Integrating LCA Tools in LEED: First Steps

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1. INTRODUCTION

The acceptance of LEED as a green building rating system has generated substantial excitement among the green building and environmental communities. It appears, in fact, that the LEED rating system has become the focus for melding the U.S. environmental and architectural movements. It is proving to be an effective tool for involving the entire building profession in a set of shared environmental goals. Those goals are embedded in the many individual credit intents, which in turn serve an overarching implicit objective.

As the USGBC grows in membership and influence it is important to explicitly state this objective, since a broader membership concomitantly means broader interests are at stake. The overarching objective, simply put, is to create buildings that are designed to minimize impacts on human and ecosystem health. We have to be cautious that in every area the combination of credit intents, requirements and submissions is always moving us toward that ultimate objective. We can only be aware of our movement and direction if we use quantifiable performance measures where they are appropriate and practical.

In our paper presented at the Austin 2002 conference, "Integrating LCA Tools in Green Building Rating Systems", we focused on the disconnect between the complexity of the building/environment relationship and the specifics of rating system credits and requirements. We argued that achieving the ultimate objective means working to minimize flows from and to nature: the use of natural resources of all kinds, and emissions to air, land and water throughout a building's complete life cycle. Through several examples, we showed how certain credit/requirement combinations do not necessarily lead to improved environmental performance in the sense of this objective function. They are based on assumptions that may or may not prove correct in certain situations. We then discussed how life cycle assessment (LCA), while not a panacea, has the ability to move us in the right direction. In the Austin presentation, Wayne Trusty suggested an ultimate vision of how credits might be structured with LCA as a central component. However, he fully acknowledged and emphasized the constraints and changes necessary for this to occur.

In this paper we want to focus on the smaller steps that can lead eventually to the major strides necessary to achieve a truly performance based assessment system using LCA tools. The need for small, first steps is a simple reality for a consensus organization such as USGBC. The consensus process almost dictates that significant changes will not be made in the rating system prior to LEED 3.0. However, in the interim we can more fully incorporate life cycle thinking, and elements of LCA methodology. In fact, a gradual process of introducing LCA will help the professionals using successive version of LEED 2 become familiar with some of the concepts, ideas and information that can make LEED 3.0 a more robust document. In the process, the benefits of the LCA approach will be apparent.

We do not intend, in this paper, to recommend specific changes to current LEED credits; rather, we want to explore several ways in which improved information could make current credits more aligned with environmental performance. Later in this paper we focus on two examples in LEED where the credit intents support the primary objective, but the requirements do not necessarily serve the intents and could be readily improved with the introduction of LCA techniques or factors. We also suggest an innovation credit approach to introducing LCA.

Before we tackle that level of detail, however, we need to be clear about the meaning of the words 'performance' and 'prescriptive' as they relate to LEED. The way in which credit intents and requirements are phrased directly affects not just the opportunities for integrating LCA thinking, but also the attitudes and approaches of those striving to achieve LEED certification.

2. THE LANGUAGE OF LEED

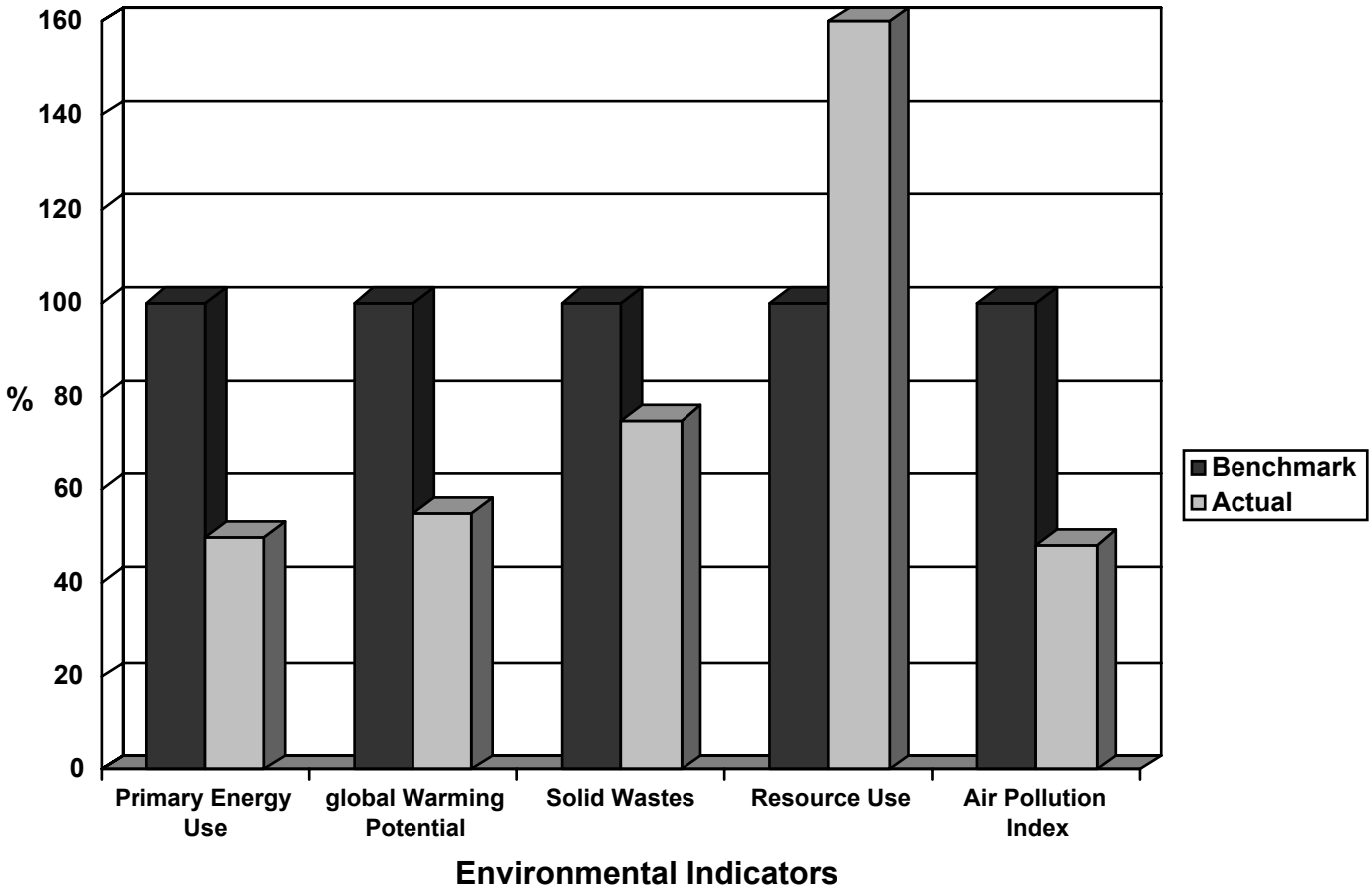
From the perspective of LEED, the word "performance" is often used in two ways:

1. performance in the sense of achieving LEED credits; and

2. performance in the sense of achieving a measured beneficial environmental outcome.

A design team reaches a certain level of performance under LEED when they meet the requirements, achieve the credits, and receive a specific rating. Some of those requirements may correspond exactly to measures of environmental performance, but others may not. However, the second usage is directly related to the achievement of environmental measures.

From an LCA perspective there is a wide range of environmental indicators used to establish performance measures. In Figure 1, for example, the performance of a final design for an academic building is shown relative to a benchmark design, using five separate environmental indicators or measures. The five measures capture selected environmental effects (e.g., primary energy use and greenhouse gas emissions) of making and moving the structural and envelope materials, on-site construction, maintenance and repair or replacement of relevant materials (e.g., roofing) over the assumed 75-year building life, demolition, and transportation to landfill of those materials that would not be recycled or reused under current practices. The measures also incorporate the operating energy effects over the building life, including the effects of making and moving the energy (pre-combustion effects).



Source: Based on Athena *Environmental Impact Estimator* estimates for a major campus redevelopment project.

Figure 1 Comparison of a final design to a benchmark design using five environmental indicators.

In this example, the actual design performs significantly better than the benchmark in all but one of the indicator categories. Assuming the benchmark properly reflects conventional practice, it is fair to conclude that the improved performance of the actual design will help to minimize impacts on human and ecosystem health — our primary objective.

When we use the term 'performance' throughout the rest of this paper, it is in the sense of environmental performance as illustrated in the graph. In contrast, the word 'prescriptive' is used in reference to specific requirements that must be met to achieve credits under an intent, without a direct or clear reference or link to a measurable environmental outcome.

LEED as a whole is not a prescriptive document in the sense of prescribing a number of specific steps that must be taken, other than those found in a few prerequisites. Design teams are free to use a variety of approaches to achieve the points and credits required for certification. But many of the requirements are prescriptive, particularly in the materials and resources category. It is those prescriptive requirements that offer the best opportunities for the initial introduction of LCA thinking and techniques. The next two sections present examples of how an LCA approach can improve currently prescriptive requirements.

3. MR CREDIT 5 — REGIONAL MATERIALS

Materials and resources credit 5 is an especially interesting credit to look at because it encompasses two distinct objectives. The intent of the credit is stated as follows:

> "Increase the demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation."

One objective of the credit is to reduce the environmental impacts resulting from transportation and the other is to support the regional economy. The basic requirement for earning points under this credit is tied to a 500 mile fixed radius within which products must be manufactured or materials acquired. The calculations are then based on the relative cost of building materials.

There has been considerable discussion and some controversy around this credit with regard to both objectives. If we look first, and only briefly, at the economic objective, there is no doubt that it fits under the general sustainability umbrella. However, there is considerable doubt about the definition of an economic region using an arbitrary 500 mile radius. The concept of local obviously varies considerably from one part of the country to another depending on population densities and the level of manufacturing activity. We also have to ask whether globalization makes the concept of local economies moot from a sustainability perspective. Final assembly of a product may occur in a defined local region, but design, basic materials manufacturing, and related sales and service activities could be located in virtually any part of the world. The local component could in fact be a minor element in the total economic impact.

There is also a more fundamental question as to whether a given credit should attempt to achieve two disparate and potentially conflicting objectives. In any event, the economic side is distinct from the environmental measures that are the purview of LCA, and therefore somewhat outside the scope of this paper.

Turning to the requirement in relation to the transportation objective, we must first explain why we see this as a prescriptive rather than a performance requirement. After all, it seems logical to assume that reducing transportation will lead directly to reduced environmental impacts; energy use and associated emissions, for example. However, the link is not directly stated and is actually somewhat tenuous because transportation energy use and emissions are a function not just of distance, but also of the type of transportation and the tonnages or volumes being moved.

Transportation requirements and associated environmental effects are generally greater for the relatively low cost, high mass products used in building construction — wood, aggregates and/or concrete, steel, etc. — and lower for the high cost, low mass materials and systems. Basing calculations on cost therefore puts the emphasis on the wrong materials if reduced transportation is the objective. Calculations based on the weight would be much better.

We should also take account of the differences in energy use and related emissions for different modes of transportation. The current prescriptive requirement is seemingly based on an implicit but untested assumption that transporting materials more than 500 miles will result in larger

environmental impacts than transporting the same materials shorter distances, irrespective of how the transportation service is provided. But we know that average transportation energy use and emissions per ton/mile differ depending on the mode of transportation. They are relatively high for truck and lower for rail as indicated in Table 1.

Table 1 Comparison of energy use by transportation mode

Transportation Mode	**Fuel Type**	**Energy Use** (BTU/ton-mi.)
Truck	Diesel	1,465
Rail	Diesel	374

Source: Franklin Associates, Ltd.

This is just one set of estimates for average energy use per ton/mile by mode, assuming the fuel types shown for each mode. In reality, a number of factors can affect these estimates (e.g., the size and type of vehicle, the topography, and the amount of urban versus rural driving in the case of truck transportation). However, using a set of estimates of this kind from a reputable source is clearly better than simply assuming that all modes are the same. This type of information is available for all transportation energy including ship, barge, single unit truck and so on. Moreover, focusing on energy use by mode provides a firm basis for estimating associated transportation emissions.

This type of transportation energy use and emissions analysis is already a critical part of any LCA, with data and software tools in place. However, there is still work to be done on both the data and tool sides before it becomes a routine exercise, especially for those less familiar with the methodology. We do not want to suggest, therefore, that LEED immediately require a full LCA of the transportation implications of purchasing decisions. But we do urge that the distance requirements for MR Credit 5 be directly related to the transportation mode(s) used.

If we stick to the current 500 mile radius for truck transportation, and apply the above energy factors per ton-mile, the equivalent distance for rail is approximately 1,960 miles.

To complicate matters slightly, we have to recognize that rail transport is unlikely to get materials to a building site without transshipment to truck for the final leg of the journey. The rail distance requirements should therefore be reduced somewhat to account for typical truck haul components of the total transportation service, preferably on a regional basis. Recognizing that some materials are likely to move by one mode, and others by another mode, we could even translate these distance targets into simple transportation energy benchmarks or budgets (i.e., so many BTUs per ton), setting those budgets as the targets instead of using distance. A simple calculator could be provided to let a design demonstrate how its purchasing decisions meet or exceed the transportation energy use budget per ton-mile.

Obviously, the rail distance shown above has little or no relationship to the concept of regions. But many maintain that the same is true of the current 500 mile requirement. In any event, adopting the above approach means this credit would deal directly with the issue of transportation and related environmental effects, and only with that issue. It would no longer be

a credit dealing with regional purchasing, but it would address the transportation objective in the current credit intent, and would be a first step in the direction of an LCA approach to the transportation aspect of purchasing decisions.

4. E&A CREDIT 1 – OPTIMIZE ENERGY PERFORMANCE

The intent of Energy and Atmosphere credit 1 is worded as follows:

> "Achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use."

In this case the corresponding basic requirement seems very performance oriented since it refers specifically to the ASHRAE/IESNA Standard 90.1-1999 (without amendments) as the benchmark against which performance must be measured. Dollars are again the unit of measure for submittal calculations.

Leaving aside the cost aspect for the moment, why would we highlight this credit/requirement combination and suggest substituting any different method in the requirement? The problem here is somewhat different than in the regional materials example. There are two critical issues:

1. not all energy forms have the same emission profiles or other environmental effects per unit of end use energy; and
2. it takes energy to make and move energy, and we should not ignore these pre-combustion effects when considering the environmental implications of energy use.

In LCA methodology, the focus is on 'primary energy' use and related emissions, where primary energy can be defined as, 'Delivered energy including production and delivery losses.' The concept of primary energy can be readily understood and appreciated in relation to electricity. With the exception of hydroelectric generation, the basic energy to fuel an electrical generating plant has to be extracted, processed and transported to the plant, all steps that themselves require energy, which also has to be produced, transported, refined, etc. At the plant itself, energy is lost because there is a relatively low efficiency factor in the conversion process. For example, typical coal and natural gas fired generating stations lose approximately two thirds of the primary energy during the process, or are about 33% efficient. Then there are additional energy losses in the transmission and distribution systems, referred to as line losses. In short, the end use energy that we simulate or measure at the building is just the tip of an energy iceberg. All of the steps required to get that energy to the building, whether in the form of electricity, natural gas, or some other fuel, involve environmental impacts — resource use and emissions to air, land and water.

Relating this back to the E&A credit 1, the requirement is prescriptive because it prescribes an end use energy requirement seemingly without regard for the true environmental implications of primary energy use. The intent aims to "…reduce environmental impacts associated with excessive energy use", but the requirement takes us only part way down the road. To get to the more meaningful primary energy measure, we have to be concerned about the amounts of energy being used by type. In the case of electricity, we have to then understand the fuel mix and efficiencies for the relevant electrical grid.

A true performance measure would focus on the environmental impacts of concern, fossil fuel depletion, greenhouse gas emissions, solid waste production, etc. An interim energy reduction requirement could be designed to relate as closely as possible to those measures. As a first step, the requirements could focus on amounts of energy use by types, as opposed to energy costs. This will automatically eliminate other distortions that may arise from the use of cost as a yardstick. As suggested by point 1, above, knowing the type of energy being used is also essential to understanding the type and level of emissions that will occur as a result of building operations.

The ASHRAE benchmark or an equivalent standard could similarly be expressed in physical energy units (e.g., BTUs) by energy form, allowing for very specific reduction requirements by energy form. Eventually, the focus can shift to primary energy use and the attendant environmental impacts. The data and software tools to make calculations at this level already exist and are used in LCA work. What remains is to establish appropriate regional benchmarks. The first steps suggested here can prepare the ground for introducing a full set of energy-related environmental performance requirements in LEED 3.

5. INNOVATION AND DESIGN CREDITS

The Innovation and Design credits offer another opportunity to integrate LCA into LEED and prepare users for future versions of LEED. The key here is that we encourage the use of LCA for decision making that leads to improved environmental performance, and not just for the sake of having LCA somewhere in the system.

The following example of an LCA-oriented innovation credit is offered as a concept, without too much concern for the specific language. There are undoubtedly several possible ways that one could structure an LCA based ID credit, and our purpose at this point is to underscore the potential rather than dealing with the details.

An LCA ID credit would encourage project teams to use life cycle thinking, prepare them for future versions of LEED, and encourage the continued rapid development of high quality data for LCA purposes.

The intent, requirement and basic submittals for such a credit could be structured as follows:

> Intent
> Improve building life cycle environmental performance by reducing the embodied environmental effects of materials used on the project.
>
> Requirement
> Use available LCA tool(s) to establish a baseline for your building type for five LCA impact categories, and use the tool(s) to assess design alternatives and support the selection of materials that reduce at least three of the five impact categories.
>
> Submittals
> - Provide a narrative that explains the rationale for your baseline design numbers.

- Provide a table showing the impact categories chosen, and the corresponding baseline and final design results.
- Explain how the tool informed your decisions and led to materials selections that differ from the baseline.
- Provide appropriate references for the LCA tool(s) and associated documentation.

We should note that we have emphasized life cycle embodied effects as only a starting point. Embodied effects refer to all of the environmental effects of manufacturing, installing, maintaining or replacing, and ultimately disposing of materials. Eventually, however, LCA can be applied to the whole building including operational effects as in the example presented in Section 2.

We should also note that the final requirement and submittals language for such a credit has to ensure a rationale comparison and decision framework. In other words, the baselines have to be reasonable, reflecting conventional design and construction practices for the building type in question. This is not a trivial undertaking, but it is quite feasible and has been done in the past for a variety of buildings in North America. Establishing baselines is itself an important undertaking, because the eventual adoption of LCA in LEED will require such baselines, just as the change to A&E credit, suggested in Section 4, requires an LCA-oriented version of the ASHRAE energy use baseline.

6. CONCLUDING COMMENTS

In this paper, we have presented ideas about how to integrate LCA thinking into LEED in areas where existing data and tools can support the integration. We have not suggested changing intents for existing credits, but have focused on changes to the requirements that would shift them from prescriptive to the performance side of the scale.

The potential for making these types of changes in the short term is not as limited as might be supposed. LEED is not overly rigid, and there are approximately 30 examples of AND, OR, or AND/OR language in the requirements of LEED 2.1. The word OR would easily allow for the insertion of an alternative method for achieving the requirements of a credit, without necessarily deleting the original requirements. Our one hesitation about using the AND/OR language to allow an option is that it could frustrate the fundamental purpose of requiring a shift in the LCA direction. Design teams could simply avoid the LCA approach if they perceive it to be more onerous than current practice. Administrative Credit Interpretation Rulings and workarounds also offer the opportunity to effectively alter specific requirements in LEED 2.0 and 2.1.

The USGBC has done an outstanding job of increasing the market penetration of LEED. The organization is providing a forum for melding the goals of environmentalists and the building profession. But continual improvement is essential if we are to achieve the ultimate objective of reduced impacts on human and ecosystem health, an objective imbedded in the intents of LEED. LCA can play a critical role in helping to make LEED an even better system by strengthening the connection between environmental performance and existing intents.