Introducing Comparative Analysis to the LEED System: A Case for Rational and Regional Application

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ABSTRACT

The LEED ™ system awards points for prescriptive and performance based environmental strategies; rightly giving more weight to decisions affecting building operations, since environmental impacts over the life of a building exceed the one-time environmental impacts affected by the building's construction. The environmental benefits of LEED ™ strategies are considered implicit and the point system is not a metric of environmental performance. Thus, guideline strategies that achieve the same points may not have analogous environmental performance.

This paper draws from our LEED ™ project experience as certified consultants to a number of design teams. We applied analysis to those experiences and argue that

- The relative environmental value of the same LEED ™ strategy may vary by geographical region and by building type.
- Scoring successive LEED ™ points beyond a 'standard practice design' significantly increases design effort and capital costs for construction.
- Without comparative analysis of the costs of alternate LEED ™ strategies and their corresponding environmental benefit, designers will not necessarily invest capital in strategies that most profoundly minimize the environmental impacts of a building.
- For design teams and owners interested in the least expensive LEED ™ certification, gaming the point system could drive investment away from sound environmental performance strategies such as energy efficiency.

Using these arguments, this paper makes a case to enhance the LEED ™ system by

- Categorizing LEED ™ strategies by their direct or indirect value towards Environmental Benefit, Healthy Buildings (Places), and Profitability
- Reformulating prescriptive requirements into performance based requirements wherever possible.
- Customizing LEED ™ guidelines by region

Introduction

The Leadership in Energy and Environmental Design (LEED ™) system introduced and propagated by the U.S. Green Building Council (USGBC) has been well received across the United States. Different levels of federal, state or local governments make specific LEED ™ version 2.0 certification levels a part of the request for proposals and some corporate entities aim for LEED TM certification when constructing new facilities. It is our observation that once committed; design teams strive to maximize acquisition of LEED TM points within their construction budget to achieve certification levels. At this juncture, the use of the LEED TM system transforms from a rating system into a green design guide. Requirements stated in the LEED TM credits become design requirements.

The authors, in their work over the last two decades, have also tried other systems for bringing clients to an awareness of the multitude of environmental issues that a design can effect for better or worse. One example of such a system is Malcolm Well's 'wilderness values' (Wells, 1981); another example is the Minnesota Sustainable Design Guide. The LEED TM system addresses a host of environmental and health concerns and in most cases provides performance criteria that a building design may meet. Herein lies its strength. It provides a basis for dialogue and a checklist of goals in the development of a building design. This paper is a critique of the LEED TM system as an applied tool; as an applied tool, two transformational features most distinguish the LEED TM system from earlier approaches: the existence of points to be scored and, a review for certification. We believe that these features, along with effective marketing of LEED TM, have made it the system of choice for building owners around the country. These same features change the design discussion and their outcomes and the power of the point system and certification to motivate may also be the Achilles heel. In effect, the third party certification offered by the USGBC absolves the users of any "need to know" regarding environmental benefits and this certification translates into environmental success for those who achieve a rating.

Over the past two years, we have been applying the LEED TM system to projects. We feel that the use of the LEED TM system is a departure for us from systems that have allowed our clients to select their most important environmental issues and address their resources accordingly. We have had a unique opportunity to observe how the LEED TM system influences decision making and an opportunity to compare those decisions to our pre-LEED TM consulting. We have examined some of the decision-making made by our clients and have based this paper on our observations. While the foundations of our arguments are rooted in our own experiences, we have discussed our observations with others and have found that our experiences are not unique. We offer our observations for open debate.

'Green' According to the UGBC

The USGBC's mission is stated as "the nation's foremost coalition of leaders from across the building industry working to promote buildings that are environmentally responsible, profitable, and healthy places to live and work." We interpret profitability within the context of the LEED TM system as improvements to a business bottom line due to environmentally responsible or healthy building choices.

The Green Building Information Center (GBIC) a non-profit from Canada, which sponsors the GBC Awards, states its mission as "to disseminate information about energy and environmental issues in the building sector from other sources and organizations around the world."

The difference in the two missions is that while the GBIC appears to focus exclusively on environmental responsibility, the USGBC attempts to balance environmental responsibility, profitability and healthy places (buildings). Through LEED TM, the USGBC appears to be attempting to bring forward a balanced approach to design. Unlike earlier movements focusing on single issues like energy, the USGBC has defined three value sets including environmental responsibility, health work places and profitability. By awarding credits toward each of these three values, the USGBC appears to seek equability in the design process. These three value axes are not necessarily synergistic. Raising a building's performance on one of the axes may compromise its performance on the other two axes. For example, increasing the environmental performance by providing 20% of the building energy through onsite photovoltaics (LEED ™ Energy and Atmosphere (EA) Credit 2) may be a poor investment strategy, thus compromising profitability; or raising the standard on interior environmental quality to meet ASHRAE comfort standards (LEED ™ Interior Environmental Quality (IEQ) Credit 2) could increase the energy cost, thus compromising environmental performance. The USGBC's LEED ™ rating system has combined these sometimes opposing directions. It is no doubt possible to combine ostensibly irreconcilable strategies through skillful and diligent design such that the performance of both is enhanced. However, a strict pursuit of the credits by no means guarantees this.

Increasing the number of LEED ™ points is "greener" according to the USGBC, but it does not necessarily imply a more environmentally responsible building design.

Separating the Three Axes

LEED ™ points are an abstraction of three performance values; Environmental Benefit; Healthy Places (Buildings) and Profitability. Given three distinct value sets, acquiring more points under the LEED ™ system does not necessarily result in the design that achieves the most environmentally responsible building. Therefore, the total points achieved only reflect the building's overall performance within the rating system. Since the overall score takes into account three disparate axes of performance, an assessment of the "green-ness" of a building based on its LEED ™ points is unlikely to be conclusive. Simply using the point total (the certification level) makes it difficult to conclusively compare one building with another in any of the three performance values.

In the absence of a better sense for the overall performance of a building design, design teams simply seek to maximize "easy" points regardless of their value to the project. In order to prevent this and to facilitate decision-making by the design teams, we propose that the credits within the rating system be disaggregated as those that address:

- Environmental concerns (air, water and resource protection and conservation)
- Healthy buildings (enabling employee attraction and retention, and increased productivity.)
- Directly measurable, ongoing economic benefits (reducing expenses for water or energy.) [1]

[1] The credits that fall under profitability (Owner $ benefits) have a direct and measurable economic benefit. This direct economic benefit can be used to offset the costs of implementing any of the strategies within the LEED™ system. For many LEED™ credit requirements, profitability is not a metric that can always be directly and cleanly derived. Although the benefits of healthy buildings and indoor environmental quality, in terms of increased productivity, have been demonstrated though post occupancy evaluations, the consequences of design choices that accomplish these and their relative magnitude cannot be directly modeled or comparatively analyzed during the design process. This makes it difficult to weigh the extent of the effects and therefore the trade-offs between alternative design decisions that may contribute to healthy buildings as they relate to productivity and profitability. In contrast, environmental responsibilities in the form of conservation of

Table 1 provides a summary and the detailed categorization is available in table 6. In some cases, where credits address more than one value axis we show the multiple benefits. This categorization will allow design teams to make choices between strategies that improve the performance of the building along individual axes.

Table 1. Credit Analysis: Energy/Environment vs. Health Credits[2]

Category	LEED Points	Energy / Environmental Credits	Health Credits	Owner $ Benefits
Site	14	14	0	0
Water	5	5	0	5
Energy & Atmosphere	17	16	1	13
Indoor Environmental Quality	15	0	15	0
Materials & Resources	13	13	0	0
Innovation Credits	NA	NA	NA	NA
TOTALS	**64**	**48**	**16**	**18**

Market Transformation through LEED TM: Going Beyond Standard Practice

The USGBC has positioned the LEED ™ system as a market transformation tool that fulfills the goals in the USGBC's mission statement. LEED ™ points therefore require designers to go beyond what they would normally do. The LEED ™ system awards points for meeting requirements listed under LEED™ credits. Each credit has a specific intent with requirements structured to meet that intent. Most design teams will satisfy a few LEED ™ credit requirements through standard practice or while complying with local building codes and other community standards. Generally, this level of standard practice will not score enough points to achieve LEED ™ certification; LEED ™ minimum certification needs 26 points.

We contend that out of the total 65 points a minimum of 6 LEED ™ points can usually be scored through standard practice. (See table 2 for a summary of our categorization of the LEED ™ points into those that fall under 'standard practice', those that need 'increased design effort but minimal construction costs' and those that need 'significant increased costs'. The detail categorization is included in table 6.) To score enough LEED ™ points for certification, additional credit requirements need to be met through changes in the design and construction process. This is the transformational mode the guidelines were apparently designed to create. Meeting additional requirements that are not a part of the standard practice involves more research, design time and effort, and often will have an additional construction first cost. The LEED ™ guide strongly implies that scoring more

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water and energy have directly measurable impacts on profitability. For example, it is easy to determine the environmental benefits and costs of providing 20% of the building energy through onsite photovoltaics (LEED™ Energy and Atmosphere (EA) Credit 2) and compare them with the benefits and costs of an energy efficiency measure like variable speed drives. However, doing a similar cost benefit comparison between the option of providing adequate daylight (LEED™ Interior Environmental Quality (IEQ) Credit 8) versus the option of meeting ASHRAE's ventilation and comfort standards (IEQ Credit 2) would be impossible.

[2] Innovation credits are marked "NA" and not included in the tabulations because they will be unique to projects and their benefit cannot be anticipated.

points through additional effort means designing "greener". We estimate up to 28 points could be scored with additional design effort and minimal construction cost[3]; 30 points can be scored with additional construction costs[4].

On 4 of our projects, design teams initially sorted LEED ™ credits into three categories with respect to their project situation: "Easy" credits, "Hard" credits, and credits that are impossible because they are inapplicable or extremely difficult or costly. These projects ranged from Wisconsin to California and the buildings were to be used as offices, courthouses and labs. We examined how many of the 'standard practice', 'increased design effort but minimal construction costs', and 'significant increased costs' were identified as "Easy" or "Hard". The table below summarizes the results. Of the credits that are categorized as 'standard practice', the design teams described 80% of their selected strategies as "Easy" and only 20% as "Hard". Of all the points categorized as "increased design effort but minimal construction first cost" the design teams described 76% of the strategies they selected as "Easy". Of the increased as requiring "increased construction costs" the design teams rated only 32% of their selected strategies as "Easy" and rated 68% of them as "Hard".

This suggests that design teams tend to describe as "Easy" those credits that are standard practice or involve increased design effort but minimal construction first costs. Requirements that involve additional construction costs are perceived as hard. Also, design teams focus their attentions on earning "Easy" credits and secondarily attempt to earn "Hard" credits if necessary to reach their desired LEED ™ rating. In other words, as design teams look for points to meet certification levels they tend to pick the requirements that do not cost more. So design teams implicitly recognize that earning additional points beyond a certain level will cost more, and seek to maximize the points they earn while minimizing costs.

Table 2. Credit Analysis: Construction Cost[5]

Category	LEED Points	Standard Practice	Design Effort; Minor Const. $	Significant Const. $
Site	14	5	5	4
Water	5	0	2	3
Energy & Atmosphere	17	0	2	15
Indoor Environmental Quality	15	1	10	4
Materials & Resources	13	0	9	4
Innovation Credits	NA	NA	NA	NA
TOTALS	**64**	**6**	**28**	**30**
Design Team Ratings of Strategies Under Consideration		80% Easy 20% Hard	76% Easy 24% Hard	32% Easy 68 % Hard

[3] However, not all of these 28 points are available to all buildings as opportunities. For example, although building reuse points for Materials and Resource (MR) Credit 1 needs mostly design effort, an appropriate building in terms of size and configuration may not be available always.

[4] The 5 points awarded through 'innovation credits' are not included in any category.

[5] Innovation credits are marked "NA" and not included in the tabulations because they will be unique to projects and their benefit cannot be anticipated.

Weighting the Point System

In table 1 we see that most LEED ™ strategies are directed towards environmental responsibility. Recognizing this fact, we focus the rest of this paper on those strategies, and base our arguments on comparing the environmental performances of LEED ™ strategies or requirements. The rating system has more strategies, thus more points that mitigate the impacts of building operations than those that mitigate the environmental impacts of construction (see table 3). This is appropriate since environmental impacts of the operation and use over the life of a building exceed the one-time environmental impacts affected by the building's construction. (AIA Environmental Resource Guide)

The abstraction of a mitigated environmental impact by a strategy into a point is a loss of information through rationalization. The effect is that all strategies that score one point each seem equal in terms of the value they have for mitigating environmental impacts. For example, material resources saved by reusing 75% of a building's structure and shell (MR Credit 1) are likely to be in several orders of magnitude larger than those saved by using salvaged or refurbished materials for 5% of the building materials (MR Credit 3). This is so because 70% or more of a building's weight is contained in the structure and shell (Weidt, 2002). Saving 75% of the structure and shell in MR Credit 1 saves more than 50% by weight of the building materials. In contrast, MR Credit 3 uses salvaged or refurbished materials for just 5% of the building materials. Yet, both strategies are awarded 1 point. All other things being equal, a design that gets a point for MR Credit 1 will have a much better environmental performance than one that scores a point for MR Credit 3. This information is lost in the rationalized point system. While aiming to get more points, a design team is likely to treat MR Credit 1 and MR Credit 3 similarly, and assuming equal opportunity for both, will incorporate the one with the lower first cost. In reality, the environmental benefit of a group of strategies cannot be considered equal with another group simply because the points for the compared groups of strategies add up equally.

Table 3. Credit Analysis: Continuing vs. One-time Environmental Impacts[6]

Category	LEED Points	Continuing Impacts from Building Operation	One-time Impacts from Building Construction	% From Building Operation
Site	14	12	2	86%
Water	5	5	0	100%
Energy & Atmosphere	17	17	0	100%
Indoor Environmental Quality	NA	NA	NA	NA
Materials & Resources	13	0	13	0%
Innovation Credits	NA	NA	NA	NA
TOTALS	**49**	**34**	**15**	**69%**

Ideally, the points need to be weighted to more accurately reflect the overall environmental performance of individual strategies within specific categories or to more accurately reflect discrete values along each of the three axes, environmental responsibility,

[6] IEQ Credits are marked "NA" because their impacts are health related rather than environmental. Innovation credits are marked "NA" and not included in the tabulations because they will be unique to projects and their benefit cannot be anticipated.

profitability and healthy buildings. This will guide decisions to designs that most effectively mitigate specific environmental impacts. Without this, design teams will try to simply maximize points. Maximizing points will not maximize environmental benefit and as a result the investments will be misplaced with regards to the objectives of building "green".

Local Relevance of Environmental Issues

Each LEED ™ credit has a specific intent that is published as a part of the rating system. In most cases the intention is to reduce environmental impacts of the building. For example, Water Efficiency (WE) Credit 2 is intended to "Reduce the generation of wastewater and potable water demand, while increasing the local aquifer recharge" and Sustainable Sites (SS) Credit 8 intends to "Eliminate light trespass from the building site, improve night sky access, and reduce development impact on nocturnal environments." These environmental impacts can be classified in to local or regional issues and global issues (Gore 1992). Most instances of water pollution, air pollution, waste dumping, heat island effect, increased runoff and erosion are local issues. Acid rain, contamination and depletion of groundwater sources are regional issues. However, atmospheric warming due to the greenhouse effect and stratospheric ozone depletion are issues that are global in nature.

Table 4. Credit Analysis: Global vs. Local Environmental Impacts[7]

Category	LEED Points	Global Environmental Impacts	Local /Regional Environmental Impacts	% Global Impacts
Site	14	4	10	29%
Water	5	0	5	0%
Energy & Atmosphere	17	17	0	100%
Indoor Environmental Quality	NA	NA	NA	NA
Materials & Resources	13	0	13	0%
Innovation Credits	NA	NA	NA	NA
TOTALS	**49**	**21**	**28**	**43%**

Within the LEED ™ system, Energy and Atmosphere credits most directly address global issues where as Sustainable Sites and most Materials & Resources credits address more immediately local or regional issues. Indoor Environmental Quality credits affect the interior environment of a building. See table 4. It is important to recognize that credits that address global environmental issues such as the ozone layer, or the greenhouse effect will have a relevance for every project in every location, but those that address essentially local or regional issues such as water conservation or waste management are likely to have a different relevance in each circumstance.

Strategies that address local/regional environmental issues have varying environmental benefits depending on the environmental features of the region. It is imperative for a building design in the southwest to give priority to water conservation credits but not as imperative if the building is located in the upper Midwest where water is relatively abundant. As a minimum, design teams and owners need to be guided to recognize the local relevance of certain strategies and be assisted in making decisions accordingly. The

[7] Same as footnote 6.

categorization that we have provided in table 7 is a start in providing this information. In addition, the LEED ™ system should be customized for geographic regions so that in addition to credits addressing global issues, the resulting regional versions would better reflect relevant local and regional issues through a more appropriate distribution of credits. Without this, design teams will try to simply maximize points. Maximizing points will not maximize environmental benefit as relevant for the region and as a result the investments will be misplaced with regards to the objectives of building "green".

Prescriptive and Performance Based Credit Requirements

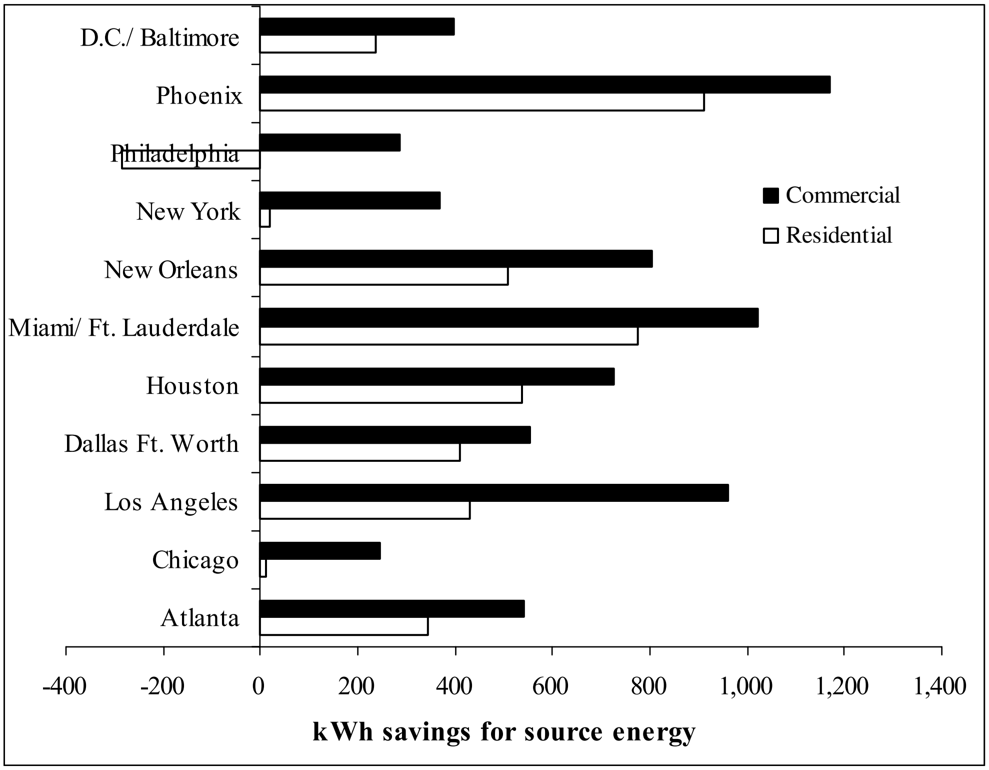
Requirements to score LEED ™ points are sometimes prescriptive in nature in that they require the implementation of a specific technology e.g. the monitoring of CO_2 in a building under IEQ Credit 1, or the installation of high albedo surfaces to reduce heat islands under SS Credit 7. Other requirements are designed as performance based e.g. SS Credit 6 Stormwater Management awards one point for not increasing the stormwater runoff from existing to developed conditions. Performance based requirements relate directly the intent of the credit and award points based on the extent of meeting the intent. The point awarded for the credit does not require the installation of a specific technology nor is there a specific solution required. Prescriptive requirements give a point for implementing a solution or a technology and their performance value is considered fixed and implicit. Table 5 shows a summary of our categorization of credits into either prescriptive or performance based requirements (table 7 shows more detail).

Table 5. LEED ™ Credit Analysis: Prescriptive vs. Performance Based

Category	LEED Points	Prescriptive	Performance	% Prescriptive
Site	14	8	6	57%
Water	5	0	5	0%
Energy & Atmosphere	17	4	13	24%
Indoor Environmental Quality	15	11	4	73%
Materials & Resources	13	3	10	23%
Innovation Credits	NA	NA	NA	NA
TOTALS	**64**	**26**	**38**	**41%**

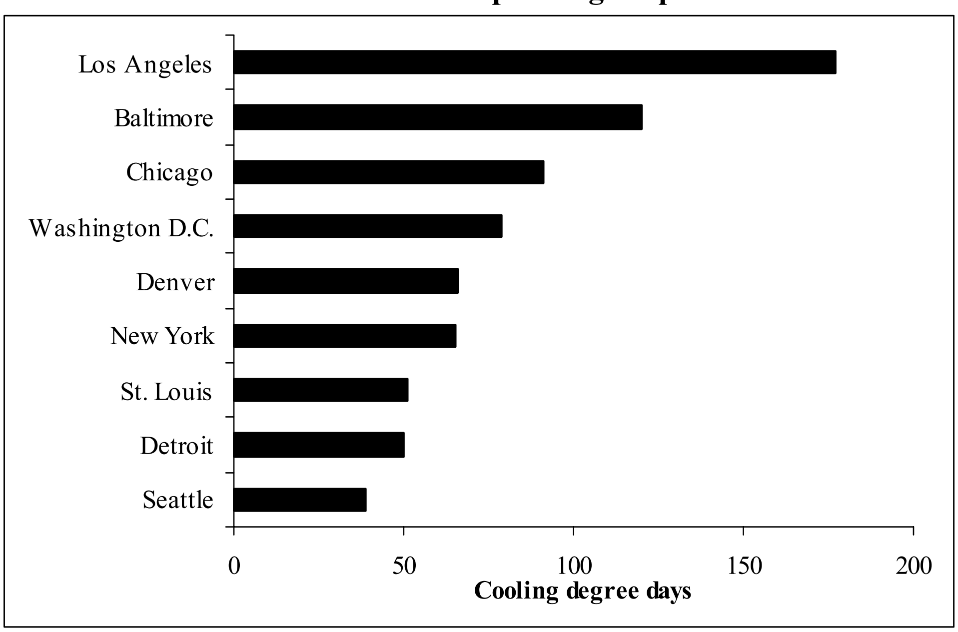
A specific technology like a high albedo roof surface will not perform the same and have a similar benefit in all cases. As opposed to the blanket SS Credit 7 requirement for high albedo surfaces, Rosenfeld and Romm (1996), subsequent to their analysis, recommend a white or light roof and adding shade trees through the Cool Communities strategy specifically in warm climates, where the heating penalty in winter is small. The varying performance of white roofs has been adequately documented through DOE2.1 simulation by Akbari and Konopacki (1998).

Figure 1. Source Energy Savings in kWh per 100m2 of Light Colored Roof Application



Source: Based on data from Akbari and Konopacki (1998)

Figure 2. Heat Island Effect in cooling Degree-Day Difference between Urban Area and its Corresponding Airport



Source: LEED ™ Reference Guide August 2000

In Figure 1, we see that the benefit of reducing source energy consumption varies for metro areas in different geographical locations and climatic conditions. Colder climates in higher latitudes have less benefit. Residential buildings with higher heating needs also benefit less from this technology, and in the case of Philadelphia, there is a penalty for source energy consumed in residential buildings. Further, heat island effects vary by location as seen in figure 2, and for buildings that are designed away from large metropolitan areas, where the heat island effect may be negligible or non existent, the value of a high albedo roof system is significantly reduced in terms of environmental benefit, whether local (improved microclimate) or global (reduced energy consumption). The difference in performance of a high albedo roofing surface for different building types has also been documented through actual monitoring (Akbari et al. 1998) and buildings with high internal cooling loads like retail stores have less benefit compared to those with lower internal cooling loads.

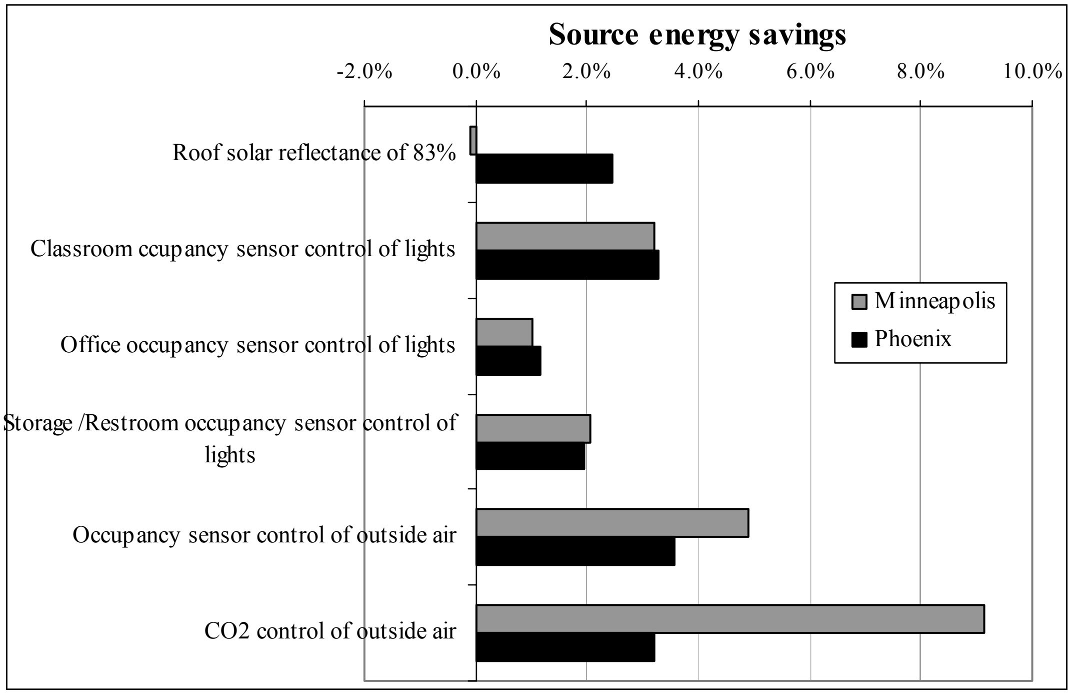
There are instances where design teams are considering adding outlets for electric vehicles in their designs to earn a point for SS Credit 4.3 for alternative refueling stations, even though none of the employees has an electric vehicle and neither does the employer. Yet, the point is awarded and the solution to get the points is being implemented. Therefore, the prescriptive requirement to provide alternative fueling stations for 3% of the vehicles would be met, but the intent – to reduce pollution and land development impacts from automobile use – is not addressed, at least in the short term, and likely not in the long term either.

LEED ™ 2.0 has moved towards performance requirements compared to the pilot version 1.0 and in the future, the USGBC is keen moving towards requirements that are performance oriented (LEED ™ Steering Committee and LEED ™ 2.1 (3.0) Committee, 2001). In the current LEED ™ version 2.0, prescriptive requirements need to be appraised for their local environmental relevance and for their value for a specific project. If in future the LEED ™ system is customized by geographical region, then the current prescriptive requirements need to be evaluated more urgently than the performance requirements.

Can LEED ™ Result in Reduced Investment in Energy Efficiency?

LEED ™ prescribes the Energy Cost Budget method from ASHRAE 90.1 1999 for evaluating the energy efficiency of a project through simulation and comparison of the energy performance of a design with that of a “budget” building. A budget building just satisfies the standard 90.1 at individual component level. Up to 10 points are awarded under the EA Credit 1 depending on the energy performance of the design compared to the budget model. Some reliable technologies and strategies such as the use of occupancy sensors to control lights and outside air, proper building orientation, or controlling the amount of outside air through the use of carbon dioxide (CO_2) sensors provide good energy savings, but are not eligible for consideration according to the ASHRAE standard adopted by LEED ™. Other strategies such as natural ventilation, good window design, appropriate building orientation and massing also cannot be counted in the energy efficiency calculations under the ASHRAE method, and therefore under LEED ™ (Eley 2001). To illustrate this we simulated a 3 storied school building using DOE2.1 in Phoenix and Minneapolis and compared the isolated interior energy savings provided by 3 technologies: CO_2 control of outside air, Occupancy Sensor control of lights, Occupancy Sensor control of outside air in classrooms and offices, and a high albedo roof surface. The source energy savings are summarized in Figure 3.

Figure 3. Comparing the Effectiveness of Energy Saving Strategies in 2 Climates



The roof solar reflectance strategy has a source energy savings of 2.4% in Phoenix, and a penalty of 0.1% in Minneapolis; the source energy savings of this strategy can be included in the calculations for energy efficiency under EA Credit 1. Occupancy sensor control of lights, Occupancy sensor control of outside air, and CO_2 control of outside air add up to a savings of 20.3% in Minneapolis and 13.2% in Phoenix; these savings from these strategies cannot be included in the calculation for energy efficiency EA Credit 1. The high reflectance roof surface will score one LEED ™ point under SS Credit 7 as well as be counted in EA Credit 1, while it provides a small source energy savings only. The CO_2 control and occupancy sensor controls will contribute towards a healthy building and will score one point each under IEQ Credit 1 and Credit 6 respectively, but their environmental benefit (much higher than the roof reflectance strategy) through source energy savings cannot be counted for energy efficiency under EA Credit 1. The lack of available points, in effect, creates disincentive for the CO_2 and occupancy sensors in the LEED ™ system. Designers and owners focused on maximizing LEED ™ points are likely to invest in the high albedo roof strategy despite its poorer energy efficiency performance. In the absence of LEED ™ points weighted for environmental benefit, or a regionalized LEED ™ system, or intentions beyond just scoring LEED ™ points, design choices are likely to cause investment in prescriptive strategies that do not maximize energy efficiency or environmental benefit.

The fundamental building systems commissioning requirement, EA Prerequisite 1, can be compared in value to two other requirements, EA Credit 1, Optimize Energy Performance and EA Credit 5, Measurement and Verification. The intent of EA Prerequisite 1- to verify and ensure that fundamental building elements and systems are designed installed and calibrated to operate as intended- is a form of quality control. The estimated value is a net improvement in operating efficiency of 5% to 10% (USGBC 2001). Commissioning costs are typically estimated at 0.75% to 1.5% of total construction costs with smaller buildings being in the higher portion of the range. A 100,000 square foot building at $120 per sq. ft. would have a total cost of $12,000,000. If commissioning were to cost 1% in this instance, the cost of commissioning would be $1.20 per sq. ft., or $120,000. By comparison, investing $1.20 per square foot in energy conservation can result in a 20%-30% improvement in operating efficiency. Assuming no commissioning, this still translates to an 18% to 27% net operating efficiency.

Similarly we can compare the merits of fundamental building systems commissioning to the merits of Measurement and Verification (M&V). M&V planned and executed in conjunction with energy simulations encompasses much of what fundamental building systems commissioning purports to do for energy efficiency; it enables ongoing tuning and refinement of a building to its conditions of use. Where as fundamental building systems commissioning is a "works-as-designed" approach, M&V is ultimately a "works-as-used" approach and offers better assurances of energy efficiency over time. By our estimates, implementation of an M&V plan could be half as expensive as a fundamental building systems commissioning plan for the same level of energy efficiency and with more long-term value.

But commissioning is a prerequisite for LEED ™ certification so a design team or owner has to spend construction budget on fundamental building systems commissioning to be eligible for certification. By having a prescriptive requirement that needs a large investment as a prerequisite, LEED ™ does not give design teams the option do commissioning if it provides significant value to the project. This prerequisite is likely to drive investment away from other energy efficiency strategies that provide more value to a specific project.

Detailed Categorization of LEED ™ Credits

The following tables show our attempt to evaluate each LEED ™ credit according to the categories presented in this paper. Certainly there is room for disagreement on how a given credit is categorized. We offer these tables to promote discussion and to facilitate improvements in the development and use of the LEED ™ system. Table 6 is the complete table which forms the basis for Tables 1 and 2 above. Similarly Table 7 shows how we formulated Tables 3, 4, and 5.

Conclusions

The LEED ™ system is an effective tool to transform the construction industry towards healthier and more environmentally responsible buildings. In order to guide decisions to designs that most effectively mitigate environmental impacts, design teams while working on projects in the current LEED ™ Version 2.0, and the USGBC in the future development of LEED ™, need to consider the categorization of the credits as presented in this paper. As the rating system currently stands in version 2.0, increasing points may not increase environmental performance of a design. As design teams maximize points to reach

LEED ™ certification levels, they are likely to not make the best investments in strategies that meet the objectives of building "green".

To facilitate decision-making, strategies within the rating system should be expressed as mitigating environmental concerns, making healthy places, or satisfying other criteria to facilitate a fair comparison across the strategies during the decision making process. Ideally the points need to be weighted to reflect the performance of individual strategies relative to their environmental benefit. The LEED ™ system should be customized for geographical regions so that in addition to credits addressing global issues, the resulting regional versions would address relevant local and regional issues; the points in the resulting regional versions should be weighted to reflect the extent of benefit of each credit to that region. For future versions of LEED ™, the USGBC should continue its efforts, evidenced in the development from LEED ™ 1.0 to LEED ™ 2.0, to minimize prescriptive credit requirements; within the current LEED ™ Version 2.0 prescriptive requirements need to be evaluated for their environmental value when considered for a project.

Tables provided in this paper that categorize LEED ™ credit requirements give a direction for this further development of LEED ™.

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Table 6. LEED ™ Credit Categories: Environment, Health, and Cost Issues

Category		LEED Points	Environ-mental Credits	Health Credits	Owner $ Benefits	Standard Practice	Design Effort; Minor $	Significant Const. $
SS Pr 1	Erosion and Sedimentation Control	0				Y		
SS Cr 1	Site Selection	1	1			1		
SS Cr 2	Urban Redevelopment	1	1			1		
SS Cr 3	Brownfield Redevelopment	1	1					1
SS Cr 4.1	Alternative Transportation: bus, rail distance	1	1			1		
SS Cr 4.2	Alternative Transportation: bicycle facilities, shower	1	1				1	
SS Cr 4.3	Alternative Transportation: alternative refuelling stations	1	1					1
SS Cr 4.4	Alternative Transportation: minimize parking, carpool	1	1				1	
SS Cr 5	Reduced Site Disturbance: native planting; footprint	2	2				2	
SS Cr 6.1	Storm Water Management: manage runoff	1	1			1		
SS Cr 6.2	Storm Water Management: treatment systems	1	1					1
SS Cr 7.1	Reduce Heat Islands: shaded or light colored landscape	1	1				1	
SS Cr 7.2	Reduce Heat Islands: energy star or green roof	1	1					1
SS Cr 8	Light Pollution Reduction	1	1			1		
WE Cr 1.1	Water Efficient Landscaping: high efficiency irrigation	1	1		1			1
WE Cr 1.2	Additional: zero irrigation	1	1		1		1	
WE Cr 2	Innovative Wastewater Technologies	1	1		1			1
WE Cr 3.1	Water Use Reduction: 20% reduction	1	1		1		1	
WE Cr 3.2	Additional:10% reduction	1	1		1			1
E&A Pr 1	Fundamental Building Systems Commissioning	0						Y
E&A Pr 2	Minimum Energy Performance	0				Y		
E&A Pr 3	CFC reduction in HVAC&R Equipment	0				Y		
E&A Cr 1.1	Optimize Energy Performance: 20% (10% rehab) better	2	2		2		2	
E&A Cr 1.2-5	Additional 40% better or more	8	8		8			8
E&A Cr 2	Renewable Energy: 5 - 20% of total load	3	3		3			3
E&A Cr 3	Additional Commissioning	1		1				1
E&A Cr 4	Elimination of HCFCs and Halons	1	1					1
E&A Cr 5	Measurement and Verification	1	1					1
E&A Cr 6	Green Power	1	1					1
IEQ Pr 1	Minimum IAQ Performance	0				Y		
IEQ Pr 2	Environmental Tobacco Smoke (ETS) Control	0				Y		
IEQ Cr 1	CO2 Monitoring	1		1	1			1
IEQ Cr 2	Increase Ventilation Effectiveness	1		1			1	
IEQ Cr 3	Construction IAQ Management Plan	2		2			2	
IEQ Cr 4	Low Emitting Materials: adhesives, paints, carpets, etc.	4		4			4	
IEQ Cr 5	Indoor Chemical and Pollutant Source Control	1		1			1	
IEQ Cr 6	Controllability of Systems: perimeter & interior	2		2				2
IEQ Cr 7.1	Thermal Comfort: comply with ASHRAE 55	1		1		1		
IEQ Cr 7.2	Thermal Comfort: temperature, humidity monitoring	1		1				1
IEQ Cr 8	Daylight and Views: 75% spaces daylit, 90% w/ views	2		2			2	
MR Pr 1	Storage and Collection of Recyclables	0				Y		
MR Cr 1	Building Reuse: 75 - 100% structure & shell, 50% non-shell	3	3				3	
MR Cr 2.1	Construction Waste Management: salvage recycle 50 %	1	1				1	
MR Cr 2.2	Additional: salvage recycle 25%	1	1					1
MR Cr 3	Resource Reuse: 5 - 10% salvaged refurbished materials	2	2				2	
MR Cr 4	Recycled Content: 25 - 50% recycled materials	2	2				2	
MR Cr 5.1	Local Materials: 20% materials within 500 mi	1	1				1	
MR Cr 5.2	Additional: 50% of that cradle to gate within 500 mi	1	1					1
MR Cr 6	Rapidly Renewable Materials	1	1					1
MR Cr 7	Certified Wood	1	1					1
IN Cr 1	LEED Innovation Credits	4	NA	NA	NA			4
IN Cr 2	LEED Accredited Professional	1	NA	NA	NA		1	
TOTALS		**69**	**48**	**16**	**18**	**6**	**28**	**30**
Design Team Ratings of Strategies Under Consideration					EASY	80%	76%	32%
					HARD	20%	24%	68 %

Table 7. LEED™ Credit Categories: Requirement Type and Impact Type

Category		LEED Points	Requirements		Environmental Impacts			
			Prescriptive	Performance	Continuing (Operation)	One-time (Construction)	Global	Local/ Regional
SS Pr 1	Erosion and Sedimentation Control	0	Y					
SS Cr 1	Site Selection	1	1		1			1
SS Cr 2	Urban Redevelopment	1	1		1			1
SS Cr 3	Brownfield Redevelopment	1		1		1		1
SS Cr 4	Alternative Transportation	4	4		4		4	
SS Cr 5.1	Reduced Site Disturbance: native planting	1		1		1		1
SS Cr 5.2	Reduced Site Disturbance: footprint	1		1	1			1
SS Cr 6.1	Storm Water Management: manage runoff	1		1	1			1
SS Cr 6.2	Storm Water Management: treatment systems	1		1	1			1
SS Cr 7.1	Reduce Heat Islands: shaded or light colored landscape	1	1		1			1
SS Cr 7.2	Reduce Heat Islands: energy star or green roof	1	1		1			1
SS Cr 8	Light Pollution Reduction	1		1	1			1
WE Cr 1.1	Water Efficient Landscaping: high efficiency irrigation	1		1	1			1
WE Cr 1.2	Additional: zero irrigation	1		1	1			1
WE Cr 2	Innovative Wastewater Technologies	1		1	1			1
WE Cr 3.1	Water Use Reduction: 20% reduction	1		1	1			1
WE Cr 3.2	Additional:10% reduction	1		1	1			1
E&A Pr 1	Fundamental Building Systems Commissioning	0	Y					
E&A Pr 2	Minimum Energy Performance	0		Y				
E&A Pr 3	CFC reduction in HVAC&R Equipment	0	Y					
E&A Cr 1.1	Optimize Energy Performance: 20% (10% rehab) better	2		2	2		2	
E&A Cr 1.2-5	Additional 40% better or more	8		8	8		8	
E&A Cr 2	Renewable Energy: 5 - 20% of total load	3		3	3		3	
E&A Cr 3	Additional Commissioning	1	1		1		1	
E&A Cr 4	Elimination of HCFCs and Halons	1	1		1		1	
E&A Cr 5	Measurement and Verification	1	1		1		1	
E&A Cr 6	Green Power	1	1		1		1	
IEQ Pr 1	Minimum IAQ Performance	0	Y					
IEQ Pr 2	Environmental Tobacco Smoke (ETS) Control	0	Y					
IEQ Cr 1	CO2 Monitoring	1	1		NA	NA	NA	NA
IEQ Cr 2	Increase Ventilation Effectiveness	1		1	NA	NA	NA	NA
IEQ Cr 3	Construction IAQ Management Plan	2	2		NA	NA	NA	NA
IEQ Cr 4	Low Emitting Materials: adhesives, paints, carpets, etc.	4	4		NA	NA	NA	NA
IEQ Cr 5	Indoor Chemical and Pollutant Source Control	1	1		NA	NA	NA	NA
IEQ Cr 6	Controllability of Systems: perimeter & interior	2	2		NA	NA	NA	NA
IEQ Cr 7.1	Thermal Comfort: comply with ASHRAE 55	1		1	NA	NA	NA	NA
IEQ Cr 7.2	Thermal Comfort: temperature, humidity monitoring	1	1		NA	NA	NA	NA
IEQ Cr 8	Daylight and Views: 75% spaces daylit, 90% w/ views	2		2	NA	NA	NA	NA
MR Pr 1	Storage and Collection of Recyclables	0	Y					
MR Cr 1	Building Reuse: 75 - 100% structure & shell, 50% non-shell	3	3			3		3
MR Cr 2.1	Construction Waste Management: salvage recycle 50 %	1		1		1		1
MR Cr 2.2	Additional: salvage recycle 25%	1		1		1		1
MR Cr 3	Resource Reuse: 5 - 10% salvaged refurbished materials	2		2		2		2
MR Cr 4	Recycled Content: 25 - 50% recycled materials	2		2		2		2
MR Cr 5.1	Local Materials: 20% materials within 500 mi	1		1		1		1
MR Cr 5.2	Additional: 50% of that cradle to gate within 500 mi	1		1		1		1
MR Cr 6	Rapidly Renewable Materials	1		1		1		1
MR Cr 7	Certified Wood	1		1		1		1
IN Cr 1	LEED Innovation Credits	4	NA	NA	NA	NA	NA	NA
IN Cr 2	LEED Accredited Professional	1	NA	NA	NA	NA	NA	NA
TOTALS		**69**	**26**	**38**	**34**	**15**	**21**	**28**
Total Percentages (categories do not sum to 100% due to "NA" credits)		**100%**	**38%**	**55%**	**49%**	**22%**	**30%**	**41%**