

Selecting LEED Credits for Courthouses Based on Frequency and Cost

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Leadership in Energy and Environmental Design (LEED) is a commonly recognized credit-based green building certification program. When collaborating to construct green buildings, project participants oftentimes need help selecting which credits to pursue for LEED certification. As constraints are added to the selection process, the decision process for selecting LEED credits becomes increasingly difficult. Previous research has been conducted to develop computerized support systems to aid the LEED credit selection process, but these tools have yet to be fully validated on multiple types of projects or for complex structures. Other research has explored determining the frequencies of credits that are awarded to commercial buildings and using high frequencies as a starting point for selecting LEED credits. This study utilizes a Credit Frequency Indicator to determine the most commonly awarded LEED points for courthouses and then compares credit frequencies to a Cost Impact Factor to determine if the most economical credits are being selected. The credit frequencies of courthouses were also compared to those compiled from a limited set of commercial buildings for validation. It is hoped that the findings presented in this paper will help project owners, designers and builders in making more informed decisions regarding LEED credits.

Key Words: LEED Rating System, Credit Frequency Indicator, LEED Credit, Green Building

Introduction

Much has been written about the health and economic benefits of green construction (Edwards, et al, 2003; Kats, 2003: Ries, et al, 2006; Ross, et al, 2006). Because of these benefits, many government agencies in the United States are implementing green building requirements, most commonly rated by way of the United States Green Building Council's (USGBC) Leadership in Energy & Environmental Design (LEED) certification program. Starting in 2007 with the United States Army's mandate that all newly constructed buildings achieve a LEED rating of Silver for fiscal year 2008 (Keysar & Pearce, 2007), several federal, state and local governments are requiring the incorporation of sustainable and green building elements into the design and construction of new and renovated facilities (Montoya, 2011).

LEED is a flexible third-party certification process in that there are versions for different types of buildings and it can be applied throughout a project's lifecycle. Also, as a point-based allocation rating system, there are several combinations of point totals building owners, designers and builders can employ to reach various levels of LEED certification. Originally devised for new construction, the USGBC has evolved the LEED system to include specific certification processes for five rating systems that can be applied over 22 project types. The LEED rating system is continuously reviewed and updated to accommodate not only how environmental problems can be reduced, but also to encourage the improvement of human health. Four levels of certification can be achieved: Certified, Silver, Gold and Platinum.

Previous Work Conducted on the Economic Selection of LEED Credits

Developing a systematic process for selecting LEED points has proven difficult due to the multitude of points available and the varied types of projects to which they can be applied. Research has aimed to create tools to simplify the credit selection process, focusing on developing algorithm-based computerized decision support systems to help practitioners optimize the selection of green building components. Many of these tools involve the use of analytic hierarchy process (AHP) analyses of data generated from Likert scale surveys submitted by professionals with extensive knowledge of green building (Castro-Lacouture, et al, 2009; Choi, et al, 2015; Florez, et al, 2010; Ogunkah & Yang, 2014; Sullivan, 2008; Yang & Ogunkah, 2013). Experts complete a survey that allows them to rate the suitability of LEED points with respect to multiple goals, such as points that are the least expensive to implement. The AHP model processes the data from those surveys and determines which LEED points are most suitable for a given building. AHP models are a logical choice for optimizing the choice of LEED credits on the surface because they were developed for organizing and analyzing complex decisions through pairwise comparisons and they rely on the judgment of experts to develop priority scales (Saaty, 2008). Current models developed for LEED credit selection allow for the economic maximization of points, however, because of complex combination of points available and the various types of projects they can be applied to, the models have only been applied or validated in limited situations, such as to a single structure (Choi, et al, 2015), non-LEED single family housing (Yang & Ogunkah, 2013), validating a model for housing in Nigeria (Ogunkah & Yang, 2014), focusing solely on material selection (Florez, et al, 2010), or material selection in Columbia (Castro-Lacouture, et al, 2009). In spite of the limited application of AHP models, they show promise and can be improved. However, in their current form, the do not alleviate the problem articulated by Keysar & Pearce (2007) of practitioners being overwhelmed by information. Furthermore, as Yang & Ogunkah (2013) determined, few working practitioners have had exposure to AHP and found the effort required to rank credit preferences via Likert scale daunting. In their current state, existing computerized systems are not easing the process of selecting LEED credits to attempt.

While computerized systems will likely evolve and become more robust and be able to handle increasingly difficult projects, there is still an immediate need among practitioners for tools to aid in the selection of LEED credits for buildings, particularly complex ones. One method that provides numerical analysis and a list of likely credits for common types of projects is to conduct a credit frequency analysis of LEED projects. This has been demonstrated in one such study of commercial buildings in Canada (Da Silva & Ruwanpura, 2009). In that study, a Credit Frequency Indicator (CFI) was used to tabulate the usage of credits in 42 building projects in Canada and provide insight into what credits future commercial projects with similar goals should consider adopting. In other words, that study provides a starting point for selecting points based on the successful inclusion of those points on LEED certified buildings.

The research presented in this paper builds upon the CFI research and applies it to complex government projects. By analyzing frequently earned LEED points and comparing them to their relative costs for implementation, this research will further refine the starting point for practitioners to select LEED credits.

Research Aim, Objectives and Scope

There is an increasing interest in green building in government buildings in the United States at the federal, state and local level. However, that level of interest is many times dependent on the financial health of the agency sponsoring the design and construction. Furthermore, many agencies, including the United States General Services Administration, mandate that credits be selected with particular attention paid to the cost of the credits (Steven Winter Associates, 2004).

The aim of this research is to develop a list of common LEED credits earned in a particular type of building and compare their frequency to their cost. The research objectives are as follows:

- Using a CFI, identify and rank order the LEED credits that are achieved for courthouse projects in the United States.
- Compare that rank ordered list of credits to the costs associated with implementing them, using the Cost Impact Factor as a proxy for cost of implementation.

The resulting list will provide project owners, designers and constructors with a starting point for selecting LEED credits to pursue. The scope of this study is limited to courthouses owned and operated by federal and state agencies in the United States. However, the processes and findings demonstrated in this paper can be applied to other technical structures, such as hospitals, institutional and educational buildings, office buildings, large residential projects, etc. Courthouses were selected for several reasons. First, there are common design and construction rules that are applied to courthouses. Federal courthouse design and construction are dictated by the U.S. Courts Design

Guide, and many states follow the federal design guide as facilitated by the National Center for State Courts. Other states have their own design guides, but they prescribe design standards that exceed those of the U.S. Courts Design Guide. Second, courthouses are complex projects. There are many constraints in terms of the green materials that can be used because the primary basis for selection of most materials is the safety and wellbeing of visitors, as well as the safe incarceration of people who are awaiting or who have been prosecuted, which means the benefits of green building are not necessarily the primary motivation for selection. Similarly, courthouses perform a multitude of functions and must accommodate many different uses and people. In addition to courtrooms, judges' chambers and holding cells, courthouses oftentimes contain cafeterias, waiting areas, office space, law libraries, etc. These constraints would likely be too complex for the computerized decision support systems previously mentioned to generate an optimal list of LEED credits to pursue, and therefore, ranking LEED credits by CFI and comparing costs is a logical starting point for selecting LEED credits. Given the code-based design of courthouses and a mandate by their owners that economic considerations be made in the selection of LEED credits to pursue, a list of commonly achieved LEED credits along with their cost for implantation would be valuable for practitioners.

Methodology and Main Findings

Phase I: Developing a Project Sample Population

Using the USGBC's LEED project database, 33 completed courthouses were identified as being qualified for this research project. Projects were limited to new construction or extensive renovations, and thus subject to LEED for Building Design and Construction (BD+C). There are currently no LEED Platinum courthouses that qualify as BD+C. Projects from LEED versions 2.1, 2.2 and 2009 (version 3) were included in the analysis sample size. There were no LEED-certified courthouses for versions 1 or 4 in the USGBC database.

Next, because multiple LEED versions were used, they needed to be normalized. Each of the versions of LEED represented in the sample size have differing credits within the categories, as well as point totals for some categories. While there have been fairly substantial changes between versions, the changes generally involve increasing material transparency and adding prerequisites that call for metering and recording water and energy usage. These can be fairly major changes, yet the LEED categories and credits remain fairly consistent between versions, and hence, the various LEED versions were normalized by aligning the similar LEED credit categories from each version to the next. Because prerequisites frequency should always be 100% and is non-negotiable, any analysis of them was not included in this research. The point distributions between categories and credits changed, but they are normalized by the Credit Frequency Indicators. Therefore, the only additional normalization that was required was to match the credit descriptions from version to version for a few specific credits.

Within each LEED category are multiple LEED credits. As the LEED versions evolved, so did some of the individual credits and the points allocated to them. Some of the changes were in the descriptions (for example, Credit MRc3.1 was Resource Reuse in version 2.1 and Material Reuse in version 2009). Other changes were associated with increasingly stringent standards (for example, Credits MRc4.1 and MRc4.2 in version 2.1 refer to 5% and 10% recycled content, while those same credits in version 2.2 refer to 10% and 20%, respectively). Lastly, in some cases, detailed breakouts of credits were replaced by broader categories with more points and flexibility (for example, in version 2.1, there are three credits, EAc2.1, EAc2.2 and EAc2.3, worth one point each, dedicated to increasing levels of on-site renewable energy, whereas version 2009 has a single credit, EAc2, for which one to three points can be earned). It should also be noted that credits for Regional Priority, which were introduced in Version 2009, were not included in the analysis. Also, they are only appropriate in certain locations (by definition). Therefore, they have different issues in terms of their discretionary nature than the other credits. The frequency of those credits, therefore, are less a function of choice and more a function of location.

Ultimately, the list needed to be normalized so that results were applied to a single list of LEED credits. In cases of wording changes, the most recent or appropriate credit description was adopted. In cases where the requirements for the LEED point were increased over time and there are two credits available, the terms Lesser Requirement and Greater Requirement were adopted. The normalized list of LEED credits can be seen below in Table 1.

Phase II: Determining Credit Frequencies

In this phase, the frequency of achieved credits was assessed. The method outlined by Da Silva and Ruwanpura (2009) for determining CFI is not well articulated, so the analysis presented in this paper may differ from that analysis. Two measures of the frequency of LEED points awarded on courthouse projects were employed. The first, % Attempted, is the simpler of the two and is simply the percentage of projects, out of the sample size of 33, that were awarded a point or points for that credit. For example, for Site Selection, 97%, or 32 of the 33 projects in the sample, were awarded the point for that credit.

CFI in this study is calculated by adding all of the points achieved for a particular credit across all projects and dividing that amount by the total points possible for that credit across all projects. For example, under version 2.1 and 2.2, Credit SSc4.4 Alternative Transportation – Parking Capacity, is worth 1 point, but under version 2009 it is worth 2 points. 18 of 29 projects from versions 2.1 and 2.2 were awarded the point, while two out of four version 2009 projects were awarded 2 points each. Therefore, a total of 22 points out of 37, or 59.5%, were awarded, and hence a CFI of 59.5% for SSc4.4. Both the % Attempted and CFI are highly correlated (96.0%). The values for both measures are shown in Table 3 below.

Phase III: Comparing Frequencies to Cost Impact Factors

It is important to understand which credits are commonly awarded because that shows acceptance by owners, designers and builders. Most owners, however, are looking for the economical achievement of LEED, as is the case for courthouses per the design standards set forth by the Judicial Conference on the United States (2007). The General Services Administration (Steven Winters Associates, 2004) commissioned a study of LEED-associated hard and soft costs for government buildings. Cost models for implementing LEED in two government buildings, a courthouse and an office building, were conducted. These buildings were analyzed because they represent a large portion of the G.S.A.'s real estate portfolio. The cost of attaining LEED credits were analyzed and categorized by cost into five levels of Cost Impact Factors:

1. GSA Mandated (no cost)
2. No Cost/Potential Cost Decrease
3. Low Cost ($<$50,000)
4. Moderate Cost ($50,000 to $150,000)
5. High Cost (>$150,000)

To compare frequencies to cost, a quantitative non-experimental study was conducted that determined the prevalence of LEED credits and compared them to their relative cost. Specifically, this research conducted a correlation study where the strength of the relationship between two variables, CFI and Cost Impact Factor, was to be determined. Given the limited nature of this this study, more sophisticated regression analyses were eschewed.

The cost impact factors for each credit are included below in Table 3. Cost Impact Factor scores of N/A were assigned to those credits that not conducive to courthouse design and construction or were in conflict of GSA standards. These reasons include costs not covered by GSA budgets, cost considered operational (as opposed to design and construction), or not applicable to court architecture.

Table 1

Summary of the Frequencies of LEED Points and Cost Impact Factors

No.	Credit Number and Description	N (out of 33 total)	% Attempted	CFI	Rank	Cost Impact Factor
	Sustainable Sites					
SSc1	Site Selection	32	97.0%	100.0%	2	2
SSc2	Development Density	27	81.8%	83.7%	10	2
SSc3	Brownfield Redevelopment	11	33.3%	33.3%	32	2
SSc4.1	Alternative Transportation, Public Transportation Access	23	69.7%	84.9%	8	2

SSc4.2	Alternative Transportation, Bicycle Storage & Changing Rooms	24	72.7%	69.7%	T19	5
SSc4.3	Alternative Transportation, Low-Emitting & Fuel-Efficient Vehicles	22	66.7%	70.7%	18	3
SSc4.4	Alternative Transportation, Parking Capacity	20	60.6%	59.5%	25	3
SSc5.1	Reduced Site Disturbance, Protect or Restore Habitat	5	15.2%	15.2%	40	2
SSc5.2	Reduced Site Disturbance, Maximize Open Space	26	78.8%	81.8%	13	2
SSc6.1	Stormwater Management, Quantity Control	10	30.3%	30.3%	33	2 or 5
SSc6.2	Stormwater Management, Quality Control	12	36.4%	36.4%	T30	4
SSc7.1	Heat Island Effect, Non-Roof	23	69.7%	69.7%	T19	2
SSc7.2	Heat Island Effect, Roof	25	75.8%	75.8%	15	2 or 5
SSc8	Light Pollution Reduction	9	27.3%	27.3%	35	2
	Water Efficiency					
WEc1.1	Water Efficient Landscaping, Reduce by 50%	28	84.8%	82.2%	12	2
WEc1.2	Water Efficient Landscaping, No Potable Use or No Irrigation	10	30.3%	34.5%	T31	2
WEc2	Innovative Wastewater Technologies	1	3.0%	2.7%	47	N/A
WEc3.1	Water Use Reduction, Lesser Requirement	26	78.8%	60.0%	24	1
WEc3.2	Water Use Reduction, Greater Requirement	24	72.7%	82.8%	11	4
	Energy & Atmosphere					
EAc1	Optimize Energy Performance	29	87.9%	44.3%	29	1, 2 or 5
EAc2	Renewable Energy	4	12.1%	9.7%	42	5
EAc3	Additional Commissioning	21	63.6%	0.0%	22	1
EAc4	Enhanced Refrigerant Management	26	78.8%	0.0%	14	N/A
EAc5	Measurement & Verification	8	24.2%	64.9%	37	4
EAc6	Green Power	10	30.3%	81.1%	34	N/A
	Materials & Resources					
MRc1.1	Building Reuse, Lesser Requirement	7	21.2%	17.1%	39	2
MRc1.2	Building Reuse, Medium Requirement	6	18.2%	18.2%	T38	2
MRc1.3	Building Reuse, Greater Requirement	4	12.1%	13.8%	41	N/A
MRc2.1	Construction Waste Management, Lesser Requirement	28	84.8%	83.8%	9	2, 3 or 4
MRc2.2	Construction Waste Management, Greater Requirement	19	57.6%	65.5%	21	3
MRc3.1	Resource Reuse, Lesser Requirement	3	9.1%	8.1%	43	N/A
MRc3.2	Resource Reuse, Greater Requirement	2	6.1%	6.9%	44	N/A
MRc4.1	Recycled Content, Lesser Requirement	32	97.0%	100.0%	1	2
MRc4.2	Recycled Content, Greater Requirement	10	30.3%	34.5%	T31	2, 3 or 4
MRc5.1	Local/Regional Materials, Lesser Requirement	31	93.9%	86.5%	7	2 or 4
MRc5.2	Local/Regional Materials, Greater Requirement	21	63.6%	72.4%	17	2
MRc6	Rapidly Renewable Materials	1	3.0%	3.0%	46	N/A
MRc7	Certified Wood	12	36.4%	36.4%	T30	4 or 5
	Indoor Environmental Quality					
EQc1	Outdoor Air Delivery Monitoring	21	63.6%	63.6%	23	4
EQc2	Increased Ventilation	6	18.2%	18.2%	T38	1 or 2
EQc3.1	Construction IAQ Management Plan, During Construction	31	93.9%	93.9%	T5	3
EQc3.2	Construction IAQ Management Plan, Before Occupancy	18	54.5%	54.5%	26	3
EQc4.1	Low-Emitting Materials, Adhesives & Sealants	30	90.9%	90.9%	6	2
EQc4.2	Low-Emitting Materials, Paints & Coatings	31	93.9%	93.9%	T5	2
EQc4.3	Low-Emitting Materials, Carpet/Flooring	33	100.0%	100.0%	T3	1
EQc4.4	Low-Emitting Materials, Composite Wood & Agrifiber	22	66.7%	66.7%	20	4 or 5
EQc5	Indoor Chemical & Pollutant Source Control	16	48.5%	48.5%	28	2 or 3
EQc6.1	Controllability of Systems, Lighting	17	51.5%	51.5%	27	4 or 5
EQc6.2	Controllability of Systems, Thermal Comfort	8	24.2%	24.2%	36	1
EQc7.1	Thermal Comfort, Design	31	93.9%	97.0%	4	1 or 5
EQc7.2	Thermal Comfort, Verification	24	72.7%	72.7%	16	1 or 2
EQc8.1	Daylight & Views, Greater Requirement	0	0.0%	0.0%	48	N/A
EQc8.2	Daylight & Views, Lesser Requirement	2	6.1%	6.1%	45	5

	Innovation					
IDc1	Innovation in Design: Provide Specific Title	*	93.9%	77.7%		
IDc2	LEED Accredited Professional	33	100.0%	100.0%	T3	2

Table 1 displays both the rank of CFI of LEED credits awarded for courthouse projects in the United States and the relative cost factor associated with implementing them. Furthermore, the correlation between CFI and Cost Impact Factor was calculated to assess if the most economical LEED credits are the most pursued. The correlation for CFI to the lower range of Cost Impact Factor (for those credits with multiple or a range of Cost Impact Factors) is -0.24. The correlation of CFI to the higher range of Cost Impact Factor is -0.19. These correlations, while not statistically significant, nonetheless suggest that LEED credits for courthouse project in the United States are not regularly selected on the basis of cost to implement.

An additional analysis was conducted to compare the CFI ranks from this study to those of the only other published CFI data. As seen below in Table 2, there are a few common LEED credits in the Top 10 from both studies (Recycled Content, utilizing a LEED Accredited Professional, and using Local/Regional Materials) and Bottom 10 (Building Reuse, Renewable Energy, Resource Reuse, and Rapidly Renewable Resources). However, the similarities end there. This suggests, in this limited comparison, that there are discrepancies in how LEED credits are selected for different building types and that the selection of LEED credits is unique and specific to different building types.

Table 2

Comparison of CFI Ranks for U.S. Courthouses and Canadian Commercial Building

Rank (current study)	Rank (Da Silva & Ruwanpura, 2009)	Category	CFI	Cost Impact Factor
Top 10				
1	10	Recycled Content, Lesser Requirement	100.0%	2
2	13	Site Selection	100.0%	2
T3	11	Low-Emitting Materials, Carpet/Flooring	100.0%	1
T3	2	LEED™ Accredited Professional	100.0%	2
4	*	Thermal Comfort, Design	97.0%	1 or 5
T5	*	Construction IAQ Management Plan, During Construction	93.9%	3
T5	15	Low-Emitting Materials, Paints & Coatings	93.9%	2
6	19	Low-Emitting Materials, Adhesives & Sealants	90.9%	2
7	4	Local/Regional Materials, Lesser Requirement	86.5%	2 or 4
8	*	Alternative Transportation, Public Transportation Access	84.9%	2
9	14	Construction Waste Management, Lesser Requirement	83.8%	2 or 4
10	*	Development Density	83.7%	2
Bottom 10				
39	65	Building Reuse, Lesser Requirement	17.1%	2
40	**	Reduced Site Disturbance, Protect or Restore Habitat	15.2%	2
41	64	Building Reuse, Greater Requirement	13.8%	N/A
42	56	Renewable Energy	9.7%	5
43	53	Resource Reuse, Lesser Requirement	8.1%	N/A
44	59	Resource Reuse, Greater Requirement	6.9%	N/A
45	17	Daylight & Views, Lesser Requirement	6.1%	5
46	63	Rapidly Renewable Materials	3.0%	N/A
47	**	Innovative Wastewater Technologies	2.7%	N/A
48	N/A	Daylight & Views, Greater Requirement	0.0%	N/A

*Outside of Top 20
**Above the Bottom 20

N/A: Current study used Version 2009, with one category of Daylight and Views, whereas Da Silva and Ruwanpura (2009) used Version 2.2 with two categories of Daylight and Views

Results and Discussion

The aim of this paper is to help project owners, designers and builders in making more informed decisions regarding LEED credits, particularly with respect to complex projects. Results from the study are mixed. In comparing the results of CFI for courthouses in the United State to commercial buildings in Canada, it would seem that there is little consistency with respect to selecting LEED credits. It was hoped that there would be a sizable group of LEED credits that are very often awarded for multiple building types, and thus project participants could start with that group of credits and extend it based on the level of LEED certification desired. It is clear from this limited comparison that no such group of consistently high frequency credits exists. The research also shows that, in the case of courthouses, there is little correlation between LEED credit frequency and Cost Impact Factor, indicating that either cost is not a major selection driver or that courthouse architecture and codes are not conducive to maximizing the economical selection of LEED credits.

However, the findings do reveal useful information with regards to the selection of LEED credits for courthouses in the United States. The research reveals that there is a clear group of high and low frequency credits that are commonly awarded for courthouses, and those credits can be compared to their Cost Impact Factor and rational decisions made in terms of credit selection. Many of the lowest frequency LEED credits do not have Cost Impact Factors because they are not conducive to courthouse design or operation, and thus avoided by the teams delivering those projects. Because many of the high frequency credits from this study match the high frequency credits determined by the Da Silva and Ruwanpura (same for low frequency credits), that shows some validity of the findings for this study.

This research would be improved with greater sample sizes and more robust measures of the cost of implementing each of the LEED credits. Such cost metrics are being investigated. With more data, a multivariate regression of multiple variable can be conducted. The continuation of the project to include more complex project types, such as hospitals, is planned. Until more data exists and computerized decision systems improved, LEED credit selection for complex projects will be a largely manual exercise. This paper presents a roadmap for the manual collection of LEED credit data and how to compare it to cost data to aid in the LEED credit decision making process.

References

Choi, J.O., Bhatla, A., Stoppel, C.M. & Shane, J.S. (2015). LEED Credit Review System and Optimization Model for Pursuing LEED Certification. *Sustainability*. 2015(7), 13351-13377.

Da Silva, L. & Ruwanpura, J. (2009). Review of the LEED Points Obtained by Canadian Building Projects. *Journal of Architectural Engineering*, 15(2), 38–54.

Castro-Lacouture, D., Sefair, J.A., Florez, L. & Medaglia, A.L. (2009). Optimization Model for the Selection of Materials Using LEED-based Green Building Rating System in Columbia. *Building and Environment*, 44(6), 1162-1170.

Edwards, B. (2003). *Green buildings pay* (2nd ed.). London, NY: Spon Press.

Florez, L., Castro-Lacouture, D. & Irizarry, J. (2010). Impact of Sustainability Perceptions on Optimal Material Selection in Construction Projects. *Second International Conference on Sustainable Construction Materials and Technologies*, Universita Politecnica delle Marche, Ancona, Italy.

Judicial Conference of the United States. (2007). *U.S. Courts Design Guide*. Administrative Office of the Courts.

Kats, G. (2003). *The cost and financial benefits of green buildings: a report to California's sustainable building task force*. Sacramento, CA: Sustainable Building Tanks Force.

Keysar, E & Pearce, A. (2007). Decision Support Tools for Green Building: Facilitating Selection Among New Adopters on Public Sector Projects. *Journal of Green Building*, 2(3), 153-171.

Montoya, M.P. (2011). *Green building fundamentals* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Ogunkah, I.C.B. & Yang, J. (2014). Validation of a Multi-Criteria Decision Support System for Low-Cost Green Building Materials and Components. *International Journal of ICT-aided Architecture and Civil Engineering*, 1(2), 11-32.

Ries, R., Bilec, M., Gokhan, N.M & Needy, K.L. (2006). The Economic Benefits of Green Building: A Comprehensive Case Study. *The Engineering Economist*, 51(3), 259-295.

Ross, B., Lopez-Alcala, M. & Small, A.A. (2006). Modeling the Private Financial Returns from Green Building Investments. *Journal of Green Building*, 2(1), 97-105.

Saaty, T.L. (2008). Decision Making with Analytic Hierarchy Process. *International Journal of Services Sciences*, 1(1), 83-98.

Steven Winter Associates. (2004). G.S.A. LEED Cost Study Final Report. October 2004.

Sullivan, J.G. (2008). Modeling the Private Financial Returns from Green Building Investments, *Associated Schools of Construction International Proceedings of the 44th Annual Conference*, Auburn University, Auburn, AL.

Yang, J. & Ogunkah, I.C.B. (2013). A Multi-Criteria Decision Support System for the Selection of Low-Cost Green Building Materials and Components. *Journal of Building Construction and Planning Research*, 2013(1), 89-130.