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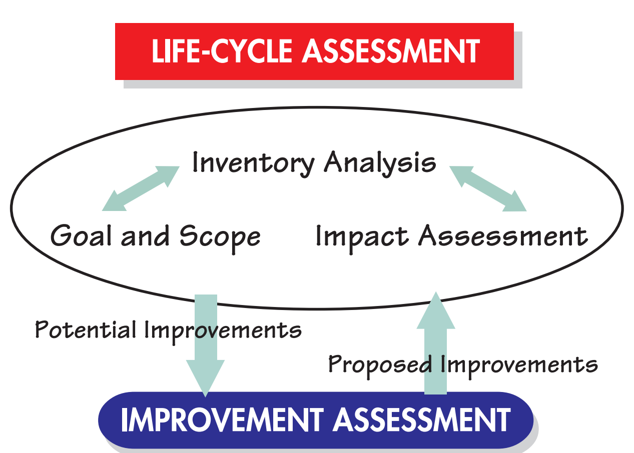
Life-Cycle Assessment for Buildings: Seeking the Holy Grail

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 at the supply yard 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 (LCA).

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. "I've been getting new signals just in the past few months that the field is really taking off in the U.S.," reports LCA expert Greg Norris of Sylvatica, Inc. in North Berwick, Maine. 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.

What is LCA?

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. *(continued, p. 2)*



Adapted from a graphic by Athena™ Sustainable Materials Institute

LCA was developed primarily as a tool for studying process changes in industry, as shown here, but it now has a wide range of uses.

In This Issue:

Quote of the month:

"What everyone wants is a simple tool in which you push a button and the answer appears."

Joel Ann Todd on LCA

(page 5)

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* (LCC), 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:

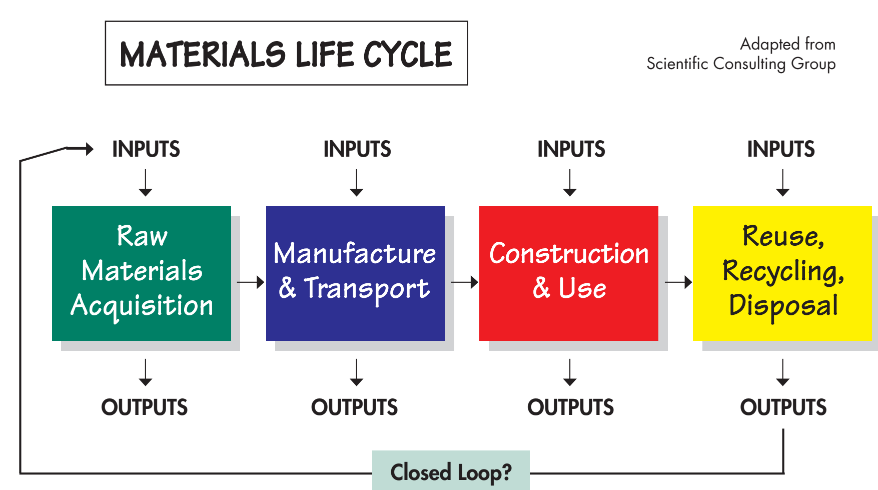
- Goal and scope definition, to clarify the questions to be answered and determine how much precision, detail, and reliability are needed to answer those questions—if an LCA is to be used for comparing competing products or materials, an appropriate *functional unit* that defines a measure of equivalent 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; and
- 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, according to Norris, when Coca-Cola wanted to determine the environmental impact of switching from glass to plastic bottles. Bill 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, Kansas, 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 comparing plastic and paper shopping bags, and 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; and
- purchasing/procurement decisions.

LCAs for building materials are different from those for disposable items like packaging, for two reasons: First,



LCA researchers quantify and characterize the inputs and outputs of every stage in a product's life to assess its overall environmental performance.

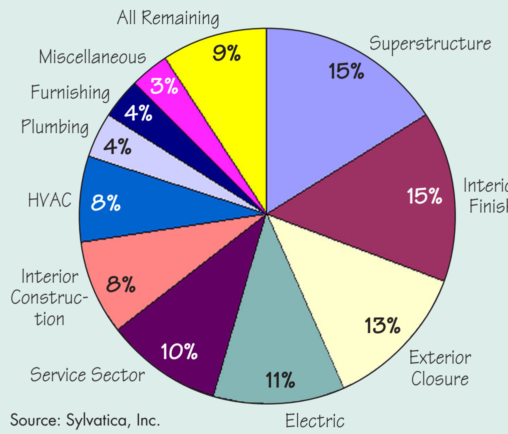
they tend to have a relatively long service life or, in LCA parlance, "use phase." As a result, any environmental impacts relating to the use of these materials, such as energy use, tend to dominate the overall life-cycle profile of the product. Second, their service life is highly variable, as even 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," notes Wayne Trusty, Director of the Athena™ Sustainable Materials Institute. 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," reports Trusty.

A Macro-scale Approach to LCA

The standard approach to LCA requires studying each step of the process in detail and building up a life-cycle inventory from those details. An alternative approach, called "Economic Input–Output LCA," starts from resource flows and emissions for entire sectors of the economy, and assigns the associated burdens to the products of each sector. Researchers at Carnegie Mellon University have created a Web-based front-end to their economic input–output model that is available for anyone to use at: www.eiolca.net. While this macroscopic approach seems very different from the more common, detail-oriented approach to LCA, its practitioners argue that it is consistent with ISO standards.

An economic input–output tool known as "Baseline Green" was developed by Greg Norris together with Pliny Fisk and Gail Vittori of the Center for Maximum Potential Building Systems in Austin, Texas, and BNIM Architects in Kansas City. This tool examines buildings using U.S. Department of Commerce data mapped to Uniformat II categories from the Construction Specifications Institute. "For every million dollars spent on materials in a generic building, Baseline Green will spit out the specific materials that are responsible for a certain percentage of Toxic Release Inventory emissions, greenhouse gases, and criteria air pollutants," explains Vittori. The value of these results is limited by data accuracy and by how well the government's reporting categories can be linked to specific materials or products. Though not a substitute for process-based LCA, economic input–output LCA can point out where the biggest environmental impacts, and therefore the most potential for improvement, can be found.

Upstream Air Pollution Burdens of a New U.S. Office Building
by Uniformat II Level 2 Category



Source: Sylvatica, Inc.

LCA Challenges

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. A few of the most significant and obvious problems are outlined here.

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 preexisting 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," notes researcher Joel Ann Todd, author of the Technical Reports in the AIA's *Environmental Resource Guide* (published by John Wiley & Sons, www.wiley.com). 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 towards 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.

Getting from inventories to impacts

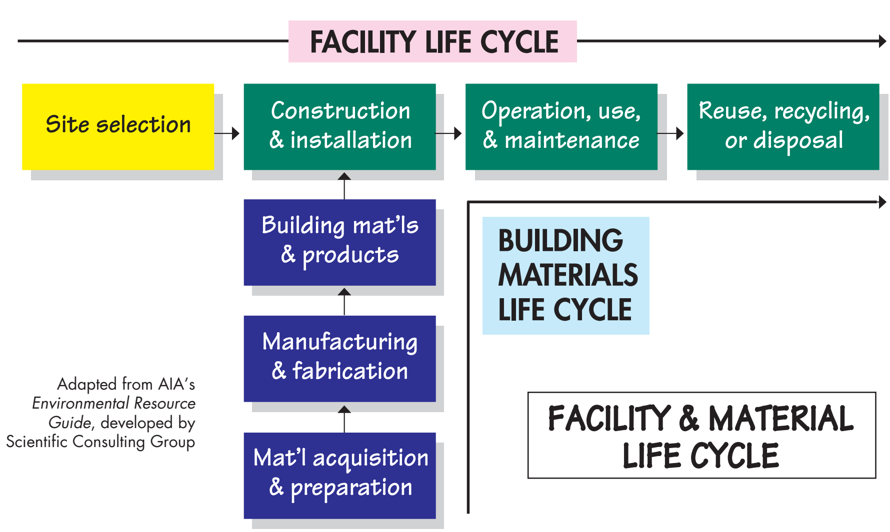
So far we have discussed problems related to compiling the inventory data, but that is, in many ways, the easy part. It is not the inputs and outputs themselves that are the issue, rather the environmental impacts of those flows. Once we have a huge table listing the life-cycle inventory of a product 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 of the Institute for Environmental Research and Education in Vashon, Washington: "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 (CO_2) 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, 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



During the "construction" stage, the life cycles of the materials and the facility merge.

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," suggests Todd. "The user could then make a decision comparable to choosing the lower-fat but high-sugar item over the higher-fat but lower-sugar item."

Making this choice between fat and sugar is an example of "weighting": the user has to decide which impact is more important for him or her 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," notes 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.

Solutions

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.

Streamlining the LCA process

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 (see sidebar, page 3) 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 and engineers 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 *EBN* 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," notes Barbara Lippiatt of the National Institute of Standards and Technology (NIST).

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. Now the Ottawa, Ontario-based Athena™ Sustainable Materials Institute is coordinating a U.S. Database Project to create a publicly accessible resource for anyone wanting to use the data.

Extensive work on a detailed protocol to guide the collection of data for this effort has just been completed, and work is set to begin compiling the actual database. This database will include modules of inventory information on basic industrial components and processes, such as electricity, fuels, and mining operations, rather than complete life-cycle inventories for finished products. Having a standard, publicly available set of data on these processes will greatly simplify the work of doing an LCA study based on those processes and ensure that LCAs performed on different products are more comparable.

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; and
- The study might show that their

product is not the best choice environmentally.

To overcome this resistance from companies, the Sustainable Products Purchasers Coalition (SPPC), a new Portland, Oregon-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 also recently published a Technical Report (ISO/WD/TR 14025) on Environmental Label and Declarations (also called "Type III Environmental Declarations") that provides guidance on reporting the results of LCA studies.

With its "BEES Please" program, NIST is preparing to publish, for the first time, the results of product-specific LCAs in the upcoming version 3.0 of the Building for Environmental and Economic Sustainability (BEES™) LCA software tool (see *EBN* Vol. 9, No. 9). Available since the release of version 1.0 in 1997, BEES provides a user-friendly interface for comparing LCA data on building materials. Lippiatt reports that carpet manufacturers are very heavily represented among the 21 manufacturers currently participating in this effort. 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 for NIST 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 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.

Impact assessment tools

The most significant efforts to help the U.S. catch up with Europe in terms of normalization factors and impact assessment systems are being coordinated by Jane Bare of the U.S. EPA's National Risk Management Research Lab in Cincinnati, Ohio. The results of Bare's impact assessment work is dubbed "TRACI," for the "Tool for the Reduction and Assessment of Chemical and other Environmental Impacts." Work on TRACI began in 1995, according to Bare. She began by reviewing the practice of LCA and "found that many in the U.S. were using older European methods." Her work became focused on impact categories and assessment methods for which these older models were least appropriate in the U.S.

Bare contracted with scientists at the University of California at Berkeley to develop impact assessment methods for human and ecosystem toxicity, and with Greg Norris to work on methods for quantifying eutrophication (excessive algae growth due to overloading of nutrients), smog formation, and acidification. Norris was also hired along with the consulting firm SAIC to develop a database of "normalization factors" that relate the effects of a product life cycle to those of one year's consumption by an average American. "For chemical emission categories, it was easy to develop methods because we have existing regulations with a whole body of science behind them," notes Bare. On the other hand, she explains, "the categories that are most controversial are those relating to resource depletion.

"At this point TRACI has what I would say is a minimal list for characterization—that is, there are other impact categories which could be included in the future," reports Bare. She hopes to have a Windows™-software version of TRACI available as a free download by sometime this summer. The forthcoming BEES 3.0 software will also incorporate methods from TRACI and the normalization factors, according to Lippiatt. Lippiatt is enthusiastic about this development: "By June 2002, U.S. LCA practice will be on a par with European practice, and for two reasons. First, with TRACI, we will no longer have to use European impact assessment methods because we will have our own. Second, we will, for the first time, have a U.S. normalization database that will relate the data to a nationwide profile." This link to a nationwide profile is important for a tool like BEES because, without it, the results of any product comparison are valid only in relation to the products in that specific group and cannot be compared with other building elements. With the new profile, "we can then compare environmental performance across building elements, permitting us to identify those elements representing the 'weak links' in a building design and deserving the most attention," notes Lippiatt.

Not everyone agrees, however, that the U.S. is finally catching up with Europe. The main concern is the lack of an open, consensus-based process for developing the methods. "Some of the elements of TRACI represent current global best practice," notes Schenck. "However, most of it has not been published, and it does not represent either a technical or a public policy consensus." Bare counters that, while the lack of consensus is inevitable in such a new field, much of the work behind TRACI has been peer-reviewed and published, and more is on the way. An international effort now under way through the United Nations Environment Programme (UNEP) should help to create greater worldwide consensus on these methods and promote greater availability and credibility of LCA data.

Even with TRACI and the normalization factors within impact categories, combining the results from each of the categories into a single overall score for a product represents yet another leap beyond what the science can support. Yet this is the final step that building designers often demand—and that BEES offers, based on a user-modifiable weighting system that determines how much importance to assign to the results from each category. Asked about the use of weighting within TRACI, Bare responds: "I think the weighting process is very difficult for users, and a lot of users are misled. There are a lot of things to consider, and without very heavy documentation and live workshops, it is difficult to do the weighting process."

Emerging Issues

For many building products the biggest impacts occur during the use phase, but these are typically building-specific and therefore difficult to generalize. A prototype tool called "Life-Cycle Explorer" was developed by Norris and Peter Yost (now with Building Science Corporation) to test some possible solutions. Using windows as an example, the Life-Cycle Explorer prototype allows users to adjust values and test the sensitivity of the results to factors such as fuel type and window thermal performance. The tool also presents a model of how data can be provided that is totally transparent for people who want to see the underlying numbers without overwhelming less sophisticated users.

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," notes 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 policymakers. 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

A Sampling of LCA Tools

• For General Building Professionals

BEES · www.bfrl.nist.gov/oae/software/bees.html

Easy-to-use, free tool for product-to-product comparisons, based on proprietary, unpublished data.

Athena · www.athenasmi.ca

Inventory data tool for comparing assemblies or whole buildings, based primarily on published Canadian data.

ENVEST · www.bre.co.uk/sustainable/envest.html

U.K.-based LCA-based building design tool, only addresses whole building, and provides results in highly summarized 'ecopoints."

EcoQuantum · www.ivambv.uva.nl/uk/

Dutch LCA-based residential building design tool, only for whole buildings.

• For LCA Practitioners

SimaPro · www.pre.nl

A tool from the Netherlands. The IVAM database of inventory data for building materials is available as an add-on, as is a version with some U.S. data from Franklin Associates.

GaBi · www.gabi-software.com

A tool from Germany for LCA practitioners, primarily European data.

TEAM · www.ecobalance.com/uk_team.php

A tool from France for LCA practitioners, primarily European data.

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.

Going Further—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 can abandon the checklist approach and rate buildings based on a comprehensive model of their environmental performance, similar to the way energy modeling is done today. 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," argues 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, for example, that simply comparing one floorcovering 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, due out this summer, 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 Vice President of the U.S. Green Building Council overseeing the LEED Rating System. Howard argues that "nearly all of the most significant decisions about a new design are made in the first ten 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 notes. 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 at left provides some pointers on how to take advantage of the power of LCA and what to look out for in the process.

– Nadav Malin

LCA Checklist for 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 reps 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, and/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:

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

  <u>What assumptions are included</u> about the functional unit and the service life of the product(s) in question; do these correspond to your situation?

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

  <u>What is assumed about the products' maintenance requirements</u> and/or impact on building operations?

  <u>Do the impact categories included in the results capture the important information</u>, 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.

For more information:

International standards documents:

International Organization for Standardization (ISO)
+ 41 22 749 01 11, + 41 22 733 34 30 (fax)
www.iso.org

In the U.S., obtain ISO Standards from:

NSF International
800/673-6275
www.nsf.org/Standards/

Other resources and initiatives:

UNEP/SETAC Life Cycle Initiative
www.uneptie.org/pc/sustain/lca/lca.htm

Sustainable Products Purchasers Coalition
www.sppcoalition.org

U.S. EPA's LCA Access page:
www.epa.gov/ORD/NRMRL/lcaccess/

U.S. Database project documents:
www.nrel.gov/lci/

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Send $7 for an electronic copy of the excellent introduction to the topic: "LCA for Mere Mortals"

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