

An Evaluation and Decision Support Tool for Improving the Understanding of Sustainable Building Assessment Guidelines' Criteria

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ABSTRACT

Sufficiently understanding the criteria off existing sustainable building assessment schemes is essential to enable designers and building owners to effectively implement sustainable design. With objectives and methodologies for achieving individual criteria provided, sustainable building assessment scheme documentations often does not suggest a realization plan, or offer any strategic approach to criteria fulfillment, based on context-related circumstances such as limited financial means, or maximizing social or environmental benefits as individual preference. This makes it difficult to render consequences beyond a general approach of planning, where all criteria considered are expected to be equally satisfied. The implementation of Evaluation and Decision Support Tools (EDST) can help stakeholders in the decision making progress of criteria implementation according to their individual preferences.

The approach of the demonstrated EDST is based on a rating and ranking method. The criteria of a selected sustainable assessment scheme are rated and compared to classify their respective performances. With individual priorities weighted, resulting scores can then be listed in a hierarchical order to identify well-performing criteria. To further support the design making process, the ranking of criteria is provided in association with the required scores for attainable certification level of the assessment scheme.

In this research, the establishment of rating criteria in association with the LEED v4 Interior Design and Construction (LEED ID&C) sustainable building assessment scheme is used to demonstrate the effectiveness of the EDST tool for improving commercial

interior design and management.

Findings indicate that the EDST allows for meaningful rating results in terms of financial, social and environmental benefits, as well as the need for specialist support. Varying priorities of stakeholders can lead to different results in the EDST criteria ranking. Thus, informed decision makings can be made to create specific strategies for the implementation of individual sustainable building criteria in the realization of projects.

KEYWORDS: Interior design, Evaluation and Decision Support Tool, Sustainable Building Assessment Guidelines, LEED v4 Interior Design and Construction

1 INTRODUCTION

Growing demand for environmentally friendly designs is raising responsibilities and challenges for project stakeholders to comply with sustainable building assessment guidelines that consist of specific criteria in building design and planning. Aspects of sustainability include environmentally sound, socially equitable and economically feasible considerations (Knox, 2015), which, in ideal cases, would lead to positive outcomes for all three when considered in their entirety (Whole Building Design Guide (WBDG) Sustainable Committee, 2015). For instance, sustainable buildings can reduce negative environmental impacts such as waste generation or natural resource depletion (U.S. Department of Energy, 2003.). They can also guarantee safer and healthier environments, provide improved human comfort and well-being to their

residents (World Green Building Council (WorldGBC), 2014), or positively impact construction costs throughout their lifecycle (Sulochana, et al., 2012).

With many national and international systems for sustainable building assessment existing (Nelson, 2012), respective guidelines aim to direct designers and building owners to create sustainable design solutions; they help evaluate the sustainable performance of a project, define goals and requirements of achievement, and state expectations of its anticipated results (Vierra, 2014). Among them, the Leadership in Energy and Environmental Design (LEED) sustainable building assessment system, the standard for rating environmental effectiveness of buildings in the United States, is commonly known and widely used third-party verification for sustainable buildings (Mendler, et al., 2006). With the assessment of sustainable buildings determined by experts and stakeholders (Medineckiene, et al., 2015), an understanding of how individual evaluation criteria relate to one another is often too difficult to overlook. Its complexity affects the viability and performance of a sustainable project, especially when criteria are used selectively.

In addition, by providing the necessary objectives and methodologies to achieve individual criteria, many assessment systems do not propose an implementation plan, or offer a strategic methodology for meeting criteria based on contextual considerations such as limited financial resources or specific preferences on environmental or social benefits. This makes it difficult to understand the implications of a general planning approach, in which all the criteria considered are treated as equal and fulfilled. As many project interests are difficult to reconcile equally, the possibility of assessing strategies to implement sustainable measures before they are actually implemented needs to be taken seriously.

Scrutinizing individual criteria in terms of benefits and requirements can support designers and project owners to steer wanted outcomes more effectively. For instance, a project with strict feasibility constraints may favor financial benefits, a project with high social awareness may prioritize criteria that yield high social benefits, or further, a project located in a remote area with limited availability of planning-experts may favor criteria, which do not require for extensive expert involvement. Thus, the rating of assessment criteria according to specific financial, social, and environmental benefits, as well as their need for expert involvement, is highly capable of providing important understanding regarding the beneficial impact of criteria, and their implementation potential for certification purposes.

In this research, an evaluation and decision support tool (EDST) is proposed and the LEED v4 Interior Design

and Construction (LEED ID&C) criteria is selected as a sample of a sustainable building assessment guideline, where respective criteria rating and ranking processes improve understanding in reference to the criteria individual qualities. The LEED ID&C is one of the guidelines in the LEED green building rating system that focuses on the development the sustainability of commercial interior projects. It consists of 7 major categories that include altogether 37 criteria. These criteria can be divided into 2 groups: prerequisite criteria, which are fundamental requirements; and credit criteria, which are the advanced requirements (U.S. Green Building Council (USGBC), 2013). By earning points across the credit criteria, LEED certifications, namely Certified, Silver, Gold, and Platinum, are rewarded based on the number of points achieved (U.S. Green Building Council (USGBC), 2015).

In adaptation to an analytical hierarchy process or AHP (Medineckiene, et al., 2015), an evaluation of criteria rating is foreseen by using a qualitative scale to determine the significance for each alternative and recognize the optimal alternatives under comparison. Based on either total or partial compensation i.e. a good performance can compensate for a bad performance (Arroyo, 2014), the AHP method not only considers the rating of alternatives used in the comparison but also weights aspects to indicate the preference of stakeholders. The weight corresponding to the aspects evaluated can be identified as suggested by Belton & Stewart (2002) as follows:

- a. Partial value function definition, i.e. in terms of a measurable scale.
- b. Qualitative scale construction to descriptively explain desirable characteristics.
- c. Criteria rating, reflecting the criterion value in relation to its reference definition.

The succeeding ranking process then allows for prioritizing preferable criteria according to set preferences made via weight distribution and automatically calculates the accumulated LEED credits while identifying the certain LEED certifications levels to be achieved.

2 METHODOLOGY

The major objective of this research is to develop an evaluation and decision support tool (EDST) that is capable of rating, and ranking of LEED ID&C criteria for project based implementation on the basis of individually specified preferences. The development of the EDST is divided into its 2 main techniques of rating and ranking.

2.1 Criteria Rating

To support effective decision outcomes, the selected priority issues address benefits in terms of finance, social and environmental issues, as well as the consideration of additional support involved. The rating of LEED criteria is realized by evaluating 4 aspects that influence the overall decision making process. They are identifying the

amount of financial, social and environmental benefits of the criteria, as well as the consideration of necessary specialist support involved. The evaluation of criteria is realized via integer scores between 0-4, with 0 indicating the lowest, and 4 indicating the highest value. An overview of the rating scores and their respective explanation is provided in Table 2.1

Table 2.1 Rating Levels and evaluation description

Key	0	1	2	3	4
Financial Benefits	No benefit: A combined costs with no potential savings	Low benefit: A combined high cost with potential savings	Moderate benefit: A combined moderate costs with potential savings	High benefit: A combined low costs with potential savings.	Very high benefit: No cost with potential savings
Social Benefits	Negative Effect: discomfort and inconvenience	No Benefit: no improvement	Low Benefit: improvement of convenience	Moderate Benefit: improvement of health	High Benefit : improvement of comfort, wellbeing & productivity
Environmental Benefits	No Benefit: no improvement	Low Benefit: initial low improvement	Moderate Benefit: initial high improvement	High Benefit: sustained low improvement	Very High Benefit: sustained high improvement
Specialist Support	Entrust to advanced specialist	Entrust to ordinary specialists	Get suggestions from specialists	No specialists' supports (complicated process)	No specialists' supports (simple process)

Respectively, financial benefits consider the amount of necessary initial investment costs in relation to the timely return of potential savings as rewarding benefits such as reduction of energy, water and raw material consumptions, or minimized costs for operation, maintenance and replacement. Considering social benefits, criteria foreseeing health improvement, physical and psychological well-being, or the improvement of productivity are understood as positive contribution. While interior spaces are capable of having positive and negative impacts on occupants, the quality of the internal environment is of concern. Accordingly, environmental benefits aim for identifying criteria supporting the reduction of environmental pollutions and the protection

natural resources (Yates, 2001). Having direct and indirect environmental impact, considerations primarily focus on direct environmental improvements where the environmental quality can affect initial and sustained improvements. Finally, the need for specialist support in selected fields can be seen as important to the realization of sustainable design projects, as their necessary contribution is highly desirable. Their rating not only helps identifying these specific criteria where specialists support is required but also the amount needed.

As a theory for measuring and judging, the Analytical Hierarchy Process (AHP) is understood as a common evaluation method (Kiran & Rao, 2013), and an appropriate multi-criteria method that evaluates the relative importance of alternatives and their overall consistency ratio (Villarinhorosa, 2013).

2.2 Criteria Ranking

To prioritize project owners' preferences when implementing sustainable building criteria for certification purposes, the EDST uses a ranking table to visualize the rating results. According to the LEED ID&C rating guideline, criteria are divided into prerequisite criteria and credit criteria. Prerequisite criteria are the baseline and mandatory requirements that must be satisfied prior to the consideration of any LEED certifications. Credit criteria are considered and evaluated, and credits will be rewarded when fulfilled. While it is not required to satisfy all LEED credit criteria in a sustainable interior project, the ranking table is developed to help the project team and the project owners select their preferred credit criteria systematically by sorting and prioritizing the credit criteria. Thus, only credit criteria are arranged in a ranking table and listed by their weighted average rating scores in a descending order. The weighted average rating score is the sum-product of a criterions achieved rating scores and its respective weights. With individual criteria having different rating scores for their aspect performances, the weight distribution and the individual strength of their evaluated

aspects determine the ranking position in the table.

Table 2.2 is a sample template of the ranking table. Manual inputs of the ranking table are shaded in light orange. They are the evaluation of the individual criteria's 4 aspect rating scores, and the overall weight distribution between the 4 aspects.

Table 2.2 Sample of Ranking Table for Credit Criteria

Rank	LEED Criteria NO#	Possible LEED Credits	Achieved LEED Credits	Weights					LEED Certification Levels	Accumulated Achieved LEED Credits
				Distribute By Numbers				Total		
				1	1	1	1	4		
				Distribute By Percentages				Total		
				25%	25%	25%	25%	100%		
Evaluation										
Financial Benefit	Social Benefit	Environmental Benefit	Independent Level of Specialist Support	Weighted Average Scores						
1	3.8.1	1	1	1	3	4	4	3.00	None	1
2	1.2	7	7	1	3	3	4	2.75	None	8

Accordingly, credit criteria will be listed in reference their aspect evaluation and the specified weight distribution between the aspects. With the credit criteria ranked and prioritized, the preferred criteria can be analyzed to recognize the sustainable features of these criteria. To deepen the study, and make the ranking result become more practical, individual criteria can be altered by selecting in the amount of 'Achieved LEED Credits' that a project stakeholders aims to achieve

3 RESULTS AND ANALYSIS

The demonstration of how this developed tool can be utilized in order to recognize individual LEED ID&C criteria potential and their impact on LEED certifications was described in a stepwise approach. Since the prerequisite criteria of the LEED ID&C are mandatory and were not included in the ranking process, only credit criteria were analyzed to simply illustrate these rating and ranking processes. However, it should be noted that the prerequisite criteria can also be rated in a similar fashion as the credit criteria.

3.1 Rating Results

The rating results represent the general sustainable awareness of each LEED ID&C credit criterion according

to the rating scores of the aspects. The rating results are then utilized to create the ranking results.

Table 3.1.1 shows the integrated rating scores of the LEED ID&C criteria. The range of the rating scores of 0-1.5, 1.5- 2.5, and 2.5- 4 represent low (red), moderate (yellow), and high (green) benefits, respectively. Most credit criteria offer high and moderate environmental benefits. The two best performing criteria are NO.1.2 Access to Quality Transit and Option 1 and NO. 3.8 Enhanced Refrigerant Management which offer high improvement of environmental and social benefits, and they are simple to be carried out by the project owners. The two least favorite criteria are Option 1 of NO.3.5 Optimize Energy Performance and NO. 6.1 Innovation which offer low improvement of all four aspects.

The project team can also analyze the rating scores of credit criteria to recognize the value of the major categories in general. From Table 3.1.2, the percentages of the rating scores according to the LEED major categories of the credit criteria can be calculated and summarized.

Table 3.1.1 Rating Scores of Aspects for LEED ID&C Credit Criteria

Major Categories	Credit Criteria	Possible Credits	Financial Benefits	Social Benefits	Environmental Benefits	Independent Level of Specialist support
Location and Transportation	NO.1.1 Surrounding Density and Diverse Uses	8	1	2	2	4
	NO. 1.2 Access to Quality Transit	7	1	3	3	4
	NO. 1.3 Bicycle Facilities	1	1	3	3	1
	NO. 1.4 Reduced Parking Footprint	2	1	1	4	1
Water Efficiency	NO.2.2 Indoor Water Use Reduction	12	1.5	0.5	3.5	1.75
Energy and Atmosphere	NO.3.4 Enhanced Commissioning	5	3	1	1	0
	NO.3.5 Optimize Energy Performance	25 (Opt.1)	1	1	1	0
		16 (Opt.2)	2	1	1.8	1.2
	NO.3.6 Advanced Energy Metering	1 (Opt.1)	3	1	1	0
		2 (Opt.2)	2	1	1	0
	NO.3.7 Renewable Energy Production	3	1	1	4	2
	NO. 3.8 Enhanced Refrigerant Management	1 (Opt.1)	1	3	4	4
1 (Opt.2)		0	0	2	0	
NO. 3.9 Green Power and Carbon Offsets	2	0	1	4	2	
Materials and Resources	NO.4.3 Construction and Demolition Waste Management	2	3	1	4	0
	NO.4.4 Long-term Commitment	1	1	1	1	4
	NO.4.5 Interiors Life-cycle Impact Reduction	5	2.92	1.25	2.33	0.75
NO.4.6 Building Product Disclosure and Optimization - Environmental Product Declarations	2	0	1	2	1	

	NO.4.7 Building Product Disclosure and Optimization - Sourcing of Raw Materials	2	1.5	1	1.5	1
	NO.4.8 Building Product Disclosure and Optimization - Material Ingredients	2	0	2.33	2.67	1
Indoor Environmental Quality	NO.5.3 Enhanced Indoor Air Quality Strategies	3	0	3.5	4	0.5
	NO. 5.4 Low-Emitting Materials	3	0	3	4	1
	NO.5.5 Construction Indoor Air Quality Management Plan	1	0	3	2	0
	NO.5.6 Indoor Air Quality Assessment	1 (Opt.1)	0	3	1	1
		2 (Opt.2)	0	3	2	0
	NO.5.7 Thermal Comfort	1	0	4	0	0.5
	NO.5.8 Interior Lighting	2	1.5	3.25	0.875	1
	NO.5.9 Daylight	3 (Opt.1)	3	2	1	0
		2 (Opt.2)	3	2	1	0
		3 (Opt.3)	3	2	1	0
NO.5.10 Quality Views	1	1	4	0	1	
NO.5.11 Acoustic Performance	2	0.25	4	4	1	
Innovation	NO. 6.1 Innovation	5	1	1	0	0
	NO. 6.2 LEED Accredited Professional	1	0	1	0	4
Regional Priority	NO. 7.1 Regional Priority	4	1	1	0	4

exceptionally good with medium and high environmental benefit levels in 5 major categories. Location and Transportation appear to perform the best of 7 major categories since it offers moderate and high levels in social and environmental benefits, respectively, and its implementation is simple and can be carried out by the project owner. Water Efficiency and Indoor Environmental Quality categories also perform well while Innovation and Regional Priority offer low benefits in all 3 aspects without needs for specialist supports.

The rating scores of the aspects of credit criteria can be utilized as inputs in the ranking table in order to prioritize the preferred credit criteria, and indicate the certain level of LEED certifications.

3.2 Ranking Results

The ranking results illustrated the application of the ranking table, in terms of identifying and prioritizing the most effective criteria for the project team and owners according to the rating scores of the aspects; as well as organizing these preferred criteria in design process and project schedule with the suggested team members needed.

The ranking table was used to sort the credit LEED ID&C criteria by listing the average score of the rating scale of the aspects in descending order. Table 3.2.1 shows sample results when the weights of the aspects were distributed equally.

Table 3.1.2 Percentage of Rating Scores of Credit Criteria by LEED Major Categories

Major category	Financial Benefit	Social Benefit	Environmental Benefit	Independent Level of Support Specialist	Major Categories' Credits in Total
Location and Transportation	25%	56%	75%	63%	16%
Water Efficiency	38%	13%	88%	44%	11%
Energy and Atmosphere	33%	33%	63%	33%	35%
Materials and Resources	35%	32%	56%	32%	13%
Indoor Environmental	16%	91%	52%	14%	16%
Innovation	13%	25%	0%	50%	5%
Regional Priority	25%	25%	0%	100%	4%

Table 3.1.2 shows that the evaluations of the credit criteria in 7 major categories are rather modest since most categories offer moderate and low benefits levels in at least three aspects except Location and Transportation category. However, the performance of environmental benefit is

Table 3.2.1 Rank Credit Criteria by Equal Weight of Four Aspects

Rank	LEED Criteria	Weights				Possible LEED Credits	Achieved LEED Credits	Evaluation				LEED Certification Levels	Accumulated Achieved LEED Credits
		Distribute By Numbers						Total					
		1	1	1	1			4					
		Distribute By Percentages						Total					
				25%	25%	25%	25%	100%					
		Financial Benefits	Social Benefits	Environmental Benefits	Independent Level of Specialist Support	Weighted Average							
1	3.8.1	1	1	1	3	4	4	3.00	None	1			
2	1.2	7	7	1	3	3	4	2.75	None	8			
3	5.11	2	2	0.25	4	4	1	2.31	None	10			
4	1.1	8	8	1	2	2	4	2.25	None	18			
5	3.9	2	2	0	1	4	4	2.25	None	20			
6	3.7	3	3	1	1	4	2	2.00	None	23			
7	5.3	3	3	0	3.5	4	0.5	2.00	None	26			

8	5.4	3	3	0	3	4	1	2.00	None	29
9	4.3	2	2	3	1	4	0	2.00	None	31
10	1.3	1	1	1	3	3	1	2.00	None	32
11	4.5	5	5	2.95	1.25	2.33	0.75	1.82	None	37
12	2.2	12	12	1.5	0.5	3.5	1.75	1.81	Certified	49
13	1.4	2	2	1	1	4	1	1.75	Silver	51
14	4.4	1	1	1	1	1	4	1.75	Silver	52
15	5.8	2	2	1.5	3.25	0.875	1	1.66	Silver	54
16	3.5.2	16	16	2	1	1.8	1.2	1.50	Gold	70
17	7.1	4	4	1	1	0	4	1.50	Gold	74
18	5.9	3	3	3	2	1	0	1.50	Gold	77
19	4.8	2	2	0	2.33	2.67	1	1.50	Gold	79
20	5.10	1	1	1	4	0	1	1.50	Gold	80
21	3.4	5	5	3	1	1	0	1.25	Platinum	85
22	4.7	2	2	1.5	1	1.5	1	1.25	Platinum	87
23	5.6.2	2	2	0	3	2	0	1.25	Platinum	89
24	5.5	1	1	0	3	2	0	1.25	Platinum	90
25	6.2	1	1	0	1	0	4	1.25	Platinum	91
26	3.6.1	1	1	3	1	1	0	1.25	Platinum	92
27	5.6.1	1	1	0	3	1	1	1.25	Platinum	Selected 5.6.2
28	5.7	1	1	0	4	0	0.5	1.13	Platinum	93
29	4.6	2	2	0	1	2	1	1.00	Platinum	95
30	3.6.2	2	2	2	1	1	0	1.00	Platinum	Selected 3.6.1
31	3.5.1	25	25	1	1	1	0	0.75	Platinum	Selected 3.5.2
32	6.1	5	5	1	1	0	0	0.50	Platinum	100
33	3.8.2	1	1	0	0	2	0	0.50	Platinum	Selected 3.8.1

As defined by LEED ID&C guideline, a project must receive 40-49 credit points to be awarded with the LEED certified certification. As shown in Table 3.2.1, the accumulated full credits of top12 criteria in the ranking table can reach 49 points assuming the full credit of each criterion can be achieved. The weighted average scores of these criteria were between 1.81 and 3, which represent the most effective criteria when the weights of the aspects are distributed equally. The last 13 criteria at the bottom of the ranking table represent the least effective criteria. Since their weighted average scores were between 0.5 and 1.25, these criteria are not recommended except in an attempt to achieve the LEED platinum certification.

As a sample evaluation of the results from the ranking table, Table 3.2.2 shows the percentage of each major category by a number of criteria and by criteria credits for only the top 12 criteria to illustrate the detail analysis. Similar evaluation can be carried out with the rest of the criteria in the ranking table for higher level of

certifications.

Table 3.2.2 Evaluations of Well Performing Criteria (Ranks 1-12) by Category when Using Equal Weight

Rank	LEED Criteria	Weighted Average	Possible LEED Credits	Major Category	Percentage by Criteria of Each Categories in Top Twelve Criteria	Percentage by Credits in Top Twelve Criteria of 49 points	Recommendation Level
4	NO.1.1 Surrounding Density and Diverse Uses	2.25	8	LT	25%	33%	High
2	NO.1.2 Access to Quality Transit	2.75	7				
10	NO.1.3 Bicycle Facilities	2	1				
12	NO.2.2 Indoor Water Use Reduction	1.81	12	WE	8%	24%	High
6	NO.3.7 Renewable Energy Production	2	3	EA	25%	12%	Low
1	Option 1 of NO.3.8 Enhanced Refrigerant Management	3	1				
5	NO.3.9 Green Power and Carbon Offsets	2.25	2				
9	NO.4.3 Construction and Demolition Waste Management	2	2				
11	NO.4.5 Interiors Life-cycle Impact Reduction	1.82	5	MR	17%	14%	Moderate
7	NO.5.3 Enhanced Indoor Air Quality Strategies	2	3				
8	NO.5.4 Low-Emitting Materials	2	3				
3	NO.5.11 Acoustic Performance	2.31	2				

As the analysis of the top 12 criteria shown in Table 3.2.2, the Location and Transportation (LT) with 3 criteria (25%) is a highly recommended category that focuses on the improvement of social and environmental benefits, as well as its simple implementation. The LT contribution to credit impact of 33% is the most significance. With only 1 criterion (8%), the Water Efficiency (WE) category, which offers the improvement in environmental benefit, is also highly recommended due to its 24% contributions to credit impact.

The credit impacts of the Materials and Resources (MR) and Interior Environmental Quality (EQ) categories are considered moderated. The MR offers good financial and environmental benefits while the EQ provides good

social and environmental benefits. The 2 criteria of MR (17%) and 3 criteria of EQ (25%) contributes to 14% and 16% of the total credits in the top 12 criteria, respectively. Finally, the Energy and Atmosphere (EA) with 3 criteria (25%) is the least recommended category as its contributions to credit impact is only 12%.

After the decision to follow the list of preferred criteria from the ranking table, it is suggested that the designers and project owners should integrate the implementations of these criteria into their design process and project schedule.

4 Conclusions

This research proposes an Evaluation and Decision Support Tool (EDST) to help identify favored rating criteria according to project stakeholders' particular preferences. It is set out to support designers, project owners to establish a coherent awareness by improved understanding of sustainable benefits and expert requirements of LEED ID&C criteria to reach targeted certification levels.

The EDST was developed using the rating scores of the features of sustainability in the following four aspects: financial, social and environmental benefits, and need for specialist support. The rating scores were utilized as inputs in the ranking table. Then, the criteria were sorted in the ranking table by listing the weighted average scores of the aspects in descending order. Accumulated credits of criteria to achieve LEED certifications were illustrated in the ranking table. The preference weight scale of the aspects allows for adjustment to express the project owners' project-related preferences, resulting in respective adjustments in the ranking list order.

Sample analysis of the ranking results, where the weights of the aspects were distributed equally, showed that at least the top 12 criteria in the ranking table should be implemented in a project to achieve the LEED-certified certification. These top 12 criteria covered five of the seven assessment categories. Among them, Location and Transportation (LT) and Water Efficiency (WE) categories are highly recommended while the Materials and Resources (MR) and Interior Environmental Quality (EQ) are moderately recommended, and the least recommended category is Energy and Atmosphere (EA).

The developed EDST should be tested and verified in an extensive and multifaceted range in real projects in order to explore the practicality of this tool in evaluating sustainable building assessment criteria.

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