection of criteria must be based on sound scientific and engineering principles.

Clearly, these requirements speak loudly to the use of LCA. While a product-specific LCA is not required to award a Type I label, obviously the LCA methodology can and should be used, if for no other purpose than to understand the overall impacts of the product category and to discern those key points where performance differentials between products can be established. Three leading Type 1 labeling and certification programs—Scientific Certification System's Environmentally Preferable Product program, Australia's Environmental Choice program, and the Scandinavian Nordic Cross program—all take this approach.

Type II Certified Products (Single-Attribute Claims)

Type II labeling typically consists of self-declared environmental claims made by manufacturers, importers, distributors, retailers, or others likely to benefit from such claims. Conformance with ISO 14021 requires that self-declared environmental claims can only be considered verifiable if such verification can be made without access to confidential business information. As a result of this requirement, companies are turning to second- and third-party product certification bodies to independently verify the claims. By doing so, the manufacturer can protect confidential business information that is required to support the claim, while giving the public confidence as to the validity of the claim, including the scientifically sound and documented nature of the supporting criteria and data.

Type II environmental claims made with regard to products may take the form of statements, symbols, or graphics on product or package labels, product literature, technical bulletins, advertising, publicity, telemarketing, or the Internet. These environmental claims and any explanatory statements are subject to all requirements laid out in ISO 14021. Such claims must be:

- accurate and not misleading
- substantiated and verified
- relevant to the particular product, and used only in an appropriate context or setting
- presented in a manner that clearly indicates whether the claim applies to the complete product, only to a component or packaging, or to an element of a service
- specific as to the environmental aspect or environmental improvement that is claimed.

LCA will, where practical, be a cornerstone of certification assessment programs. Although there continue to be areas where LCA is more an art form than a science—for example, in the assessment of a product's toxicity profile or land-use impact—LCA has come a long way in the last 20 years. We can feel confident about its ability to guide us in making correct choices when it comes to the consumption of energy resources, global warming, and ozone depletion.

Among the claims that can be made for the product under this program are the following:

- "Compostable"
- "Degradable"
- "Designed for disassembly"
- "Extended life product"
- "Recovered energy"
- "Recyclable"
- "Recycled content" (including pre-consumer, post-consumer, and recycled material)
- "Recovered (reclaimed) material"
- "Reduced energy consumption"
- "Reduced resource use"
- "Reduced water consumption"
- "Reusable"
- "Refillable"
- "Waste reduction"

Product certification programs currently in place that reflect Type II labeling scenarios include the SCS recycled content certification program, the Carpet and Rug Institute Green Label and Green Label Plus program, the U.S. EPA's Energy Star program, and the Resilient Floor Covering Institute's FloorScore program.

While these types of claims tend to be the most prevalent in the marketplace, they have the least direct linkage to LCA. Consequently, we must be vigilant in verifying that the claims being made do indeed lead to reduced environmental impact, or even to environmental improvement.

Type III Certified Products (EcoProfiles and Environmental Declarations)

Without a doubt, Type III environmental declarations represent the closest alignment of LCA and product claims. ISO 14025, which describes the requirements for preparing a Type III label (in conjunction with draft standard ISO/DIS 21930 regarding the environmental declaration of building products), requires declarations based on life cycle assessment as described in the ISO 14040 series and on environmental declaration principles as described in ISO 14020.

A Type III environmental declaration is described as quantified environmental life cycle product information that: 1) is provided by a supplier, 2) is based on independent (i.e., third-party) verification, 3) offers systematic data, and 4) is presented as a set of categories for a sector group. Type III environmental declarations must be nonselective but must present the information in a format that facilitates comparison between products.

In preparing a Type III certification, the following must be declared:

- Methods of data collection and assessment, including the role of values and subjectivity, often referred to as "value choices"
- The choice of life cycle inventory analysis (LCI) data categories and life cycle impact assessment (LCIA) impact categories
- The means of ensuring quality of environmental information in terms of relevance, accuracy, and uncertainty
- The means of ensuring that environmental information is relevant and not misleading
- The means of communicating with purchasers

and potential purchasers in an accurate and not misleading way

- Ensuring international compatibility, maximum comparability, and the use of sufficiently specific product information.

SCS and the United Kingdom's Building Research Establishment (BRE) Certification Ltd. are considered to be leaders in Type III product certification. This field of product certification is continuing to evolve, driven by the need to continually refine the assessment methodology while expanding the scope of assessment—for example, into issues of human toxicity and land-use impacts.

Type III environmental declarations are considerably more complex and detailed in their disclosure than Type I or Type II labels. In general, Type III labels are intended to provide detailed information about the product (think nutritional label on a bag of potato chips). It is then up to the user to undertake a comparative analysis to determine whether Product A or Product B is better for the particular application under consideration.

However, both SCS and BRE recognize that users often want an additional evaluation metric—for example, a comparison of the product or service to a recognized baseline. In that case, the certification label may be able to provide data in both quantified form (for example, "tons of CO_2 emissions for greenhouse gas loadings") as well as comparative form ("Is the quantity of greenhouse gas emitted high or low for this product category?").

In addition to SCS and BRE, the Swedish Environmental Management Council, through its support of the Global Environmental Declaration (ged-net) program, and NIST, with its development and support of the Building for Environmental and Economic Sustainability (BEES) program, are also key players in the development of environmental product declarations. While neither of these organizations issues product certifications, the methodologies, research, and data resources they provide are invaluable to the progress of environmental product declarations.

Scientific Fact Versus Subjective Value

The main advantage of LCA is in supporting decision making with scientific data and competence, thereby distinguishing as much as possible between scientific facts and subjective values. In this context, its ambition is very close to the mandate of product certification organizations, whose mission is to balance science, cost effectiveness, and clarity of product claims.

It remains to be seen how the building product industry and the design and construction market will respond to the various environmental labeling and certification options now available to them. The success of such certification marks as the UL label would lead to the assumption that a Type I "seal of approval" labeling scheme has the greatest market opportunity. However, with the growing familiarity of Type III labels, such as nutritional labels on food packages, it is possible that they could become the mainstream.

Regardless of the labeling type, LCA will, where practical, be a cornerstone of certification assessment programs. Although there continue to be areas where LCA is more an art form than a science—for example, in the assessment of a product's toxicity profile or land-use impact—LCA has come a long way in the last 20 years. We can feel confident about its ability to guide us in making correct choices when it comes to the consumption of energy resources, global warming, and ozone depletion.

Applying a Life Cycle Perspective to Federal Construction Specifications

By Alison Kinn Bennett

Alison Kinn Bennett is on the staff of the U.S. Environmental Protection Agency's Environmentally Preferable Purchasing Program, in Washington, D.C. In 2003, she completed an assignment in the Office of the Federal Environmental Executive that resulted in the publication of "The Federal Commitment to Green Building: Experiences and Expectations." She co-chairs the EPA Green Building Workgroup and is the Federal Liaison to the National Capital Region chapter of the USGBC. She holds a BA in political science and geography from the University of California at Berkeley and a master's in urban and environmental planning from the University of Virginia School of Architecture.

While life cycle assessment is applicable to the design process primarily by informing design decisions, the construction specifier's role is crucial in delineating the specific, enforceable submittal and environmental performance requirements for the contractor. To do so, specifiers need accurate and meaningful information about the life cycle impacts of products and services.

There is disagreement, however, on the most effective way to take this information and apply a life cycle perspective to purchasing. To some, a thorough, methodical analysis is indispensable, no matter how time-consuming and expensive it may be. To others, an abbreviated life cycle process, in which a long list of potential environmental attributes or impacts (or both) is narrowed to a few, allowing for comparison across a product or service category, would be preferable. Ideally, specifiers would have all the necessary data and easy-to-use tools to make scientifically defensible purchasing decisions based on LCA methodologies.

However, LCA is an evolving science with significant data gaps and limited tools. Given these current realities, the EPA-sponsored "Federal Green Construction Guide for Specifiers" promotes LCA in construction projects "to the greatest extent possible" and provides guidance for collecting and utilizing environmental and health impact data where available.[1]

The Federal Guide encompasses more than 60 sections, organized according to the Construction Specifications Institute's MasterFormat. It is a voluntary tool providing multiple performance-based options that allow for flexibility in application. It contains sample language intended to be inserted into project specifications as appropriate to the owner's environmental goals. In addition, through a number of notes, the Federal Guide educates specifiers about life cycle impact issues, federal environmental mandates, and helpful resources on green building.

The Federal Guide's key contribution with regard to LCA is in its identification of submittal requirements for the collection of life cycle-based environmental performance data. Specifically, in Section 01611—Environmental Requirements for Products, model language is presented for requiring product and service providers to submit data via an ASTM standard questionnaire, an expanded Material Safety Data Sheet, or an acceptable LCA methodology.

ASTM E2129-05, "Standard Practice for Data Collection for Sustainability Assessment of Building Products," includes a 10-page survey of general and product-specific questions covering the five categories: 1) materials (product feedstock); 2) the manufacturing process; 3) the operational performance of the installed product; 4) the impact of the building product on indoor environmental quality; and 5) the corporate environmental policy of the company manufacturing or fabricating the building product. By requiring contractors to solicit these survey responses from product manufacturers or suppliers (or both), specifiers can gain access to useful information that will assist them in making environmentally preferable purchasing decisions.[2]

Similarly, Material Safety Data Sheets (MSDSs)

[1] The Federal Green Construction Guide for Specifiers may be found on the Whole Building Design Guide at: http://fedgreenspecs.wbdg.org.

[2] Refer to ASTM's website at: www.astm.org/cgi-bin/SoftCart.exe/DATABASE.CART/REDLINE_PAGES/E2129.htm?E+mystore

Toxicological information	Identify acute data, carcinogenicity, reproductive effects, and target organ effects. Provide a written description of the process used in evaluating chemical hazards in the preparation of the MSDS.
Ecological information	Include data regarding environmental impacts during the acquisition of raw materials, manufacture, and use. Include data regarding environmental impacts in the event of an accidental release.
Disposal considerations	Include data regarding the proper disposal of chemicals. Include information regarding recycling and reuse. Indicate whether or not the product is considered to be "hazardous waste" under the US EPA Hazardous Waste Regulations 40 CFR 261.
Transportation information	Identify hazard class for shipping.
Regulatory information	Identify federal, state, and local regulations applicable to the material.
Other information	Include additional information relative to recycled content, biobased content, and other information regarding environmental and health impacts, and give the date MSDS was prepared.

can be a gold mine of environmental and health impact information. An MSDS is required by the Occupational Safety & Health Administration to include information such as the physical and chemical characteristics and hazards of hazardous chemicals in the product, including health hazards and the potential for fire, explosion, and reactivity; precautions for safe handling and use; and emergency and first aid procedures.[3]

By actively seeking and considering life cycle information, the federal government can send a clear signal that its business will go to those who most thoroughly address their product's environmental impacts. Thus, federal specifications are not only critical to furthering the science of LCA but also to fostering competition and encouraging a market-driven approach to continued improvement of environmental performance.

Building on these required elements, the American National Standards Institute has developed a standard format (ANSI Z400.1) that includes six additional topics that may be useful for gaining a broader environmental perspective on products. This expanded MSDS is required in a number of other countries; thus, many manufacturers doing business outside the U.S. may already have the information. The Federal Guide includes model language for requesting product manufacturers to submit information in these additional areas (see table).

Finally, the Federal Guide provides model language intended to assist agencies in applying LCA methodologies to the greatest extent possible. In doing so, the Federal Guide delineates various options for developing acceptable LCA data for submittal. Options include the following:

- ASTM E1991: Standard Guide for Environmental Life Cycle Assessment of Building Materials/Products
- ISO 14040: Environmental Management—Life-Cycle Assessment—Principles and Framework
- BEES
- Other per agency policy or project goals (or both).

On a higher level, these submittal requirements, as well as those identified in Technical Sections 2-16, are useful beyond the task of product selection. First, the documentation serves to verify and record compliance with specified construction procedures—which is of key importance to federal agencies in meeting their responsibilities under EPA's Comprehensive Procurement Guidelines, USDA's Biobased Purchasing Guidelines, the USGBC's LEED rating system, and various "Greening of Government" executive orders.

More importantly, by actively seeking and considering life cycle information, the federal government can send a clear signal that its business will go to those who most thoroughly address their product's environmental impacts. Thus, federal specifications are not only critical to furthering the science of LCA but also to fostering competition and encouraging a market-driven approach to continued improvement of environmental performance.

[3] *MSDSs are required under OSHA Hazard Communication Standard 1910.12001.*

Selecting Environmentally Preferable Products

Under Executive Order 13101, EPA issued Final Guidance on Environmentally Preferable Purchasing for federal agencies in 1999. See *www.epa.gov/oppt/epp/guidance/finalguidancetoc.htm.*

In the third guiding principle, EPA encourages purchasers to select products and services with as few adverse environmental impacts in as many life cycle stages as possible. A product's life cycle includes activities associated with raw material acquisition, manufacturing, packaging, transportation, product use, and ultimate disposal. When examining the life cycle of a service, particular emphasis should be placed on the use phase of the products required to provide the service, although the entire life cycle of the products being used should be examined carefully. To determine environmental preferability, EPA suggests that purchasers compare the severity of environmental impacts throughout the life cycle of the product or service with those of competing products and services.

Environmental preferability should also reflect the consideration of multiple environmental attributes, such as increased energy efficiency, reduced toxicity, or reduced impacts on fragile ecosystems at each phase in the life cycle. Although the determination of environmental preferability should be based on multiple environmental attributes examined from a life cycle perspective, purchasing decisions can be made based on a single environmental attribute such as recycled content or energy efficiency when that attribute is the strongest distinguishing characteristic of a product or service's environmental preferability.

For more about the EPA Environmentally Preferable Purchasing Program's tools and guidance, see *www.epa.gov/oppt/epp*.

LCA's Role in the Manufacture of Construction Materials

By Stanley P. Graveline

Stanley P. Graveline is vice president for technical services at Sarnafil Inc., a roofing manufacturer in Canton, Mass. He holds a bachelor's in chemical engineering from the University of Ottawa and is registered as a professional engineer in Ontario. A veteran of 20 years in the roofing industry, he is secretary of the board of the Cool Roof Rating Council, director of the North East Roofing Contractors Association, and a member of the Roofing Consultants Institute.

It is estimated that the construction industry consumes about 40% of all raw materials and energy, making it the largest single user of these precious resources. All stakeholders in the building segment recognize the need to move toward more ecological designs, installations, and materials.

There are challenges, not the least of which is deciding which products and materials are environmentally preferable. In the early days of ecological awareness, many manufacturers simply labeled their products as "green," often with little or no basis for the designation. Clearly, these efforts were being driven by their marketing departments, not their technical groups.

A variety of certification programs have evolved, some developed by the suppliers themselves, some by third-party organizations; often these certifications and designations focus on single issues, such as recycled content or impact on indoor air quality. The U.S. Green Building Council's Leadership in Energy and Environmental Design rating program has moved the industry a major step forward. Although the number of LEED-certified buildings is still small, the USGBC's meteoric growth and the tremendous market awareness of LEED clearly demonstrate a strong interest in sustainable building practices. But, even LEED provides few specific guidelines for selecting the most environmentally preferable products.

Thus, the basic challenge remains: how best to assess the environmental profile of a material or product in a comprehensive, transparent manner. Even more importantly, how can this be accomplished in a way that provides useful information upon which architects, engineers, building owners, and contractors can base their material choices?

Life cycle assessment may just be the solution. An LCA provides a methodology for studying a product from the harvesting of the raw materials, through production, use (and reuse), to the end of the product's service life. It can be applied to both individual materials and complete assemblies. The assessments are based on scientific analysis with quantifiable outputs which clearly allow for comparisons among various alternative solutions for a given application. Given that ISO standards governing how LCAs should be conducted already exist, and with sustainability rapidly becoming a key design tenet in many AEC firms, all the elements are in place for LCA to become *the* environmental assessment tool for the construction industry.

LCA in the Construction Industry

Although LCA has been around for decades, its use in the construction industry has been very limited. A comprehensive literature search located only a few European reports—and not a single North American reference—to LCA analysis of commercial roofing materials or systems. Although LCA was one of two bases of analysis of competing materials within the LEED Technical Science and Advisory Committee's recent study of a PVC-based credit in LEED, less than 2% of the documents submitted for consideration were "comparative LCA" related.[1]

Why such a shortage of readily available information? A simplistic answer may be a lack of demand. Conducting even a modest LCA is not inexpensive, especially when an outside consultant is used. Without any regulatory requirement or market demand, why would anybody invest the time and money required to conduct an LCA?

Building material manufacturers might do so if:

- They perceive an imminent threat to their product, such as potential legislation, and are looking to address the issue before someone else does.
- They wish to benchmark their product against other similar materials or against competing technologies. Such an exercise might serve as a basis for modifying or improving specific elements of their product, such as reducing the amount of nonrenewable resources used to produce it, increasing recycled content, producing it more efficiently, or improving product durability and consequently life expectancy.
- They see conducting LCAs on their products and systems every few years as an integral part of the company's continuous improvement program. Depending on the goals of such a corporately funded LCA, a company may or may not make the results public. In some instances, the improvements over a previous generation of product may be the basis for a marketing campaign. In others, highlighting a weakness in the product, even if it is being improved upon, is something many companies would rather avoid, particularly with regard to environmental issues.

The most likely justification a company would have for investing in a publicly released LCA would be to show their product is superior to others with regard to

[1] *Public Review Draft Approved for Release by TSAC, December 17, 2004: Assessment of Technical Basis for a PVC-Related Material Credit in LEED, LEED Technical and Scientific Advisory Committee, U.S. Green Building Council, Washington, D.C.*

[2] *Ecological and Economical Balance Assessment of US Flat Roofing Systems, Carbotech AG, Basel, Switz., 2004.*

[3] *Life Cycle Assessment of PVC and of Principal Competing Materials, April 2004. PE Europe GmbH, IKP Universität Stuttgart, IPU DTU, Randa Group.*

one or more environmental assessment parameters. Building Teams would benefit from this information, since it would help them identify products with lower environmental impacts.

Although there has been limited demand from the marketplace for such assessments, leading-edge material suppliers could gain a competitive advantage conducting such studies and disseminating the results. Any attempt to do so, however, would require overcoming a number of obstacles. The following highlights some of the challenges experienced conducting a comparative life cycle assessment of various commercial roofing products by the Swiss consulting company Carbotech AG.[2]

Scoping: Is it a Material or a System?

The challenges begin with the definition of the scope of the LCA. The simplest form of an LCA would involve the assessment of the production of a single component. Most manufacturers are likely to have good data on this and could produce a highly accurate assessment. However, most building products represent a single component or material which is integrated into a complete assembly on the construction site—for example, a wall assembly might be constructed of bricks, insulation, air barrier, through-wall flashing, and other components, all of which are critical to the long-term performance of the wall unit.

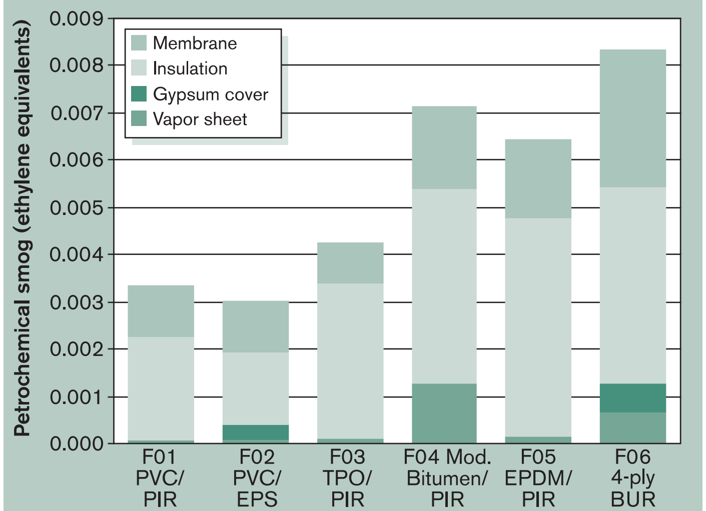
Therefore, studying a single material in isolation, and limiting the scope of the analysis to the production stage, is not likely to provide meaningful information. In a review of 100 LCAs for the European Commission, it was noted that LCA comparisons performed at a material level often provide misleading results: environmental impacts during use and after end of life are often more important than those related to material production.[3]

In many construction systems the performance of one component is often highly dependent upon the performance of other components. For example, in a low-slope roof, the durability and effectiveness of the insulation will depend largely on the performance and life expectancy of the membrane covering it, while the membrane's service life can depend largely on the dimensional stability and cohesive strength of the thermal insulation. That's why it is important to study complete systems.

In some cases, the impacts related to a secondary component are greater than those of the material under study. In the Carbotech study, for example, the objective was to identify the optimal membrane choice from among four membrane types. The same thermal insulation type and thickness were used in four of the assemblies. An additional system incorporating a second type of insulation (same R value), with the first membrane, was also studied. As Figure 1 shows, the thermal insulation has a greater impact on photochemical smog than any of the membranes.

Clearly, the impacts of all construction materials which make up a given system need to be considered in an analysis, ideally from "cradle to grave." Conducting an analysis based on an entire building

Figure 1. Life Cycle Impact by Component for Various Roofing Systems



Source: Carbotech AG, 2004

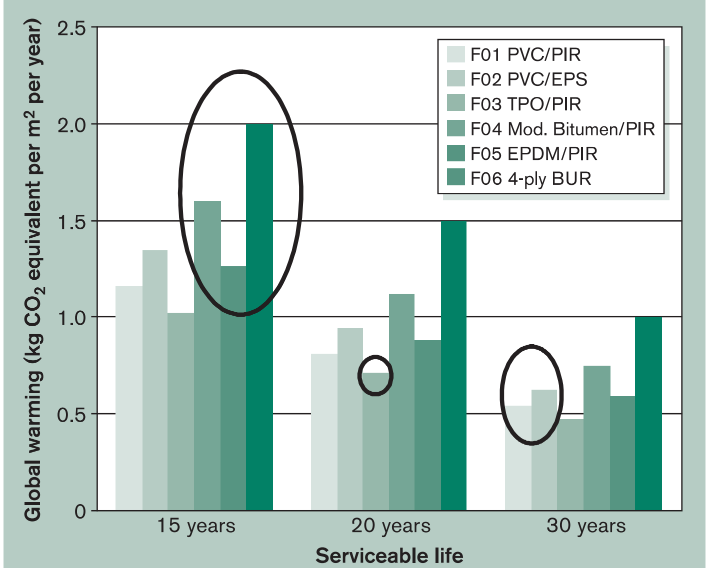
system requires sourcing data from a variety of component suppliers in addition to generating the data for a company's specific product. Typically, sourcing such data is not overly difficult, providing the various vendors are not competitors. Manufacturers supplying complete systems or assemblies incorporating a number of private label components are typically able to access the required information from vendor partners.

Most design and construction professionals are unfamiliar with life cycle impact categories, such as those defined in the U.S. EPA's Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts (TRACI). It will take some time for global warming (kg CO_2 equivalent), acidification (kg SO_2 equivalent), nonrenewable primary energy (MJ), photochemical smog (ethylene equivalents), and eutrophication to work their way into the construction industry's vernacular.

Life Cycle Inventory Data

Conducting an LCA of numerous competitive sys-

Figure 2. Sensitivity Analysis of Life Cycle Impacts to Service Life for Various Roofing Systems



Source: Carbotech AG, 2004

tems presents significant issues. Although a manufacturer may have good data on its own product and may be able to acquire data on system components from partner vendors, getting the same information from competitors can be quite difficult, to say the least.

Life cycle inventory databases do exist, but they are limited. Of all the documents submitted to the USGBC TSAC, less than 0.5% provided LCI information or data. Public databases depend on manufacturers supplying the data, but most manufacturers consider this information proprietary. They are concerned about confidentiality, misuse of data, and exposing the strengths or weaknesses of their manufacturing processes. Industry associations might help fill this gap by working with their members to generate industry segment data for distribution to credible LCI databases. This could insure databases are populated with accurate, representative data without exposing company-specific information.

For NIST's BEES LCI database, data on roofing materials is limited to residential products such as shingles, which makes it unsuitable for commercial applications.

Where data *is* available for a given product or system, such as in BEES (or Canada's Athena Sustainable Materials Institute's database, which does contain information on commercial roofing products), it must be asked how representative the data is for all the products within a given generic category—for example, vinyl membranes, polyisocyanurate insulation, bituminous air barriers, etc. In all likelihood a comparative analysis of the mass and energy balances used to quantify the various impacts associated with each step in the production of the product would reveal that they are quite similar for generically similar products from different manufacturers. Within the context of the entire assessment any differences are likely to be small and would not be expected to significantly affect the accuracy of the final results.

A much more critical variable is life expectancy. For a building with a 75-year design life, a roof assembly with a 15-year life expectancy would have to be replaced five times within that span versus three times for a roof with a 25-year service life. This has obvious implications for the magnitude of each of the impacts associated with the system. Figure 2 illustrates a sensitivity analysis from the Carbotech study. The "bubbles" indicate the life expectancies assumed for the various roofing systems based on a variety of sources. In terms of global warming, the impact of system F06 with a life expectancy of 15 years is roughly four times that of system F01 with a life expectancy of 30 years. However, if both are assumed to have a life expectancy of 15 years, the difference in impact drops to double. As can be seen from the graph, for systems with more similar levels of impacts, a shift in life expectancy can reverse the relative positions of two alternatives.

Different studies of the life expectancy of roofing assemblies (and presumably other construction systems) often present confusing and contradictory data. The statistical rigor with which these studies are carried out varies tremendously, often offering more anecdotal than scientific evidence. Even within a given generic group, different levels of quality can be discerned. A study of 87 large retail stores across the U.S., all constructed with the same basic build-up of components, noted significant differences in quality and ageing behavior of the products from four different producers of the same generic roof membrane material.[4]

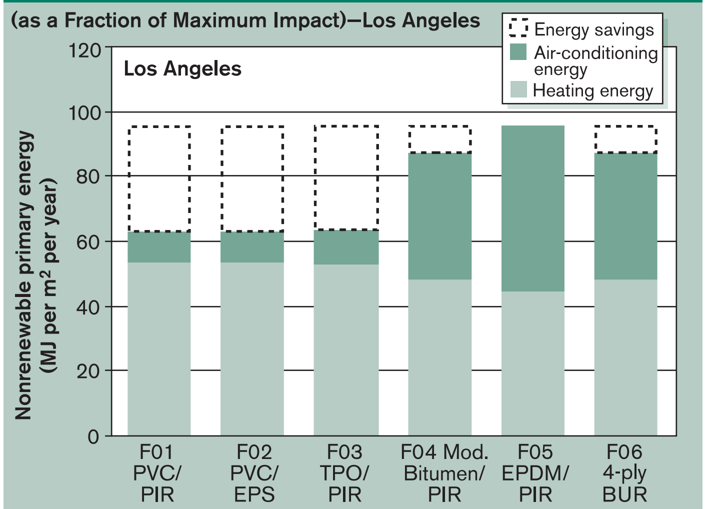
One entity that conducts life expectancy studies in a rigorous manner is the British Board of Agrément. Traditionally, it provided an estimate of the life expectancy for a specific material being assessed for certification by having inspectors physically go back to old installations (typically about every five years) and analyze samples as the materials aged. More recently, the board has been relying on lab assessments to project life expectancies for building products. But, as the esteemed roof consultant C.G. Cash has noted, "The only rational system for selecting a roofing system is its past performance on the roof, in the same climate

[4] *Ageing and Hail Research of PVC Membranes, F.J. Foley, J.D. Koontz, J.K. Valatis, 12th International Roofing and Waterproofing Conference, 2002.*

[5] *Comparative Testing and Rating of Thirteen Thermoplastic Single-Ply Roofing Membranes, C.G. Cash, from* Durability of Building Materials & Components*, Volume 2, National Research Council Canada, 1999.*

Figure 3. Operational Impacts Related to Heating and Cooling Through Various Roof Systems

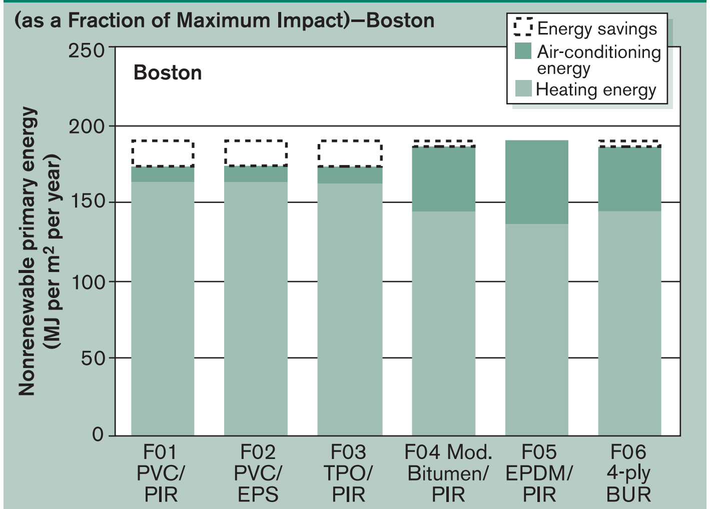
(as a Fraction of Maximum Impact)—Los Angeles



Source: Carbotech AG, 2004

Figure 4. Operational Impacts Related to Heating and Cooling Through Various Roof Systems

(as a Fraction of Maximum Impact)—Boston



Source: Carbotech AG, 2004

as the new project."[5] Nor is it wise to look to warranty durations as a proxy for life expectancy data. This is the worst of all options, as many suppliers offer warranties that are multiples longer than their actual field experience with the product.

Energy consumption resulting from the operation of a building generates significant impacts. Building envelope systems will have a major effect on these. This implies that for a comprehensive analysis to occur, both direct impacts (raw material extraction, production, installation, maintenance, removal, recycling or disposal) and indirect operational impacts (heating and cooling impacts related to the building envelope system) should be considered. This may necessitate evaluations for regional climatic conditions for companies selling products across the country. As can be seen in Figures 3 and 4 (nonrenewable primary energy), operational impacts for Boston are about double those for Los Angeles. The reduction in impact due to the use of light-colored, highly reflective membranes (systems F01, F02 and F03) versus darker materials (systems F04, F05, F06) is evident, particularly for Los Angeles.

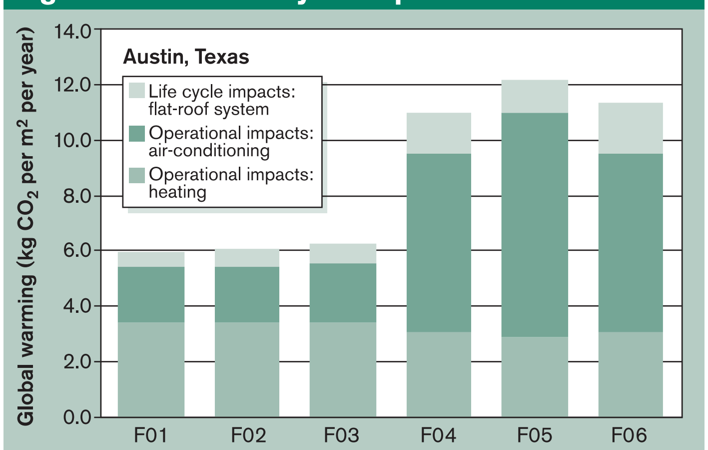
More significantly, it was found that the *cumulative life* cycle impacts for all components for each assembly, calculated on an annualized basis over each system's life expectancy, were typically only a fraction of the operational impacts (see Figure 5 for Austin), reinforcing the need to calculate both direct and indirect impacts to get a true and complete assessment of the total impacts.

Completing the Life Cycle Assessment

After sourcing the available data and making the necessary assumptions, the life cycle assessment can be completed using any one of a variety of available software systems. The question becomes how to present the data such that it provides the maximum benefit to the end users. Depending on the number of criteria considered for the assessment, a dozen different parameters might have to be interpreted if all those listed in TRACI are considered. For the Carbotech study it was decided to limit the analysis to four parameters (nonrenewable primary energy, global warming, acidification, and photochemical smog). Even this modest number of parameters results in a tremendous amount of data to absorb and process.

Some experts propose weighting the parameters

Figure 5. Total Life Cycle Impacts



Source: Carbotech AG, 2004

Figure 6. Eco-efficiency

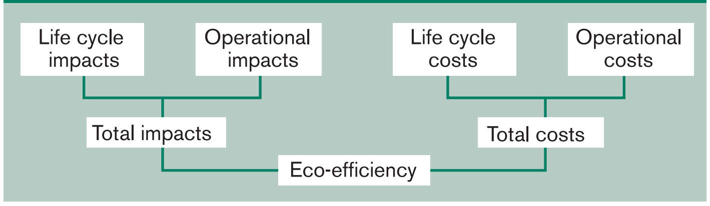
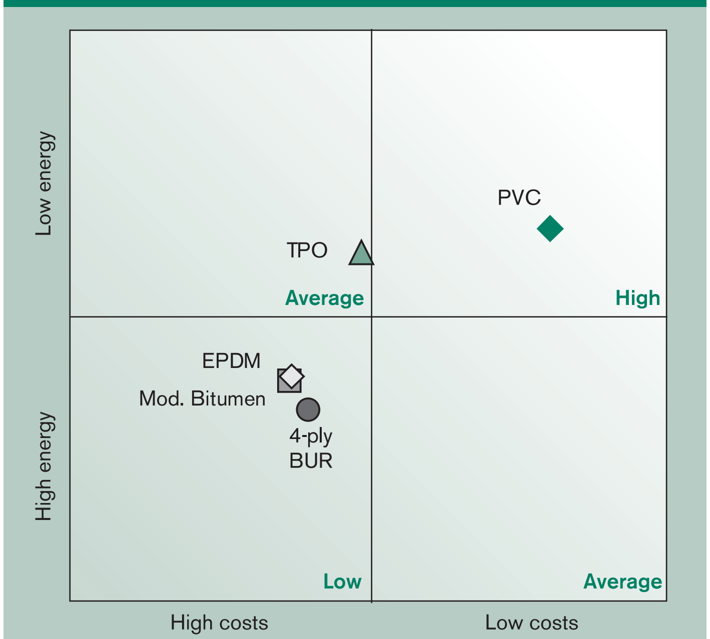


Figure 7. Eco-efficiency of the Various Roofing Systems (for Los Angeles)



Source: Carbotech AG, 2004

and generating a single, all-encompassing impact rating. Although this topic goes beyond the scope of this article, it should be noted that any weighting scheme introduces bias to some extent. If only aggregate results are presented, a degree of transparency is lost.

Achieving Economic Sustainability

While it is safe to assume that most, if not all, stakeholders would like to minimize the environmental impacts of the facilities they design and build, not all are willing to pay a significant premium to do so. Any architect, engineer, contractor, or owner's representative seeking to drive environmentally preferable material or system selection should also strive to demonstrate "economic sustainability" as well.

This can be done by also conducting a life cycle cost (LCC) analysis (on an annualized basis), including operational costs, in a manner analogous to what was done with the life cycle and operational impacts. Combining the total impacts and costs, including both life cycle and operational components of each, yields an "eco-efficiency" rating (see Figure 6). Conducting both analyses and combining them provides for a valuable metric which can be used to establish what, if any, economic tradeoffs are required to achieve the superior ecological performance.

Figure 7 illustrates the results for Los Angeles on the basis of nonrenewable primary energy. In many instances (including the case in the Carbotech study), the system generating the lowest total impacts also generates the lowest overall life cycle costs. In light of both the impacts and the costs being highly dependent on life expectancy and energy consumption during the use phase, this finding is not surprising. However, the cost angle will no doubt be invaluable in making a case for the environmentally preferred option.

In conclusion, life cycle assessment clearly has the potential to be a valuable tool on the road to ever more sustainable construction materials and practices. The USGBC's initiative to include LCA in its LEED program is to be commended and supported. Although the task of doing so is quite daunting, there is no doubt that when they achieve their goal, they will have raised the sustainability movement to a whole new level.

Nonetheless, few building product manufacturers have attempted to adopt and use LCA methodology. Without some form of market demand, most companies are likely to neglect it as long as they can. Moreover, since some products will clearly be shown to have measurably more environmental impact than others, the manufacturers of such materials and systems are not likely to be publishing LCAs or providing data to LCI databases voluntarily.

As the Carbotech study has clearly demonstrated, there are a number of hurdles to overcome in conducting an LCA in the construction materials industry. At this stage of the game, the best anyone can do is clearly document the sources of all information—and, most importantly, provide users with all the assumptions made in arriving at the results.

Only in doing the assessments can the issues to be addressed be identified and solutions developed. As in any endeavor, "first movers" will have the steepest learning curve. However, leading-edge companies will no doubt see the benefits in attempting to apply these methods to their product lines, both in terms of achieving a better understanding of their own systems and in promoting their ecological and economical benefits.

USGBC's 'LCA into LEED' Project

By Nigel Howard, C Chem FRSC, and Tom Dietsche

Nigel Howard recently assumed the title of chief technical officer of the U.S. Green Building Council, based in Washington, D.C. Before joining the USGBC in 2001 as vice president for LEED and international programs, he served as director of the Centre for Sustainable Construction at the Building Research Establishment (BRE) in the U.K., where he developed several assessment tools linked to sustainability, notably BREEAM (the BRE Environmental Assessment Method) and the life cycle design tool Envest. Earlier in his career, he worked for British Gas plc and the former Greater London Council's Scientific Branch. He graduated in chemistry from Kingston University, Surrey.

Tom Dietsche is program manager for the USGBC's Leadership in Energy and Environmental Design (LEED) rating system. He joined the council as its sixth employee in March 2001, after working on IAQ and energy-efficiency programs at the International City/County Management Association, assisting the President's Council on Sustainable Development and the National Town Meeting for a Sustainable America, and consulting for several architects and local governments on building materials issues. He holds a BA degree in audio engineering.

The U.S. Green Building Council has long recognized the value of incorporating LCA-based credits into its Leadership in Energy and Environmental Design (LEED) rating systems, for its potential to holistically assess building materials and assemblies. In order to explore critical issues of LCA methodology and the practicality of LCA application within the rating system, the LEED Steering Committee commissioned an ad hoc initiative to develop a report of recommendations. The Steering Committee will then decide how to implement the results of this work, with the assistance of its technical and product committees.

Two characteristics are considered essential for incorporating LCA into LEED:

1. The LCA basis of LEED credits must provide a level playing field based on a consistent methodology applied across all products and at all stages of their production, transport, use, and disposal or recycling at end of life. Current U.S. databases do not necessarily provide data using consistent methodology to a consistent scope.

2. LCA is inherently complex, and the LCA tool and methods used for LCA-based LEED credits must be very practical and intuitive for designers, specifiers, and facilities managers to use at appropriate stages in the life cycle of buildings.

The USGBC introduced the project concept to 120 interested stakeholders at a meeting in September 2004. More that 60 people volunteered to be part of working groups. Volunteers are representatives of material and product manufacturers (from within the USGBC membership) and related trade associations; LCA tool and database providers; and relevant LEED committees (the Materials and Resources Technical Advisory Group and the Technical & Scientific Advisory Committee).

Groups A, B, and D have been active since holding face-to-face meetings in April, and coordination between groups is occurring on an as-needed basis. Their work products will inform subsequent groups. Cross-pollination will continue to ensure that issues are coordinated between the theoretical, methodological, and practical perspectives.

Working Group A has determined that LCA is primarily relevant to EA (Energy & Atmosphere) and MR (Materials & Resources) credits, excluding management and planning activities. Some water and site credits might also be amenable to LCA, but are problematic for data or other reasons and thus will be deferred. At this time, LCA is not able to address indoor environmental quality. Several approaches are on the table with regard to scope, including the ranking of building assemblies; LCA used during the design phase; and LCA at the building level, relative to a benchmark of common building performance.

> **The USGBC intends** that the "LCA into LEED" project will significantly influence related industry. Materials and product suppliers will be motivated to generate consistent data across a level playing field. Tool and database providers will be motivated to generate practical tools and methods that make this data accessible to LEED clients. LEED clients will be motivated to use these tools and methods to design and construct location-appropriate buildings that exhibit low environmental impact.

Working Group B has decided to use ISO's LCA standard as a framework and refine the details as necessary for the building's context. Progress has been made regarding inventory allocation and inventory analysis (i.e., cut-off criteria for small quantities or impacts), impact assessment, normalization, and comparison of existing standards of LCA methodology and databases (ISO, ASTM, US LCI database, and TRACI).

Recommendations for implementation within LEED credits are scheduled to be developed during the third quarter of 2006, although as a project of this magnitude evolves there may be need to modify the work program and the proposed schedule. Meanwhile, it is envisaged that a series of reports will be prepared to document progress as each task is completed. This will provide an evolving source of information as the methodology, data, tools, and methods all come together.

The USGBC intends that the "LCA into LEED" project will significantly influence related industry. Materials and product suppliers will be motivated to generate consistent data across a level playing field. Tool and database providers will be motivated to generate practical tools and methods that make this data accessible to LEED clients. LEED clients will be motivated to use these tools and methods to design and construct location-appropriate buildings that exhibit low environmental impact.

The accompanying chart describes the tasks assigned to the six Working Groups, which have been asked to utilize existing standards, methods, and tools to the greatest extent possible.

Working Group Assignments for the 'LCA into LEED' Project

LCA Metholodogy		
Task 1 (Group A)	Defining the LCA Goal and Scope	To define LCA goal and scope (e.g., cradle to gate, cradle through building life span) as appropriate to the various LEED rating system products and to the corresponding decision points that should be awarded by LEED credits. This task is considered crucial to many other aspects of the proposed work program.
Task 2 (Group B)	Inventory Analysis and Allocation	To determine the way data is processed toward a consistent treatment of materials and products and whether these provide the level playing field needed for LEED.
Task 3 (Group B)	Impact Analysis	To determine sufficiency of available sources of characterization date in the U.S.
Task 4 (Group B)	Normalization	To decide whether LCA data needs to be normalized for practical application and, if so, how. Note: The most common unit of normalization internationally is the proportion of impacts per capita for a country.
Task 5 (Group C)	Benchmarking	To define performance benchmarks against which to set LEED point achievement.
Task 6 (Group D)	Weighting	To consider how LCA issues might or should be weighted for use within LEED.
Practical Tools and Methods for LEED		
Task 7 (Group E)	Available Tools and Methods Survey	To review and assess the characteristics of existing tools and methods and the extent to which they can provide a suitable, practical basis for LEED credits.
Task 8 (Group E)	Definition of Required Characteristics for LEED Tools and Methods	To determine generic requirements that any party could use in developing practical, easy-to-use, low-cost tools.
Task 9 (Group E)	Pilot Test of Tools	To conduct a pilot test of any tools that meet the requirements of Task 8, to determine users' perception of the ease of use and practicality of the tools.
Recommendations for LEED Credits		
Task 10 (Group F)	Design of Draft Credit Recommendations	The working group will recommend how to implement the results of all of the preceding tasks into the LEED Version 3 framework, from which all LEED rating systems products (i.e., LEED for New Construction, LEED for Commercial Interiors, LEED for Existing Buildings, etc.) will draw.

The eLCie System: A New Addition to the LCA Toolkit

By Deborah Dunning and Rob Watson

Deborah Dunning is founder and president of the International Design Center for the Environment (IDCE), Raleigh, N.C., and a member of UNEP-SETAC Life Cycle Initiative WorkGroup II. She has headed a large development firm, served as president of a building restoration consulting firm, and worked for the Sierra Club. She serves on work groups for the USGBC "LCA into LEED" project. A graduate of Sweet Briar College, she also attended the University of London.

Rob Watson is a senior resource specialist and director of international energy and green buildings projects for the Natural Resources Defense Council. Active in international utility issues and sustainable building issues in a dozen countries, including China and Russia, since 1987, he led environmental design efforts for NRDC's award-winning New York and Washington offices. A graduate of Dartmouth College, he holds a master's degree from the University of California at Berkeley. Watson serves as chair of IDCE and chair of the National LEED Steering Committee of the U. S. Green Building Council.

Decisions regarding the selection of materials during the construction and operations and maintenance life cycle of a building have serious impacts on the natural and indoor environments, as well as on the building's economics. While they might want to contribute to a sustainable world, many architects, engineers, developers, contractors, and facility managers feel confused about the scope and process of life cycle assessment. They want to do the right thing by the environment, but they're overwhelmed by the complexities of LCA.

To address these needs, the International Design Center for the Environment (IDCE) three years ago initiated development of the eLCie System, starting with a segment on LCA in our "KnowRoom" for the U.S. Environmental Protection Agency.

IDCE's goals for eLCie are to help make product-oriented LCAs more useful, and therefore more used, and to add to the existing spectrum of LCA tools a system for "practical LCA" that:

- Provides a scientifically robust yet user-friendly tool for product evaluation and selection
- Encourages many manufacturers to do product LCAs by being both cost and time efficient
- Insures a level playing field through an industry-specific software tool for product data collection
- Presents LCA results in an efficient manner, enabling comparison of many products on one screen
- Includes both environmental impacts and life cycle costs and links to performance standards
- Downloads easily into a number of existing specification programs, such as the Construction Specification Institute's MasterFormat 2004.

As currently conceived, the eLCie System consists of four elements: the eLCie Corporate Sustainability Index, the eLCie Industry Wizard, the eLCie Web-tool, and the eLCie Purchasing Wizard.

The eLCie Corporate Sustainability Index, developed in collaboration with Sustainable Research Group, Grand Rapids, Mich., answers questions a purchaser might have about whether a manufacturer's companywide policies integrate best practices in sustainable business. The manufacturer must answer 110 questions, achieving at least 55 points to be listed as having met IDCE's benchmark for environmental responsibility. The CEO must also sign a letter stating that the firm is committed to continuous improvement in the use of sustainable business practices.[1]

The eLCie Industry Wizard, the most complex of the four tools, entails the development of a complicated, scientifically robust data collection and analysis system that will give users key information in a simple and easy-to-understand way.

Industry-specific "wizards," starting with the eLCie Carpet Wizard, are being developed.[2] Data collection, submission, and analysis protocols must insure that data on products from a given industry are complete, comparable, and transparent.

IDCE plans to achieve such a level playing field by customizing an eLCie Wizard for key building product industrial sectors and then requiring that all participating manufacturers use this software for data collection and submission. As an added precaution, each product LCA will be reviewed by an LCA practitioner familiar with the industry in question to ensure that the data is complete, credible, and transparent. In addition, IDCE is working with the INTEND Project, an effort by the European Union to create globally accepted "product specification requirements" for each industrial sector.

When the eLCie Industry Wizard is completed for a given industry and used to create at least three full product LCAs from that industry, IDCE will integrate all of the life cycle information into a single dataset and offer it to other LCA tool developers for inclusion in their databases.

The eLCie Web-tool is the piece building design professionals will use most widely, as it is the part which will enable Building Teams to compare the environmental impacts, both individual and aggregated, of like and unlike products. In effect, it's the graphic user interface of the product LCAs generated by the eLCie Industry Wizards, presented in an easily accessible manner. It will enable decision makers to compare the environmental impacts (and, later, the life cycle costs as well) of up to 10 brand products on the same computer screen. The Web-tool will have a back engine that will store all the data on products in the eLCie System, converting that data into environmental impacts and related performance numbers using the TRACI software program developed by the U.S. Environmental Protection Agency.

The eLCie Web-tool makes building product evaluation, comparison, and selection efficient by offering the user a summary of the product LCA results placed in five product rating groups based on the performance numbers held in the back engine. Products which achieve a score that is 25% above industry average will be placed in the Registered category, followed by Silver (40%), Gold (60%), and Platinum (90%). The Platinum rating group will be reserved for products which truly achieve high performance through significantly reduced environmental impacts.[3]

The eLCie Purchasing Wizard will facilitate uploading product LCA results and life cycle costs from the eLCie Web-tool in several frequently used purchasing software programs. Currently under development, the eLCie Purchasing Wizard will utilize concepts based on the work of IDCE board member Kevin Lyons, associate director and research scientist for supply chain environmental management and policy at the Rutgers EcoComplex and author of Buying for the Future: Contract Management and the Environmental Challenge. Lyons has conducted applied research on developing and integrating global environmental, social, economic, and ethical criteria and data into supply chain and procurement systems and processes.

Ongoing Peer Review Process

IDCE is working within the "Life Cycle Initiative" framework established jointly by the UN Environment Program (UNEP) and the Society of Environmental Toxicology & Chemistry (SETAC).[4] The purpose of this initiative is to develop and disseminate practical tools for evaluating the opportunities, risks, and tradeoffs associated with products and services over their entire life cycle to achieve sustainable development. As part of its commitment to "continuous improvement," IDCE has also created an 18-person advisory panel comprised of many of the top professionals in building design, construction, life cycle assessment, manufacturing, and facility management.

The Toolkit Approach

No single tool can answer every need. The best approach, in our opinion, is to create a toolkit in which there is a spectrum of resources with different distinguishing characteristics (see chart). This will allow users to look in the toolkit to see which LCA resource would best provide the life cycle information they need.

Such a toolkit might contain a number of LCA resources. The Athena Environmental Impact Estimator is an excellent tool for assessing the likely environmental impacts of building materials and systems (rather than specific products). BEES (from the National Institute of Science & Technology) is useful for comparing the relative environmental impacts of generic products and life cycle costs during design programming.

The Sustainable Products Purchasing Coalition's EcoProfiles will offer a streamlined method to determine environmentally and socially preferable products for institutional purchasers by providing either life cycle inventory or LCA information on products. It will include summary information on various Type I, II, and III labeling claims if they are in alignment with the ISO Standard for LCA tools.

Such a toolkit would also contain the eLCie System. Beginning with industry- and product-specific data (using the eLCie Wizard), the eLCie System will enable users to compare up to 10 generic and brand products at the same time on a single screen. The eLCie System first provides the rating group in which a product is placed based on its product LCA. Then the user can click to see the performance number behind this grouping and the full product LCA. The user can then download the life cycle information into his or her specification software.

Over the next five years, IDCE will add building products from at least 10 new industries each year. These products will be added in groups—for example, "cladding materials"—in order to develop benchmark data for each industrial sector and provide incentives to manufacturers to improve the environmental footprint of their products.

[1] *Examples can be found at www.IDCE.org and www.eLCie.org.*

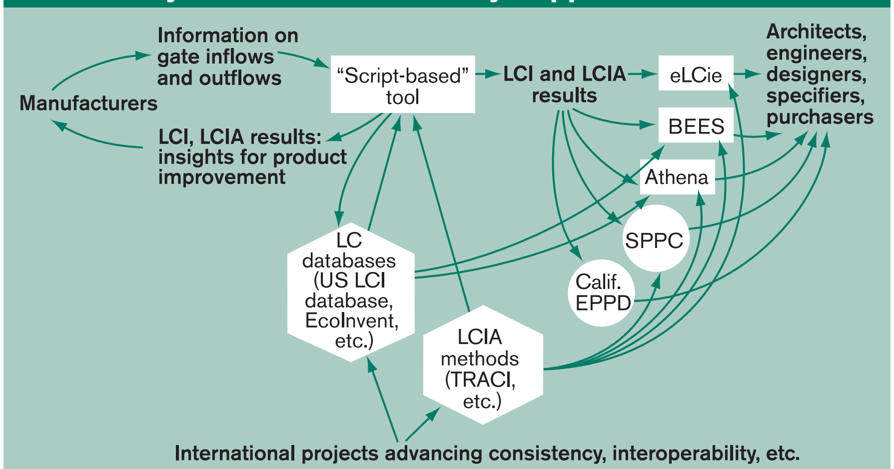
[2] *In cooperation with the Carpet & Rug Institute and these manufacturers: C & A Floorcoverings, Interface Flooring Systems, J & J—Invision, Mannington, Milliken, and Mohawk Industries.*

[3] *Building professionals and other stakeholders may comment on the beta version of the eLCie Web-tool by e-mailing: eLCieManager@IDCE.org.*

[4] *An overview of best practices, "Life Cycle Approaches: The Road from Analysis to Practice," is available at: http://www.uneptie.org/pc/sustain/lcinitiative/home.htm.*

NOTE: For the carpet industry, eLCie will be using data developed for the Consortium for Competitiveness in the Apparel, Carpet and Textile Industry by Drs. Matthew Realff of the National Science Foundation and Georgia Institute of Technology and Michael Overcash of the Journal of Cleaner Production and North Carolina State University, who have compiled datasets for latex-backed carpet broadloom and PVC-backed carpet tile.

How LCA Systems Can Be Mutually Supportive



Source: Gregory Norris, PhD, Sylvatica, "Report on Practical LCA for the IDCE Board"

LCA and the Green Globes Environmental Assessment and Rating System for Commercial Structures

By Jiri Skopek, AA Dip., OAA, MCIP, RIBA

Jiri Skopek is an architect, community planner, and technical consultant to the Green Building Initiative, the nonprofit organization which owns the rights to Green Globes for New Construction in the U.S. Through his company, ECD Energy and Environment Canada, he directed the creation and evolution of the Green Globes system in Canada and is responsible for its continued technical development. As a senior designer with Bregman and Hamann Architects, Skopek contributed to the BCE complex in downtown Toronto. He also managed Santiago Calatrava's office in Paris, was a planning consultant to the governments of Omar and Qatar, and was chief urban designer for the King Abdulaziz University in Saudi Arabia. Skopek currently serves as a representative of the Canadian committee to the ISO TC59/SC3 international team on sustainable building construction and is a founding member of Sustainable Buildings Canada.

The process of integrating life cycle assessment into green building rating systems in North America represents a fundamental shift in the way these systems have traditionally approached green building—away from a prescriptive methodology to one that relies on objective environmental performance scoring, especially in the area of material and resource use.

When the Green Building Initiative (GBI) acquired the rights to distribute the Green Globes environmental assessment and rating system in the U.S., its goal was to encourage more people to build green—by providing a tool that would serve as an educational resource during the design process as well as a rating system for completed structures.

Likewise, the GBI's efforts to further integrate LCA into the Green Globes system is intended to simplify the green design process by clarifying alternatives and facilitating informed, scientifically based choices. The system already incorporates LCA in its resource section, and work is under way to include it to a greater degree throughout. However, in so doing, the GBI faces a number of challenges, both philosophical and technical.

Few would argue with the concept of LCA, through which materials, assemblies, and even whole buildings can be compared and impartially rated in terms of a range of environmental impact indicators. However, problems have arisen because rating systems tend to base their scoring on a long-established understanding of environmental issues—conceptions which, in some cases, have taken on an aura of conventional wisdom that doesn't stand up to objective analysis.

One example is the fairly entrenched idea that it's better to choose materials or products that are manufactured locally. In many cases, this is the best environmental choice. But factors such as the type of manufacturing process and the weight of the finished products (which must be factored into transportation costs) could mean otherwise. This is an example of a prescriptive approach used as a surrogate for the underlying environmental benefits, providing guidance where scientific data is presumed to be unnecessary. LCA may challenge that presumption.

Without LCA, there is also a risk of confusing means and ends, with the means becoming objectives in their own right—at the cost of designer flexibility, and to the possible detriment of environmental performance. Instead of rewarding solar energy, for example, it makes sense for a rating system to reward any design that minimizes the use of nonrenewable fossil fuels to a similar degree, whether through solar, geothermal, wind, or other renewable energy source.

Technically, integrating LCA requires that the assessment system be predisposed to award scores based on objectively determined benchmarks, rather than a prescribed list of "green" features and strategies. This is difficult and time consuming, but it is entirely doable.

Understanding the Green Globes System

It is necessary to understand Green Globes' basic characteristics to understand how LCA is treated now and the work under way to integrate LCA more fully into the protocol.

Green Globes is a Web-based tool for building designers to use when assessing the environmental performance of new and existing structures, from project initiation to final building commissioning. Designs are evaluated through a point system, with scores based on completed measures that minimize environmental impacts. The objective is to help designers create structures that optimize resource use and operating effects, while minimizing emissions and pollution. Green Globes encourages designers to use an integrated approach by awarding points for achieving and certifying various interrelated objectives.

The system has a number of characteristics targeted to "mainstream" users who may have limited environmental design experience. Reports are written with as little jargon as possible to provide a framework for communication between the design team and client. First-time users are offered a free 30-day trial period, and its relatively low cost makes the system viable for smaller buildings, such as low-rise offices and schools. Because the system is Web-based, it requires minimal infrastructure. Green Globes also provides feedback and helps users add green attributes during the design process.

Efforts under way to more fully integrate LCA into the system are also tied to the objective of making green building more accessible to the mainstream building design and construction community. The intent is to simplify the process of comparing the environmental impacts of alternate design options and to facilitate informed choices.

Evolution of Green Globes

Although relatively new to the U.S., Green Globes has a long history.

Partly inspired by the widely known British Research Establishment's Environmental Assessment Method (BREEAM), which was brought to Canada in 1996, Green Globes underwent various iterations before becoming BREEAM Green Leaf in 1999 and Green Globes in 2002.

The U.S. version was adapted last year from its Canadian counterpart—which is one of two green building rating systems (along with LEED) recognized by the Canadian government. Under the trade name Go Green Comprehensive, it is also the basis of the Building Owners and Managers Association of Canada's national energy and environmental program for existing buildings. In adapting Green Globes for the U.S. market, the only changes made were non-substantive, such as units of measure and the addition of U.S. references and standards.

For an environmental rating system to be effective, it must evolve to reflect the latest developments in scientific thinking, technology, and societal values—as evidenced by the current effort to integrate LCA more fully into Green Globes and to introduce LCA into LEED.

This past September, the Green Building Initiative submitted an application to have Green Globes recognized as a standard by the American National Standards Institute. As per ANSI requirements, the GBI is assembling a technical committee—which will include a balance of users, producers, and interested third parties—to oversee the Green Globes system.

Green Globes and LCA

In green design, the selection of materials is a balancing act that requires designers to trade one not-so-good effect here for a desired result elsewhere. LCA is essential to fully appreciate the tradeoffs and ensure that decisions are grounded in an understanding of the various options and their consequences.

Without life cycle modeling at an appropriate level (i.e., at the level of complete assemblies or the whole building), design teams risk making unfair comparisons because they fail to account for the implications of using one material over another. For example, if a team chooses steel wall studs over wood, this could lead to the choice of one type of insulation over another, or perhaps to the choice of a different sheathing material. In this case, the full range of affected products must be taken into account to properly gauge the impact on the environment. As the design progresses and major systems are selected, direct product-to-product comparisons become relevant and LCA can be brought to bear at a different level.

However, the process of integrating LCA into green building rating systems is in its infancy.

The architects, environmental planners, and others who contributed to the development of the Green Globes system made some headway with the current version. We believed not only that LCA would become increasingly important to the design and evaluation of green buildings, but that we had an opportunity—and to some degree an obligation—to facilitate this end. By integrating LCA, even to a limited degree, our objective was to help the concept take root and encourage designers to view it as an option, in addition to rewarding its use.

Among the technical hurdles was the fact that LCA data was not consistently available in a readily usable form. Although work is being done to rectify this problem, the options were limited. Nonetheless, a case could be made for initiating the process of philosophical transformation.

At the time (the late 1990s and early 2000s), there was a general awareness in the design and construction community that LCA was the most reliable way to calculate and compare cradle-to-grave effects, though it was discussed more in theoretical than practical terms (except by those involved in research). It seemed clear that a significant shift would be required to move away from the prescriptive approach discussed above to one based purely on performance. However, even though LCA represented unfamiliar terrain, it was our experience that most designers wanted the data to base decisions on fact instead of assumptions, and they wanted control over the inevitable tradeoffs required in the selection of materials.

As it currently stands, Green Globes awards half the points in its resources section for incorporating life cycle assessment of the building assemblies and materials. This provides encouragement to conduct full or partial LCAs of foundation and floor assemblies and materials, column-and-beam or post-and-beam combinations, walls, roof assemblies, and other envelope assembly materials (such as cladding and windows).

At the schematic design stage, the system recommends the use of modeling tools such as the Athena Environmental Impact Estimator to examine the life cycle environmental effects of a complete structure or individual assemblies. This is the time that broad, conceptual issues are discussed and materials chosen that will have far-reaching implications for the structure's overall environmental impact. Users are encouraged to experiment with alternate designs and different material mixes in order to achieve the most beneficial combination—a process that is aided by the educational component of the Green Globes system.

The objective of the Athena simulation is to help the user select building assemblies with the lowest reported impact in terms of energy consumption, air and water toxicity index, global warming potential, and solid waste emissions.

At the construction documents stage, different types of decisions must be made, so designers are encouraged to use the BEES (Building for Environmental and Economic Sustainability) software to compare the environmental impact of specific products and materials. Like the Athena software, BEES measures environmental performance using the LCA approach specified in the ISO 14000 standard. It goes further, however, by combining environmental measures with economic performance measures to provide a final rating.

Next Step: Further Integration

The strategy, when LCA was introduced into the current version of the Green Globes system, was to incorporate it more fully once it was viable to do so. This process began recently with the release of an RFP for the comparative analysis of U.S. building systems.

The primary impetus is to move Green Globes away from prescriptive scoring and toward a greater reliance on quantitative and objective data—giving rise to an assessment system that rewards performance results instead of the means to achieve them.

The intent is to separately assess and rank or rate building assemblies, such as complete wall or roof assemblies, using established LCA methodology. Design teams could then be credited within the Green Globes system for using highly ranked assemblies. The Building Research Establishment has successfully used this approach in its UK BREEAM assessment system by drawing on assembly rankings in its Green Guide to Specifications.

It is also the intent to establish a relative basis from which progress can be measured. The system already incorporates benchmarking as it relates to operating energy and water use, with a score based on how the building under consideration performs against the benchmark. A similar capability must be established for comparing and scoring LCA results.

That said, it is early in the process and there are still too many unknowns to say precisely how the system will evolve. Among the issues to be investigated and resolved: At which stage of the assessment process should it be incorporated? Can the current system of performance scoring provide the necessary incentive to complete an LCA assessment? How shall targets or benchmarks be determined for various design scenarios? What type of verification is needed to ensure proper use of LCA and LCA results?

Given that the Green Globes system itself will be subject to a full ANSI review, this work will likewise be subject to review by the ANSI technical committee.

LCA and the Future of Green Design

Anyone who has tried to integrate environmental considerations into the design of a structure knows that building green is more complex than it appears. Simple rules of thumb are rare, and Building Teams are hampered by the time and resources expended searching for reliable information.

However, given the current tremendous push to obtain life cycle data for a more comprehensive range of materials, systems, and products and to incorporate it into rating systems, it's fair to say that LCA will drastically alter the way green buildings are designed. Eventually, designers will have access to quantifiable and objective data for all of their design options. Until then, there is a great deal of work to be done.

Using LCA to Evaluate Cladding Options For a New Charter School

When a U.S. charter school chose the Athena Environmental Impact Estimator (EIE) to conduct a life cycle assessment of cladding options for its new building, the intent was to combine traditional decision-making factors (such as cost and maintenance) with environmental considerations (such as the pollution produced by alternate materials).

In particular, the client wanted to understand the environmental tradeoffs inherent in choosing one cladding material over another. For example, brick cladding may require a greater initial investment than wood, but could reduce maintenance costs. Steel siding will have a greater impact on water quality, while brick fares less well in terms of energy use. The purpose of the LCA was to review and clarify tradeoffs such as these and attempt to justify a decision based on the owner's budget, maintenance concerns, and environmental considerations.

Athena's EIE software was used to evaluate four options: brick, wood siding, steel siding, and stucco. Each material was evaluated based on its relation to the others as opposed to its individual characteristics.

In the accompanying figure, the environmental impact of steel siding on a per unit basis has been normalized to make it 100% across all categories; the other materials are compared to that baseline. Because certain assumptions were made (for example, the service life of the building was set at zero, meaning that maintenance and end-of-life issues were not factored in), these are basic estimates as opposed to absolute life cycle performance indicators.

As the figure indicates, brick has a high initial impact in every category except water pollution, while stucco and wood have the lowest. However, to guide a final decision, the service life of the building must also be considered.

If a 40-50 year service life is realistic, shorter term environmental considerations are important, as are issues related to deconstruction and recycling. On the other hand, a building intended to last 100 years or more raises other issues, such as functional malleability, which allows future tenants to be accommodated without the need for demolition.

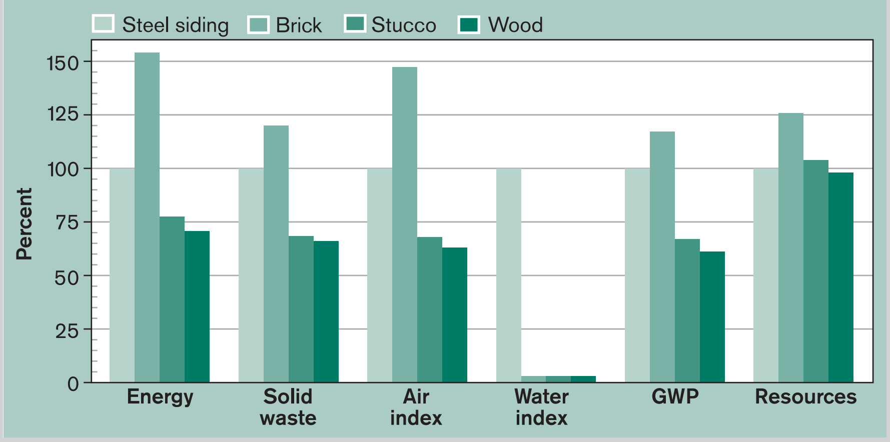
Based on the above factors, it was determined that, for a building intended to last less than 50 years, wood has the least environmental impact, followed by stucco, steel, and brick, in that order. If a longer life is intended, wood's benefits decrease relative to the other materials because of maintenance requirements, with brick becoming more beneficial as the timeframe is extended.

In the end, the developer placed a high priority on a very long service life with minimal maintenance and chose brick—but used recycled brick to ensure as low an environmental footprint as possible within this product category.

The point is that every material has its own environmental footprint. LCA techniques allow designers to consider all the various factors—in this case, manufacturing and construction impacts, service life and maintenance requirements, appearance, and the desired service life from the developer's perspective—to be viewed in a holistic decision framework.

Comparison of All Measures

(with steel siding as project baseline normalized at 100%)



MasterFormat 04 and LCA

By Paul R. Bertram, Jr., FCSI, CDT, LEED AP

Paul R Bertram, Jr., is a fellow of the Construction Specifications Institute and principal of PRB Planning, Orlando, Fla., specializing in green building product marketing strategies. He is chairman of ASTM E 2129 Data Collection for Determining the Sustainability of Building Product and is a member of the Florida Green Building Coalition and the Sustainable Building Industry Council. He serves on the U.S. Green Building Council's Materials and Resources Technical Advisory Group.

MasterFormat and life cycle assessment are two separate but useful tools that can be utilized to organize and report information.

The process of evaluating and specifying sustainable building products in green building projects requires many complex considerations that go beyond the analysis of basic performance criteria typically found in specifications.

Many green building experts strongly advocate LCA as the accepted methodology to scientifically understand all the synergies and tradeoffs required to properly select products, components, systems, and assemblies for a project.

LCA as related to evaluating and specifying building products requires the reporting of data points that represent a wide spectrum of environmental information, including: fossil fuel depletion, other nonrenewable resource use, global warming potential, stratospheric ozone depletion, ground-level ozone creation (smog), nitrification and eutrophication of water bodies, acidification and acid deposition (dry and wet), and toxic releases to air, water, and land.

Currently, LCA evaluation for environmental impacts and attributes of products, components, and systems as related to specific green building criteria is in the draft protocol phase of development and application.

As a result, LEED credits have become the de facto criteria for product evaluation, even though LEED focuses primarily on environmental attributes at the expense of performance and durability.

The Construction Specifications Institute's first recommendation in product evaluation begins with CSI Form 20.1—The Product Knowledge Checklist, in accordance with CSI's Project Resource Manual.

The list calls for reporting on numerous aspects of the product: the product's advantages, available information for specifiers, characteristics and uses, compliance data, competitive product comparison, environmental/energy concerns, life expectancy, how the product is manufactured and its raw materials contained, initial cost, installation methods, interface with other products, limitations, long-term costs, rated capacity, and sources of supply.

During early costing analysis of a project, systems and assemblies are analyzed for the purpose of preliminary budgeting.

CSI's UniFormat classifies these systems and assemblies into a logical sequence:

Project Description
- A. Substructure
- B. Shell
- C. Interiors
- D. Services
- E. Equipment and furnishings
- F. Special construction and demolition
- G. Building site work
- Z. General

This forms the basis for organization of LCA outputs from the Athena Environmental Impact Estimator. This tool assists with material selection in the context of LCA of an entire building and focuses at the level of whole buildings or complete building assemblies and therefore captures the systems implications of product selections related to a building's structure and envelope. UniFormat provides an organizational platform to report the LCA outputs. These can be used to arrange brief project descriptions and preliminary cost information. The General Services Administration uses UniFormat in its costing analysis.

Selection of building materials usually begins with performance requirements, aesthetics, and costs before environmental attributes are considered. Performance criteria are typically written into project specifications and organized in the project documents according to CSI's MasterFormat, which is the organizational standard for the written instructions for construction work results and other information for most commercial, industrial, and institutional building projects in the U.S. and Canada.

The 2004 edition of MasterFormat is the result of a significant rewrite over the last few years and now represents the work results over the life cycle of a project. In order to better accommodate the life cycle of a project, MasterFormat 2004 Edition expanded from the traditional 16 divisions to 50 divisions.

MasterFormat and 'CSI Format'

MasterFormat 2004 works in conjunction with SectionFormat and PageFormat. Dennis Hall, FCSI, FAIA, committee chair of the MasterFormat expansion, calls these three documents "CSI Format," as they converge into the project manual.

For example, LCA requirements on a project would be written into Division 01 of MasterFormat 04, while LCA requirements and sustainable reporting for products would be organized within SectionFormat and PageFormat in their respective divisions.

Commercial specification system developers (including BSD SpecLink by Building Systems Design, Inc.) feature several automated LEED submittals for many sections. MasterSpec (by ARCOM) features 95+ sections with LEED requirements, text, or commentaries within each section.

The Athena EIE and NIST's BEES and can be referenced in the administrative section of Division 01.

There are also a number of CSI forms that have been created specifically to report product and project information relating to instructions within the MasterFormat guidelines. Currently, the CSI Sustainable Facilities Task Team LCA requirements can be listed in Division 01 and under 01 30 00 in the administrative requirements. These instructions then set the parameters for other specification requirements. The additional specification requirements will incorporate SectionFormat and PageFormat.

SectionFormat provides a uniform approach to organizing specification text continued in a project manual. These parts organize text consistently within each section. The 1997 edition describes the function and content of each of the three parts, addresses environmental concerns, and reflects revisions and updates made in the 1995 edition. It is currently being updated to reflect changes in MasterFormat 04.

PageFormat describes the recommended arrangement of text on a specification page. It provides a system for consistently formatting and designating articles, paragraphs, and subparagraphs, and includes guidance for page numbering, margins, and other aspects of formatting. It is also being updated.

Some of the references may include industry standards, nongovernmental organizations, and third-party certification. For example, in Part 1 of SectionFormat, references such as ASTM E 2129-01 Standard Practice for Data Collection for Sustainability Assessment of Building Products could be referenced. This applied standard offers a set of instructions for collecting data to be used in assessing the sustainability of elements or products for use in both commercial and residential buildings.

This standard is intended to help manufacturers that are self-reporting data to understand basic information areas that are relative in environmental assessment. The data reported from ASTM E 2129 could be considered in LCA preliminary scoping. It should be noted that as of this writing ASTM E 2129 is the only ASTM standard for reporting product information.

LCAs provide data created from a scientific process that should provide a level playing field for the comparison of building material environmental impacts. However, LCA is not the sole answer to product selection; ultimately, it will become yet another tool to help Building Teams understand the tradeoffs in the selection of building products.

The use of LCA to support specification of environmentally preferable products (EPP) can be enhanced by reducing the data-reporting burden on manufacturers, lowering the cost of LCA studies, and elevating the availability of LCA results for a relevantly wide set of product alternatives. The use of LCA for EPP identification can also be promoted through specification organized within MasterFormat.

Digital design and Web-based communication systems make some tasks easier, but the underlying information still must be addressed, used, and communicated precisely by Building Teams. The storage and effective use of this information throughout the structure's life cycle is extremely complex. Even in the most sophisticated communication environment, data must be accessed using a meaningful taxonomy within a classification system that is navigable by all.

OmniClass will eventually be used by all industries involved with creating and sustaining the built environment—from conception though demolition—and will be the basis for organizing, storing, and retrieving information and deriving relational applications.

Achieving reasonable results in product evaluation requires the review of as many issues as possible and the effort to use the most cost-effective green building strategies available for a given project. Until LCA becomes a clearly defined protocol with supporting tools for product evaluation, there will continue to be market confusion.

The U.S. Green Building Council has created the momentum behind the reality of LCA becoming a required practice in building product evaluation. Thanks to the development of BEES and the Athena EIE tool, along with LCA efforts by building product manufacturers, a better understanding of data information needs has been realized.

MasterFormat has expanded to represent the life cycle of the structure and has appropriate areas to instruct designers as to sustainable project requirements. It is organized for the inevitable change that sustainable design and LCA reporting will generate.

The debate will go on as to what products require LCA, third-party verification, and acceptable parameters for self-reporting of environmental data. The answer is education, research, and a business model that embraces and supports green building principles.

MasterFormat 2004 Edition Division Numbers and Titles

Procurement and Contracting Requirements Group

Div. 00	Procurement and Contracting Requirements

Specifications Group

General Requirements Subgroup

Div. 01	General Requirements

Facility Construction Subgroup

Div. 02	Existing Conditions
Div. 03	Concrete
Div. 04	Masonry
Div. 05	Metals
Div. 06	Wood, Plastics, and Composites
Div. 07	Thermal and Moisture Protection
Div. 08	Openings
Div. 09	Finishes
Div. 10	Specialties
Div. 11	Equipment
Div. 12	Furnishings
Div. 13	Special Construction
Div. 14	Conveying Equipment
Div. 15	Reserved for Future Expansion
Div. 16	Reserved for Future Expansion
Div. 17	Reserved for Future Expansion
Div. 18	Reserved for Future Expansion
Div. 19	Reserved for Future Expansion

Facility Services Subgroup

Div. 20	Reserved for Future Expansion
Div. 21	Fire Suppression
Div. 22	Plumbing
Div. 23	HVAC
Div. 24	Reserved for Future Expansion
Div. 25	Integrated Automation
Div. 26	Electrical
Div. 27	Communications
Div. 28	Electronic Safety and Security
Div. 29	Reserved for Future Expansion

Site and Infrastructure Subgroup

Div. 30	Reserved for Future Expansion
Div. 31	Earthwork
Div. 32	Exterior Improvements
Div. 33	Utilities
Div. 34	Transportation
Div. 35	Waterway and Marine
Div. 36	Reserved for Future Expansion
Div. 37	Reserved for Future Expansion
Div. 38	Reserved for Future Expansion
Div. 39	Reserved for Future Expansion

Process Equipment Subgroup

Div. 40	Process Integration
Div. 41	Material Processing and Handling Equipment
Div. 42	Process Heating, Cooling, and Drying Equipment
Div. 43	Process Gas and Liquid Handling, Purification and Storage Equipment
Div. 44	Pollution Control Equipment
Div. 45	Industry-specific Manufacturing Equipment
Div. 46	Reserved for Future Expansion
Div. 47	Reserved for Future Expansion
Div. 48	Electrical Power Generation
Div. 49	Reserved for Future Expansion

Source: Construction Specifications Institute
www.csinet.org/masterformat

Shannon Lloyd, PhD, Anne Landfield, and Brian Glazebrook make up the Life Cycle Management service team at First Environment, a global strategic environmental management and engineering consulting firm headquartered in New Jersey. Combined, they have over 25 years of experience with LCA, green design, and the green building industry, and are members of the USGBC's LCA into LEED Task Force.

Dr. Shannon Lloyd is a senior environmental specialist in the firm's Washington, D.C., office. She has conducted LCA's of products for a wide range of industries and has held engineering and management positions in several industries. She earned a PhD in engineering and public policy and an MS in civil and environmental engineering from Carnegie Mellon University.

Anne Landfield is a senior environmental specialist in the Portland, Ore., office. She has worked extensively with the metals and mining industry on LCA and developed an LCA handbook for corporations under the auspices of the UNEP Life Cycle Initiative program. She holds an MS in environmental management from Duke University.

Brian Glazebrook is a senior associate in the Washington, D.C., office. He has experience providing design for environment support to a range of industries, and has led the company's support for the BEES software tool. He holds an MS in environmental science and an MA in public affairs from Indiana University.

Integrating LCA into Green Building Design

By Shannon Lloyd, PhD, Anne Landfield, and Brian Glazebrook

During the design process, a broad range of stakeholders—architects, engineers, designers, contractors, subcontractors and owners—combine technical expertise to produce one-off buildings with long life spans. They must consider the consequences that their decisions have on many performance criteria—building cost, intended functionality, and occupant comfort, safety, and aesthetics. Green building design is an integrated design approach for evaluating and minimizing the potential environmental impacts of a building while also evaluating and optimizing the many other performance criteria.

The green building design process focuses on using energy, water, and materials more efficiently in the design and operation of a building. Green buildings often combine strong environmental performance with increased economic, health, and productivity performance. While decisions made throughout a building's useful life influence the impact it can have on the environment, the critical time to employ green building principles is during the design process.

The top figure on page 53 shows a hypothetical comparison of when committed and incurred environmental impacts occur. It assumes that the determination and realization of environmental impact during a building's life cycle follow a similar pattern to that of building cost. The horizontal axis represents the building life cycle stages. During site selection and early design, various sites and building types are considered. In later design phases, the specific design of the building and the materials, components, and systems that will be used are selected. Most of a building's material, energy, and environmental loadings are likely to be committed during the design phase, whereas the environmental impacts attributed to a building occur largely during its use phase and may extend beyond the building's useful life. The opportunity to reduce the building's environmental impact decreases substantially after it has been designed and built.

Green Building Design and LCA

Evaluating the environmental consequences of a specific building design is difficult because every building is a unique, complex system of interrelated components and subsystems. Efforts to optimize a single performance criterion, such as environmental impact, may affect other performance criteria. Given the long life cycles of most commercial, industrial, and institutional structures, reducing the environmental impact requires designers to use long-range planning horizons. Finally, environmental impact depends not only on the building system, but also on its interaction with the natural environment and its occupants.

In order for Building Teams to be able to balance environmental concerns with other performance requirements, they need clear and concise information. For certain decisions during the design process, qualitative guidance, such as design checklists or guidelines, make sense. For other decisions, however, qualitative information may not be sufficient for evaluating the environmental tradeoffs between different building materials, products, and designs. In this case, quantitative information, such as that generated through a life cycle assessment, provides the most value.

LCA provides a systematic approach to evaluating the environmental impacts of a product or system over its entire life cycle. As the lower figure on page 53 shows, the building life cycle includes the extraction of raw materials that make up the building, manufacturing building components or products, transporting and installing building materials and products, and operating, maintaining, and decommissioning the building. By integrating LCA into the building design process, design and construction professionals can evaluate the life cycle impacts of building materials, components, and systems and choose the combinations that reduce the building's life cycle environmental impact.

Several types of green building tools have been developed to help building designers incorporate LCA into building design. They can be used to guide general building planning, select building materials and components, and evaluate complete building designs. The amount of LCA expertise and time required to employ the different types of tools varies widely. The appropriate tool depends on a project's specific environmental objectives and budget.

The following tools have been used to incorporate LCA into building design: green building standards and rating systems, tools for evaluating building materials and components, software for evaluating whole buildings, and general LCA software.

1. Green Building Standards and Rating Systems

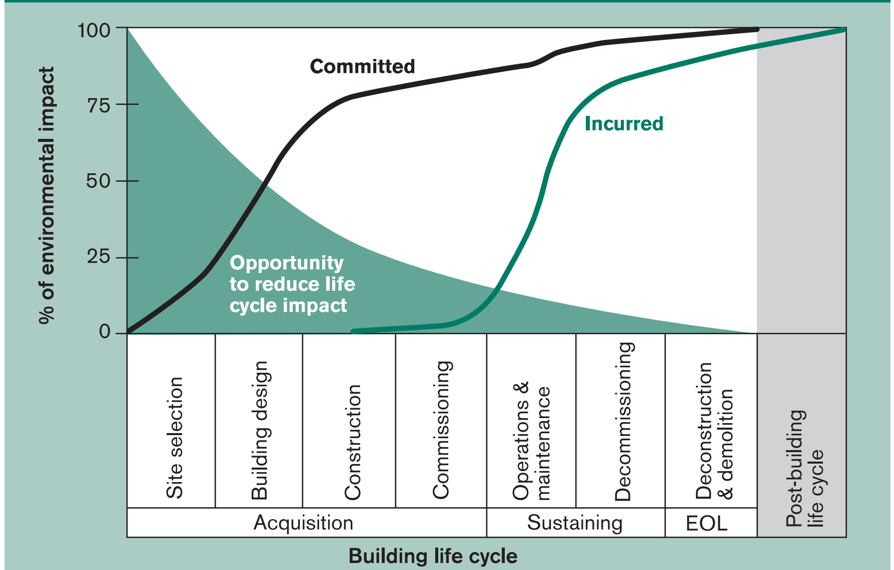
Standards and rating systems prescribe practices for reducing the environmental impact of buildings and some certify buildings meeting these standards. Some green building standards and rating systems are based on general guiding principles—for example, giving preference to recycled material. Other rating systems take a more comprehensive approach, using a more holistic life cycle framework. For example, the United Kingdom's Building Research Establishment Environmental Assessment Method (BREEAM) rating system uses LCA-based materials credits. The Green Globes assessment protocol awards points for using LCA. The U.S. Green Building Council is studying approaches for incorporating LCA into its LEED green building rating system. In general, building standards and rating systems require little or no expertise in life cycle assessment to be useful to building professionals.

2. Tools for Evaluating Building Materials and Components

LCA databases and software have been developed to help building professionals select building materials and components. Results of life cycle studies are embedded in the tool, allowing building professionals to readily compare the life cycle impact of different materials and components. This information can be used to guide material and component specification and procurement.

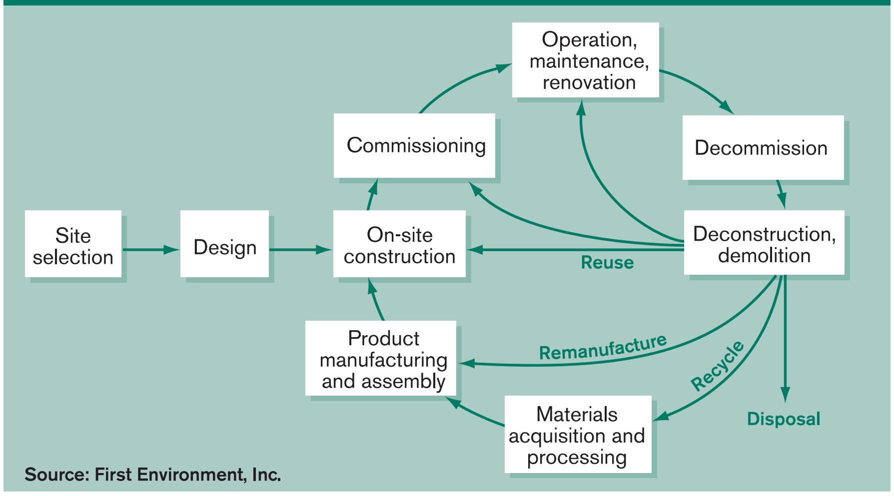
The National Institute of Standards & Technology's (NIST) Building for Environmental and Economic (BEES) software is one of the most widely used material and product oriented LCA tools available to Building Teams. It is a publicly available Windows-based decision support software that enables designers and builders to evaluate the environmental and economic performance of several hundred building products. Among the categories of products found in BEES are framing, exterior wall finishes, wall sheathing, wall and attic insulation, roof coverings, interior wall finishes, floor coverings, slab on grade, beams, and parking lot paving. The key benefit of using software such as BEES is that users don't need to know the intricacies of conducting LCA studies and very little time is required to evaluate the material or product of interest.

Hypothetical Comparison of Committed Versus Incurred Environmental Impact



Source: First Environment, Inc.

Typical Building Life Cycle



Source: First Environment, Inc.

Building professionals may want to use material- and component-focused tools embedded with LCA data when they wish to:

- Compare the environmental implications of different materials or components for a defined building application.
- Select environmentally preferable materials or components.
- Identify cost-effective green materials and products.
- Assess the range of options of building materials for a defined building application

Another important resource for obtaining high-quality, consistent LCI data is US LCI database, which is managed by the High Performance Buildings Initiative at the U.S. Department of Energy's National Renewable Energy Laboratory. This database contains U.S.-specific data for building and construction products, as well as other products and technologies. All building products contained in the next version of BEES, due to be released in June 2006, will be included in the U.S. LCI Database. Databases such the US LCI Database, used on its own or implemented in software like BEES, strive to provide high levels of data quality and consistency in analysis methods so that Building Teams can compare various building products fairly using life cycle assessment.

3. Software for Evaluating Whole Buildings

Evaluating the environmental implications of individual building materials and products becomes more complex when the goal is to evaluate or reduce the total environmental impact of a specific building during its lifespan. The choice of a specific building material, component, or system often influences other design decisions. For example, selecting either a wood, steel, or concrete structural system affects the extent and type of insulating material that can be used. Overall building performance depends on the interactions between individual components and subsystems as well as interactions with the occupants and the natural environment.

Several software tools seek to assess overall building design. Like the material and component LCA tools described above, whole building LCA tools use embedded life cycle inventory data for individual building materials and components, but they go one step further, taking a more holistic and integrated design approach that assesses how different building components, assemblies, and subsystems interact with each other to impact overall building performance

One such tool is the Athena Institute's Environmental Impact Estimator, which can be used to assess the environmental implications of industrial, institutional, office, multiunit, and single-family residential designs. The Athena EIE can simulate over 1000 different building assembly combinations. Other whole building LCA tools include Envest from the U.K.'s Building Research Establishment and EcoQuantum from IVAM in the Netherlands.

The level of LCA knowledge and time required to use whole building LCA tools varies. Building Teams may find these tools useful when they want to:

- Develop a comprehensive environmental life cycle model of a building design.
- Compare the environmental impacts of different building designs.
- Evaluate how substituting different materials or components in a building design affects its overall environmental impact.

4. General LCA Software

Commercial life cycle assessment software (such as SimaPro, GaBi, Umberto, and TEAM) can be used to conduct a comprehensive LCA of specific building materials and components or of specific building systems. These programs include extensive LCI databases that are not restricted to building products, provide an interface for modeling additional product life cycles, and analyze and report the life cycle environmental impact of modeled products.

General LCA software gives users more control over the life cycle inventory data, underlying assumptions, model development, and impact assessment. For example, such LCA software could be used to generate a detailed model of a specific building, assess its overall environmental impact, and evaluate an almost infinite number of material and component substitutions and design alternatives.

General LCA software requires a level of expertise that usually exceeds that of most building professionals, which means internal LCA expertise must be developed or a consultant must be hired. The software itself must be purchased, along with fees for annual data updates. In addition, collecting original life cycle inventory data can be time-consuming and expensive.

Selecting an Appropriate Tool

The four different types of tools for incorporating LCA into building require different levels of LCA knowledge, ranging from no LCA background to highly specialized LCA expertise. Each tool provides a different level of decision support, ranging from general prescriptions for reducing the environmental impact of buildings to detailed analysis of a specific building design.

The appropriate tool depends on the specific environmental objectives of the project. In general, building standards and rating systems are used to obtain green building certification and labels, material and component LCA tools are used to select and procure environmentally preferable building materials and components, whole building LCA software is used to model and evaluate whole building designs, and general LCA software is used to conduct detailed LCAs of specific building materials, components, and designs.

LCA into the Future: Going Global, Getting Social

By Gregory A. Norris, PhD

Gregory A. Norris founded and directs Sylvatica, based in North Berwick, Maine. He manages the life cycle inventory program for the United Nations Environment Programme/SETAC Life Cycle Initiative, and teaches graduate courses on LCA and Industrial Ecology at the Harvard School of Public Health, where he is a visiting scientist. He consults on LCA and sustainable consumption and is the founder and executive director of New Earth, a global foundation for grass-roots sustainable development. Norris has developed several software tools to assist analysis and decision making related to LCA and sustainable enterprise. He is an adjunct research professor at the Complex Systems Research Center, University of New Hampshire, program associate in the Center for Hazardous Substance Research at Kansas State University, and an editor of the International Journal of Life Cycle Assessment. *He holds a bachelor's in mechanical engineering from MIT, an MS in aeronautics and astronautics from Purdue, and a PhD in natural resources from the University of New Hampshire.*

Three decades ago, as the environmental movement was just beginning to gain credibility and acceptance, small teams of engineers and physicists in the U.S., continental Europe, and the United Kingdom, acting independently, were called upon by corporations and government policy makers to provide a comprehensive account of the environmental and resource implications of a popular new consumer item—disposable plastic packaging and bottles. Each of these teams invented a methodology that subsequently, in the 1990s, came to be called environmental life cycle assessment.

With the rise of "product policy" and "extended product (or producer) responsibility" in the 1990s, LCA shifted from a little-known cottage industry to become an internationally standardized analytical tool in support of environmental management. LCA is now used by thousands of companies, by many governments, by consumer and environmental groups, and even by the United Nations Environment Programme, to shed light on the "cradle-to-grave" environmental consequences of product-related decisions.

In 2002, the leaders of many of the world's national governments, along with representatives from industry and civil society, converged in Johannesburg at the World Summit on Sustainable Development. At this meeting the participants took stock of the successes and failures of the past 30 years, and looked ahead to the promise and perils facing humanity in relation to the challenge of sustainable development—development which, according to the popular definition from the Brundtland Commission, meets the needs of the present with out sacrificing the ability of future generations to meet their needs.[1]

Among other outcomes, the World Summit led to a "Plan of Implementation for Changing Unsustainable Patterns of Consumption and Production." Among the key elements of this plan is a call to "improve the products and services provided, while reducing environmental and health impacts, using where appropriate, science-based approaches, such as life cycle analysis."

Thus, life cycle analysis (or, as it has been called throughout this White Paper, life cycle assessment), originally developed to inform environmental policies at the dawn of modern environmentalism, finds itself called upon to assist the current search for sustainable patterns of consumption and production. This article takes a look at the future of LCA in the context of two important trends: 1) the widening geographic scope of participation in LCA and 2) the increasing scope of impacts, including social impacts, being examined in life cycle assessments.

Widening Geographic Scope of Participation in LCA

Until the 1990s, nearly all LCA activity took place in Europe and North America. This activity included: a) development of the databases of "inventory data" about the pollution and resource flows in product supply chains; b) development of methods for impact assessment, which aggregate pollutant and resource flows in terms of their relative expected strength of influence on different impact categories; and c) applications of LCA within companies and by policy makers. During the 1990s, first Japan and later Australia and Korea saw significant increases in LCA activity. However, until the 21st century, LCA activity in the rest of Asia, in Latin America, and in Africa was quite limited. This has begun to change, and quite dramatically.

It should be noted, however, that at Johannesburg, the call for activity on "sustainable consumption and production" and life cycle methods was resisted by many developing nations, for fear that it represented a potential barrier to trade. The concern stemmed from the observation that companies operating in the rich nations had greater financial resources and greater levels of prior investment in pollution controls and efficient use of energy and material inputs. From this basis, officials from developing nations feared that life cycle-based methods such as eco-labeling would favor the products produced in the richer countries, blocking imports from developing regions of the world. This concern continues to be raised.

At the same time, however, activity in life cycle assessment is rapidly growing in Latin America, and to a lesser but still significant extent in South Asia and Africa. The Brazilian government recently launched a national project to develop life cycle inventory data. LCA practitioners are also actively developing data and impact assessment methods and applying them in

[1] *WCED, World Commission on Environment and Development, 1987. Our Common Future. Oxford: Oxford University Press.*

the public and private sectors in Mexico, Argentina, Chile, Colombia, Peru, and other nations in Latin America and the Caribbean. Several of these countries have initiatives for national-level purchasing of "environmentally preferable products" which include the development of life cycle-based criteria for environmental preferability.

At the global level, the United Nations Environment Programme (UNEP) and the Society for Environmental Toxicology and Chemistry (SETAC) teamed up to launch the Life Cycle Initiative.* The variety of global task forces operating under this initiative share the goals of raising the availability, credibility, capability for, and comparability in life cycle management approaches, inventory data bases, and impact assessment methods worldwide. The initiative has helped spawn and strengthen regional LCA networks in Africa, Latin America, and South Asia. The African LCA Network recently hosted an LCA training workshop in which the participants began the development of life cycle inventory data for their respective countries, starting with the supply chains up to and including the generation of electricity.

Increasing Scope of Impacts

As LCA activity grows in developing regions, so does the influence of those regions upon LCA itself. One way this will increasingly take place is by adding new categories of impact. Historically, LCA impact categories have focused on direct damages to the environment, environmental pathways to human health impacts, and depletion of natural resources. Thus, among the three "pillars" of sustainability—environmental, economic, and social—LCA historically focused strictly on the environmental pillar. Within this pillar, increased LCA activity in new regions is bringing new impact categories, such as soil salinization from irrigation.

As noted above, environmental issues are increasingly seen by stakeholders and companies alike as embedded within the broader context of sustainable development and corporate social responsibility. As LCA opens up to these other types of impacts, it can help decision makers avoid "burden shifting" among the social, environmental, and economic objectives, and highlight ways that purchasers and product designers can drive not only environmental improvement but social and economic progress—perhaps especially in the developing world, where needs and opportunities are greatest.

Here we touch on two ways in which this expansion can take place. First, by integrating economic models and databases, LCA is able to address impacts and performance measures which are routinely tracked at the level of economic sectors rather than engineering unit processes. An example of such an impact group is occupational health and safety. A recent investigation concluded that the health effects of occupational health and safety issues and incidents in product supply chains appear to be in the same order of magnitude as the expected near-term human health consequences of supply chain pollution releases.[2]

Secondly, integrating economic modeling approaches and databases into LCA allows us to acknowledge that product supply chain activities bring *benefits*—as well as burdens to the agenda of sustainable development. Sustained growth in economic output in developing countries is linked to major gains in human health, through the mechanisms of poverty reduction, greater investment in and access to education, and increased public investments in the public health infrastructure.[3] As we have seen, traditional LCA, with its focus on pollution impacts and a blind eye to development benefits, is seen by some in developing countries as biased against their primary concerns. By addressing the benefits of economic development alongside the costs of pollution and resource degradation, extensions of LCA have the potential to address these concerns head-on, empowering purchasers and building designers to harness the power of product supply chains to reduce poverty and improve public health.

The 2002 European Health report underlines the relation between socioeconomic factors and health. Poverty, in particular, is recognized as "the most important single determinant of ill health." The report notes the influence of gross domestic product on health at the national level, and explained: "While GDP [has] a significantly positive correlation with life expectancy, this relationship works mainly through the impact of GDP on a) the incomes of the poor and b) public expenditure ... faster economic growth with a strong employment component [leads to] the enhanced economic prosperity being used to expand relevant social services such as education, social security and health care. … Unemployment as a cause of poverty and ill health is a major issue in all European countries."[4]

The importance of poverty in the global burden of disease is even clearer in the World Health Organization's 2002 report, which found that "in both Africa and Asia, unsafe water, sanitation and hygiene, iron deficiency, and indoor smoke from solid fuels are among the 10 leading risks for disease. ... As with underweight, these risks con-

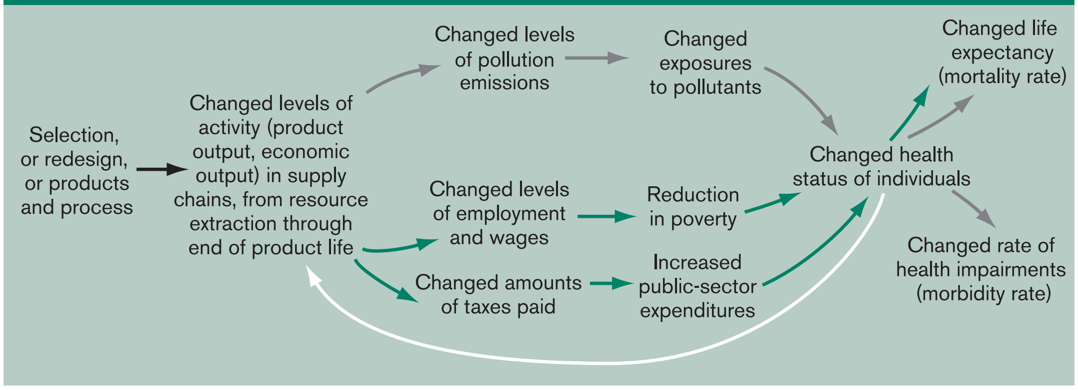
* *www.uneptie.org/pc/sustain/lcinitiative/home.htm*

[2] *Hofstetter, P. and G. Norris, 2003: "Why and how should we assess occupational health impacts in integrated product policy?" Environmental Science and Technology 37(10):2025-2035.*

[3] *World Bank, 2001. World Development Report 2000/20001: Attacking poverty. Washington, D.C.*

[4] *WHO Europe, European Health Report 2002, Copenhagen, 2002.*

Pathways from Product Decisions to Human Health Outcomes



tinue to be some of the most formidable enemies of health and allies of poverty."[5]

Health and socioeconomic status influence each other in both a vicious and virtuous way: On the one hand, improvements in health promote economic development over time, while research shows that countries with the weakest conditions of health and education find it much more difficult to achieve sustained growth than do those with better conditions of health and education.[6]

Pathways from product decisions to human health outcomes are charted in the accompanying figure. The gray arrows indicate the pathways traditionally modeled in LCA, from process activity levels to human health. These pathways start with increased pollution emissions, leading to changed levels of human exposure to hazardous substances. The final health impacts may be measured strictly in terms of mortality impacts (e.g., life-years lost), or may also include non-lethal impacts on health (impaired functioning, chronic pain, and other morbidities).

Green arrows indicate the new pathways addressed in this paper. They show how changed levels of economic activity throughout the supply chain lead to the two impacts on socioeconomic pathways to health. For example, increased output will increase employment or wages (or both), as well as tax receipts by the government. These in turn will reduce income poverty, and thereby increase individuals' health status—provided the wage and employment benefits reach people who are otherwise in poor socioeconomic status. Likewise, increased tax receipts by the government can improve health if the greater amount of tax receipts results in an increase in health-promoting public investments.

Long-term benefits of an incremental increase in GDP vary significantly by country. In general, in countries below $5000 per capita GNP, there is a very steep influence of economic growth on life expectancy; while above $5000 per capita, the influence becomes much slighter. International data on life expectancy and GDP per capita were used to develop a country-level simplified model of the possible health gains from product life cycle output at the country level. These factors were used in a multi-nation LCA case study of Dutch electricity production, which found that while less than 10% of the economic output in the this commodity's supply chain takes place in developing countries, this output has the potential to bring gains in life expectancy which may well exceed the total health impacts from the life cycle pollution.[7]

Now, economic development does not occur in a vacuum. The construction and operation of a major factory in most locations on earth—in industrialized countries and especially in developing countries—have significant impacts on lifestyles, social dynamics, and even the culture of the affected region.

The results of the preliminary investigations cited above indicate that the average, long-term influences of socio-economic development on health can be at least as powerful as the pollution consequences of the related processes. Combining this finding with the reality that there are profound differences in the social influences of new economic output per year from one location to another leads me to make two forecasts for socio-economic impact evaluations within LCA:

1) Social impacts of product life cycles, on health and other impact indicators, are profound, especially within developing countries.

2) Addressing social impacts in life cycle assessment will pose major new challenges—and opportunities—to develop and apply entirely new systems for publishing and using site-specific information in life cycle assessments.

[5] *WHO 2002: World Health 2002. Geneva: World Health Organization, pp. xiv-xv.*

[6] *Commission on Macroeconomics and Health. Macroeconomics and health: investing in health for economic development. Geneva: World Health Organization, 2001.*

[7] *See, for example, Norris, 2003: "Life Cycle Sustainable Development: Evaluating the health impacts of income changes and development in life cycle assessments", available via http://unit.aist.go.jp/lca-center/english/symposium/e-program031212.html, and Norris, Suppen, Ugaya, and do Nascimento, 2005, "Socio-economic impacts in product life cycles", in Caldeira-Pires, Armando, ed., 2005: Life Cycle Assessment in Latin America.*

White Paper Action Plan

In two previous White Papers, the editors of *Building Design & Construction* have offered positive recommendations to our 76,008 subscribers, the U.S. Green Building Council, government officials, NGOs, environmental groups, and others involved in the sustainable design and construction movement.

The following scorecard offers a review of progress to date, with recommendations for future action. We start with past Action Plan items with positive outcomes.

Federal Initiatives

1. Convene a White House Conference on Green Building.

The Office of the Federal Environment Executive, under OFEE Director Edwin Piñero, will sponsor a White House Summit on Sustainability on January 24-25, 2006. Although plans were tentative at publication time, the summit is expected to draw 200-250 to Washington for high-level discussions of green building issues. The summit will undoubtedly have the effect of spotlighting the green building movement in the media. Score one for the OFEE.

2. Sign a Memorandum of Understanding at the senior federal staff level promoting best practices in green building for federal departments and agencies, and issue an Executive Order to that effect.

This "MOU" has been in the works for two years, and, at this writing, it appears that the Bush Administration will indeed issue it at the White House Summit in January. Such a memorandum would energize federal departments and agencies to take positive steps with regard to sustainability in federal construction projects; it's also possible that the MOU could morph into an even more powerful Executive Order. One point for the OFEE, the Office of Management and Budget, the Federal Green Building Council, and the Interagency Sustainability Working Group, which initiated the MOU process.

While we're at it, we also applaud the OMB and OFEE for coming through on our recommendation (in the 2003 White Paper) to establish the Federal Green Building Council, a senior-level group within the administration charged with establishing green-building policy.

State and Local Initiatives

3. Develop model guidelines for green-building legislation and regulation at the state and local level.

There is a need to provide guidance to governors, mayors, and county officials on their options for introducing sustainability laws or regulations into their jurisdictions. Too many politicians have simply jumped on the LEED bandwagon without considering whether LEED is the best option for local conditions. However, on a more positive note, Portland, Ore., has steadily adapted LEED to meet local climatic, economic, and social conditions. Likewise, the city of Chicago has been streamlining its building permit process for green projects, giving priority of staff time to projects that clearly have a positive environmental agenda. Kudos to these cities, and let's see other cities and states use some imagination when it comes to green building laws and regulations.

USGBC Initiatives

4. Admit trade associations to the U.S. Green Building Council.

In a somewhat surprising move, the USGBC Executive Board voted to overturn the council's longstanding opposition to membership. The rationale behind this had to do with the USGBC planning to have LEED go through the standards-setting process set up by ANSI, the American National Standards Institute. Industry groups had for years complained that LEED should not be adopted by federal agencies, state governments, or municipalities because (they said) the LEED system failed to meet ANSI rules for transparency and consensus building.

Score one for the USGBC board and CEO Rick Fedrizzi for using sound business judgment, and to the trade groups that pushed for membership. Now it is up to trade associations that choose to join the USGBC to show that they can be honorable members and uphold the mission and goals of the council. Any trade groups that disrupt the council's mission should be disciplined or expelled. As a loyal member of the USGBC, we at *BD&C* will be the first to call attention to any inappropriate activities by trade groups with regard to disrupting the council's mission.

5. Place greater emphasis on life cycle assessment in the building products industry.

The USGBC's "LCA into LEED" initiative is to be applauded for recognizing the need for more scientifically based evaluation of "green" building products and materials. Three cheers for the USGBC and the building products industry for creating this task force, and to the many volunteers who are doing the legwork to make LCA a reality in LEED and other green-building rating tools. This is hard work, but it has to be done if "green" is going to be more than "greenwash."

6. Continue to upgrade LEED.

Congratulations again to the USGBC staff and volunteers for their work on LEED version 2.2, which addresses many of the shortcomings of earlier versions. There is still a long way to go to move to LEED 3.0, which will seek to incorporate LCA in some way (see above). But 2.2 is a big step in the right direction.

Finally, we would be remiss if we did not salute the work of the PVC task force of the USGBC Technical & Scientific Advisory Committee for its report (two years in the making) recommending against singling out vinyl for exclusion from LEED. The task force reviewed the scientific evidence and made the right decision, and a courageous one.

Those are the plusses. On the negative side, our recommendation to have contractors recycle or reuse at least 50% of construction and demolition waste has been taken up by some leaders in the industry, but the great majority of construction firms are still dragging their feet on C&D waste disposal. The Associated General Contractors of America needs to move more aggressively in this arena.

We're also still seeing slow adoption of sustainability by healthcare organizations and hospital chains. Even with the Green Guide for Health Care to aid them, the medical and health establishment has been slow to go green—which is ironic, since our hospitals should be more sustainably designed and operated than any other building type.

The biggest disappointment, though, is that we still have no scientific study by a major federal research agency (such as the National Research Council) proving definitively that green buildings, whether LEED or otherwise, are in fact "healthier" for occupants, or that they do indeed make workers (in offices or factories) and children (in schools) more productive. That's a huge shortcoming. Without such a study, the real estate industry has to fall back on marketing and public relations to find some reason to justify going green. Armed with a rigorous scientific study by a major federal research entity, progressive developers would be able to go into the marketplace and get a premium for their green buildings.

So, time to roll up our sleeves. There's still plenty of work to be done.

Building Design & Construction White Paper: Life Cycle Assessment and Sustainability

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Building Design & Construction White Paper Life Cycle Assessment and Sustainability

'Life Cycle Assessment and Sustainability' at Greenbuild IV Conference

Robert Cassidy, editor-in-chief of BD&C, will host a one-hour discussion of LCA issues with several of the authors of this White Paper, including Wayne Trusty and Kirsten Ritchie.

Join us from 1:30 to 2:30 p.m., Wed., November 9, 2005, Room A410 of the Georgia World Congress Center, Atlanta.

Greenbuild attendees are cordially invited to join in the discussion of LCA.

BD&C White Papers Available for Download on BD&C Web Site
The entire contents of our 2003 White Paper on Sustainability, 2004 Progress Report on Sustainability, and 2005 White Paper on Life Cycle Assessment and Sustainability may be downloaded in .pdf form at:
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