 

# A Conceptualization for Using Analytical Hierarchy Process in Green Building Market Research

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Sustainability has become more than a trend but a necessity in the building industry. In recent years, as the general public is becoming more informed and aware of sustainability related issues, they are becoming major players in the building design and construction related decision making process. However, there are still challenges with how sustainability is communicated to occupants and owners of buildings. As the global economic crisis is continuing, the marketing of green buildings needs to be refined to communicate the full life-time benefits of green practices in design and construction. One of the ways to develop more effective marketing strategies is to understand what the occupants value the most among many advantages and aspects of green buildings. Knowing this information can help develop more focused and intelligent marketing solutions. In an effort to achieve this, authors present a conceptual methodology using Analytical Hierarchy Process (AHP) toward identifying consumer ranking and weights of LEED 2009 New Construction Rating System categories. Authors use sample non-representative data and criteria to illustrate the proposed methodology, while sharing preliminary qualitative data from the research project in progress.

**Key Words**: LEED, Sustainable Buildings, Occupant Value, Criteria Weightings, AHP

## Introduction

Sustainability efforts are comprised of complex criteria and require complex methods for decision analysis and support (Omann, 2004). Decision making in sustainability related research and practice is an important aspect of achieving the ultimate goals of sustainability. One of the challenges of decision-making in sustainability is due to its interdisciplinary nature, thus the existence of multiple quantitative and qualitative criteria when making a decision. To further add to the complexity of the issue, there are multiple stakeholders involved in sustainability decisions who have different perspectives and goals. Multi-criteria decision models can aid in identifying these differing perspectives.

Sustainability as it applies to the building industry generally involves the evaluation of buildings' performance based on design, construction, and operation phases in relation to achieving the goals previously defined by sustainability research. These goals can turn into decision-making criteria to evaluate the public perception of sustainable buildings. Although decision makers in commercial/institutional sustainable design and architecture are rarely the occupants of those buildings, the public as well as the building occupants are the ones that are mostly impacted by the sustainability decisions within buildings. Assuming decision-makers within building projects are ultimately searching for occupant satisfaction, it is crucial to determine the occupant perspective on sustainable buildings in order to develop strong marketing strategies for sustainable buildings. Celik and Attaran (2011) state that assuring the occupants about the high value of green buildings can be difficult, and developing marketing strategies that take occupants' preferences into consideration can be a step towards the solution.

Developing marketing strategies for sustainable buildings involves understanding the occupant perception of these buildings. The term "green building" is widely used as a response to sustainability concerns in the building industry. However, it is rarely researched how building occupants and the general public perceive green buildings. One of the ways to do so is to introduce the positive aspects of these buildings to a chosen audience and research how those aspects are ranked by the subjects when evaluating green buildings. The determination of characteristics of green

buildings that occupants value the most can ultimately allow development of more targeted marketing strategies for green buildings to a defined group of occupants or even decision makers.

With the lack of consumer knowledge regarding sustainable products and practices becoming a barrier for the implementation of such practices, it is important for the industry to facilitate awareness for consumers. By determining the criteria that consumers find important, marketers are better able to provide the benefits that consumers really care about, promote sustainable products more efficiently, and therefore implement sustainable practices. Such information can help to differentiate products so as to promote their consumption, protect consumer interests by sharing ways to improve consumer well-being, support informed consumer choice so consumers are aware of the benefits of such products and to stimulate behavior change such as demand for sustainable buildings (OECD, 2001).

It is evident that in a multi-criteria decision-making problem, such as evaluating green buildings from various aspects, it is also important to determine how those criteria are weighted in the evaluation of various attributes. This paper introduces a conceptual methodology in order to determine the occupant or public perception of green buildings. Leadership in Energy and Environmental Design (LEED) system and its five major green building categories are utilized as an example in this paper.

## Literature Review

### *Decision Making in Sustainability Issues*

OECD Environmental Directorate Programme (OECD, 2001) discusses policy-making models in sustainable development. On a report based on an *Experts Workshop on Information and Consumer Decision-Making For Sustainable Consumption*, rational decision making is said to include two activities: knowing and evaluating (OECD, 2001). The report explores these two activities using subgroups: the identification of the possible alternatives; the selection of criteria by which to assess them; the assessment itself with respect to the criteria; the weighting of the criteria and; the aggregation of the partial assessment in an overall assessment (OECD, 2001). This procedure is similar to the methodology being used in this paper: Analytical Hierarchy Process (AHP).

AHP is a technique for analyzing complex decisions. Decisions are broken up into a hierarchy of sub-problems that can be analyzed by comparing them to one another two at a time. Since comparisons can be based on concrete data or human judgment, any issue related to the decision can be considered. Evaluations are then converted into numerical values with weights. Harker and Vargas (1987) explain the numerical evaluation process in their research on the theory of ratio scale estimation. Conversion to numerical weights allows diverse elements to be compared in a consistent and rational way, uncovering the marked advantage of using AHP over other decision-making techniques (Sataay, 2008).

### *Determining Criteria for Sustainable Buildings*

According to United States Green Building Council (USGBC), and its LEED rating system, green buildings can reduce the negative impacts of buildings on occupants and the environment in five categories: sustainable sites, water efficiency, energy and atmosphere, materials and resources, and indoor environmental quality. USGBC utilized the National Institute of Standards and Technology (NIST) process to compare LEED credits to environmental impact categories defined by the "Tool for the Reduction and Assessment of Chemical and Other Environmental Impacts" (TRACI) (US EPA, n.d.). An important change from the most recent LEED rating system version 2009, to a new upcoming version 2012, is that USGBC has changed how they determine category weights. They also changed the criteria they used in the process. This means that the weight of each LEED category on the final score of a building is not determined by the criteria determined by TRACI. In the new LEED 2012 system, USGBC has developed a set of impact categories as the new criteria that more closely align with their mission and vision for ongoing LEED development (USGBC, 2011). The new criteria, or impact categories as USGBC refers to them, are listed below (USGBC, 2011):

- Reduce contribution to global climate change

- Enhance individual human health, well-being, and vitality
- Protect and restore water resources
- Protect, enhance, and restore biodiversity and ecosystem services
- Promote sustainable and regenerative material resource cycles
- Build a greener economy
- Enhance community: social equity, environmental justice, and quality of life.

LEED 2012 is currently in the process of modifying the weight of LEED categories by creating their own impact categories.

## Conceptualization

This paper presents a conceptualization of AHP methodology as it applies to ranking different LEED categories. The methodology behind AHP as it applies to LEED categories is illustrated in Figure 1. (SS: Sustainable Sites, EA: Energy and Atmosphere, WE: Water Efficiency, IEQ: Indoor Environmental Quality, MR: Materials and Resources)

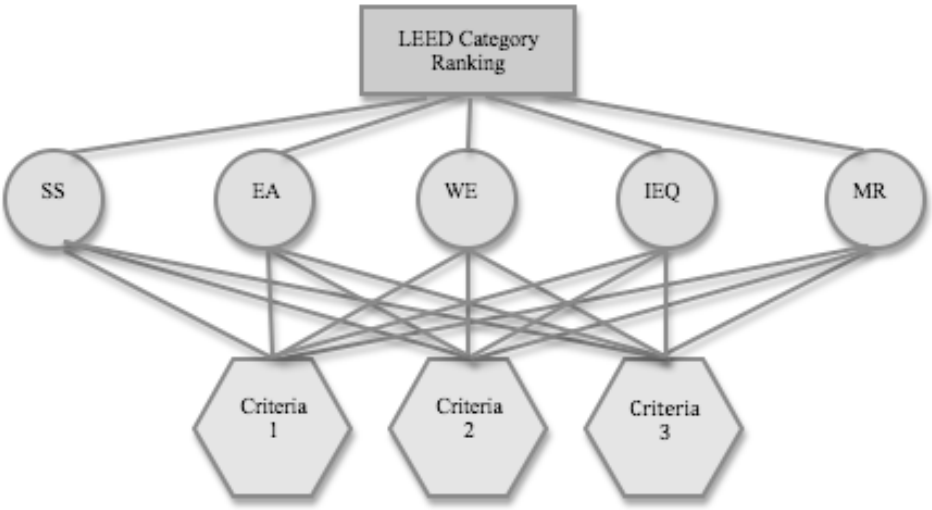



*Figure 1:* AHP methodology as it applies to ranking of LEED categories.

The methodology conceptualized in this paper aims to resolve the following challenges of multi-criteria decision making in green building marketing:

Step 1. Determine alternatives of different aspects of green buildings

Step 2. Select criteria that the occupants utilize when choosing between alternative green building aspects found in Step 1.

Step 3. Determine the weight of each criterion identified in Step 2.

Step 4. Assess alternative aspects of green buildings (identified in Step 1), with respect to the criteria (identified in Step 2)

Step 5. Normalize and rank the alternative aspects of green buildings (identified in Step 1 and compared in Step 4), based on criteria (identified in Step 2), and the criteria weights (identified in Step 3)

Each step in the proposed methodology is described in more detailed in the upcoming sections.

## *Determining Alternatives of Different Aspects in Green Buildings*

As discussed briefly in the literature review section of this paper, determining aspects of green buildings is the initial step of the proposed methodology. These aspects are the basis of what defines a "green building". Defining green buildings and the magnitude of how green each building is may not be an easy task. Many researchers and practitioners, as well as institutions such as USGBC in the US, or Building Research Establishment (BRE) in the UK, are continuously looking for ways to solve this problem. USGBC's LEED Rating System, and BRE's BRE Environmental Assessment Method are a few examples of these attempts. A comparison of the categories used in BREEAM and LEED green building rating systems can be seen in Table 1. The conceptualization introduced in this paper uses five of the LEED 2009 categories as an example. This can be justified with the fact that LEED has become a significant assessment system in the US for certifying green buildings. Following the steps introduced in this paper would allow researchers to rank these categories from an occupant perspective and based on a given set of criteria in order to emphasize each category accordingly in a LEED certified green building marketing plan.

Table 1

***LEED-NC 2009 and BREEAM 2008 Categories (USGBC, n.d.), (BRE, n.d.)***

| **Assessment Categories** | |
|---|---|
| **BREEAM 2008** | **LEED 2009** |
| Management | Sustainable Sites (SS) |
| Health & Wellbeing | Water Efficiency (WE) |
| Energy | Energy and Atmosphere (EA) |
| Transport | Materials and Resources (MR) |
| Water | Indoor Environmental Quality (IEQ) |
| Materials | Innovation in Design (ID) |
| Waste | Regional Priority (RP) |
| Land Use & Ecology | |
| Pollution | |
| Innovation | |

## *Selecting Criteria the Occupants Utilize When Ranking Importance of LEED Categories*

This step of the methodology requires researchers to identify the criteria that subjects utilize when making their choices between different categories of green buildings. As an example, if an occupant believes that conserving water resources is more important than sustainable planning of a building's site management, there has to be one or more criteria while making that decision. This methodology offers two ways to execute this step:

- Utilize an existing criteria list
- Develop a survey with open ended questions to obtain criteria

Utilizing an existing criteria list can be achieved by conducting a literature review. Researchers can review existing literature to find information on what criteria is generally used in evaluation of green buildings. An example for this is USGBC's approach to criteria development for LEED ratings systems prior to version 2012. Before determining importance of each category, LEED utilizes TRACI model for evaluation of categories. The Environmental

Protection Agency (EPA) developed the TRACI model and some of the criteria described in the model are listed below (US EPA, n.d):

- Global Warming
- Cancer
- Fossil fuel use
- Land use
- Water use

It is also common for researchers to collect criteria from different resources to create a complete list of criteria that satisfies the needs of the specific decision making dilemma.

Developing a survey with open-ended questions is another way of creating a list of decision criteria. This method is more time consuming and requires a level of expertise in qualitative research. The authors of this paper are in the process of analyzing the results of a recent survey conducted with university students regarding the importance of various LEED categories. In the survey, students were asked to rate each LEED category based on how important they consider that category to be. The lack of provided criteria in the ranking allowed the authors to add an open-ended question asking subjects to provide the reasoning behind their choice. A review of the answers to the open-ended questions helps determine the criteria that were used by the subjects to make their choices. As an example, one of the subjects gave a high ranking to indoor environmental quality and stated in the comment box, "*I would want to know that the classrooms and dorm rooms I am in do not harm my health in any way, shape, or form*". The analysis of this and similar responses then led researchers to consider "Human Health" as one of the criterion that needs to be included in the upcoming steps of the proposed methodology. Another response received after a subject was asked to rank the importance of the energy and atmosphere category in the LEED rating system stated, "*buildings are contributing to harming the ozone layer for not only my generation but for future generations".* An analysis of this response and similar ones in the survey led to using the criterion of "Future Generations" when ranking various green building aspects. Authors are also utilizing qualitative research tools such as NVivo 9.0 to code and analyze the data gathered by the open-ended questions. It is important to note that the subjects in the above examples were provided extensive information about the intents of each LEED category prior to collecting any responses in order to avoid the commonly stated obstacle of lack of consumer knowledge regarding sustainable practices.

## *Determining the weight of each criteria*

This step of the methodology requires the criteria identified in Step 2 to be weighted against one another. In an AHP model, researchers can assume that although there might be multiple criteria when making a decision, not all the criteria may have the same impact on the final decision. It is then the task in this step to determine the criteria weights as perceived by the building occupants.

In order to accomplish this step, researchers can use the AHP methodology along with a survey in which occupants can complete pair-wise comparison of all identified criteria. Subjects are given a scale and asked to choose a certain point on the scale based on which criteria they weigh more heavily. Figure 2 illustrates an example of a scale that is commonly used in AHP.

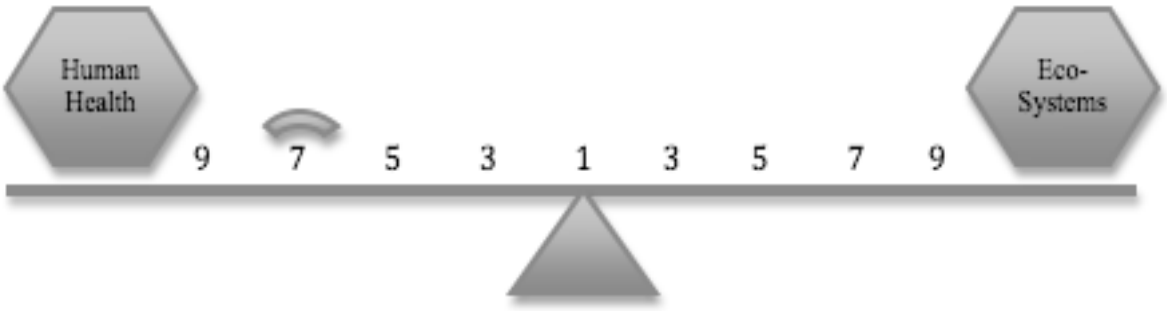
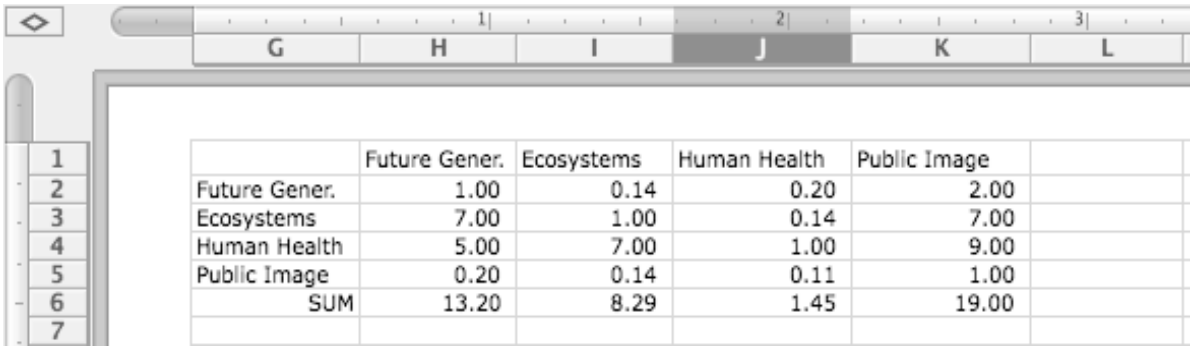



*Figure 2:* Example scale to be used in criteria comparison surveys

By completing the pair-wise comparison of all criteria, researchers can build a matrix similar to the one given in Figure 3. Assuming the choice given in Figure 2 is real data, researcher would give "Human Health" criterion a score of 7 while giving "Preserving Ecosystems" criterion the reciprocal, 1/7. Figure 3 illustrates a sample matrix to clarify the process.



| | Future Gener. | Ecosystems | Human Health | Public Image |
|---|---|---|---|---|
| Future Gener. | 1.00 | 0.14 | 0.20 | 2.00 |
| Ecosystems | 7.00 | 1.00 | 0.14 | 7.00 |
| Human Health | 5.00 | 7.00 | 1.00 | 9.00 |
| Public Image | 0.20 | 0.14 | 0.11 | 1.00 |
| SUM | 13.20 | 8.29 | 1.45 | 19.00 |

*Figure 3:* Pair-wise comparison of criteria

Once all comparisons are completed, values given to each criterion are normalized and converted into a percentage criteria weight. Normalizing each cell is achievable if the cell is divided by the sum of the entire column. The formulas for normalization and the overall results of the sample data are shown in Figure 4. In this case, researchers can choose to eliminate the criteria that have considerable small values. For instance, looking at Figure 4 reveals that the criteria weight for "Future Generations" and "Improved Public Image" scored considerably poor compared to "Preservation of Ecosystems" and "Human Health". If the researchers want to eliminate the two low weighted criteria from the research, they can do so by normalizing values of the criteria with higher weights.

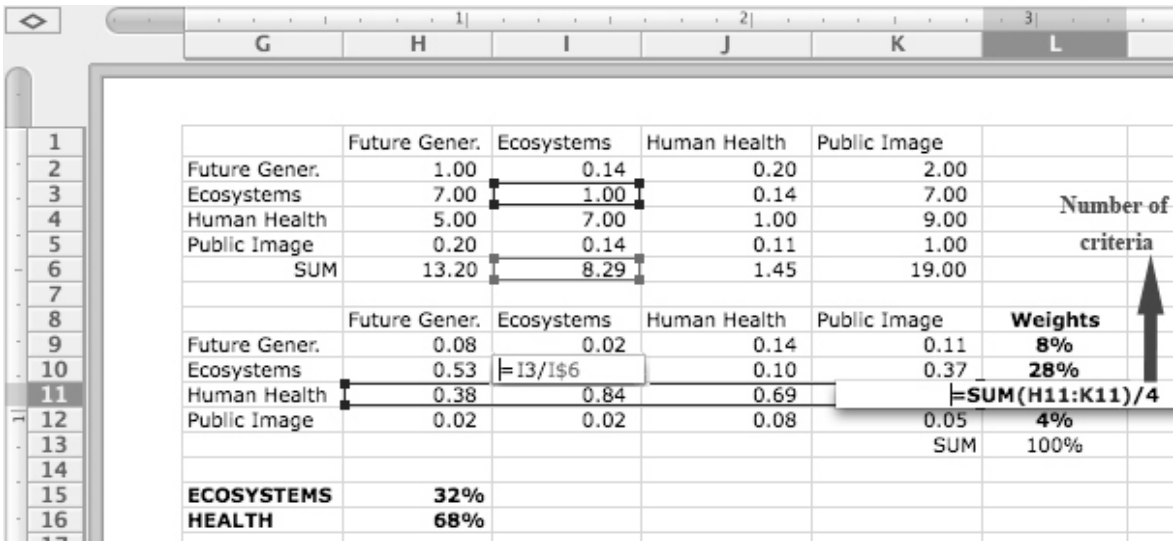



*Figure 4:* Normalized and final criteria weights

### *Assessing Alternative Aspects of Green Buildings with Respect to the Criteria*

This step of the methodology is very similar to the previous one in terms of mathematical calculations. In this step, subjects will be asked to do a pair-wise comparison between green building aspect alternatives. However, unlike the survey example mentioned in the second step, subjects will be given the selected criteria to consider while making their choices. Referring to Figure 2, instead of having two different criteria on the sides of the scale, LEED categories will be on each side, along with a criterion in mind. For example, subjects will be choosing which one of LEED category they favor more when it comes to "Preserving Ecosystems". They will then be asked the same question for "Human Health" criterion.

As discussed earlier, it is very important to inform the subjects of all characteristics and intent of each LEED category prior to asking for the comparison. On the other hand, alternative future research can choose to explore the correlation between rankings of LEED categories based on the knowledge of green building industry. In that case, it can be acceptable to choose different subject groups with different levels of green building education to prove a correlation among ranking patterns.

Figure 5 illustrates an example of the pair-wise comparison as well as the normalized and final importance values for each LEED category.

### *Finalizing the Ranking of Alternative Aspects of Green Buildings*

In this final step of the methodology, weighting of each green building aspect (LEED categories) will be combined for a final weighting and ranking. The final results from the example data, as can be seen in Figure 6, show that Indoor Environmental Quality was the most important criteria based on the example data, with a score of 39.9%. This step will reveal the results of occupant perspective (or any other specific population in other studies) on different LEED categories. The significance of achieving this and its contribution to the researchers' on-going research project toward determining marketing strategies for green buildings will be discussed in the conclusion section of this paper.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 18 | **SCALING BASED ON ECOSYSTEM CONCERNS** | | | | | | |
| 19 | | EA | WE | SS | IEQ | MR | |
| 20 | EA | 1.00 | 0.33 | 5.00 | 9.00 | 5.00 | |
| 21 | WE | 3.00 | 1.00 | 3.00 | 9.00 | 0.33 | |
| 22 | SS | 0.20 | 0.33 | 1.00 | 9.00 | 3.00 | |
| 23 | IEQ | 0.11 | 0.11 | 0.11 | 1.00 | 0.11 | |
| 24 | MR | 0.20 | 3.00 | 0.33 | 9.00 | 1.00 | |
| 25 | SUM | 4.51 | 4.78 | 9.44 | 37.00 | 9.44 | |
| 33 | | | | | | | |
| 34 | | EA | WE | SS | IEQ | MR | **WEIGHT** |
| 35 | EA | 0.22 | 0.07 | 0.53 | 0.24 | 0.53 | **32%** |
| 36 | WE | 0.67 | 0.21 | 0.32 | 0.24 | 0.04 | **29%** |
| 37 | SS | 0.04 | 0.07 | 0.11 | 0.24 | 0.32 | **16%** |
| 38 | IEQ | 0.02 | 0.02 | 0.01 | 0.03 | 0.01 | **2%** |
| 39 | MR | 0.04 | 0.63 | 0.04 | 0.24 | 0.11 | **21%** |
| 40 | | | | | | | |
| 41 | **SCALING BASED ON HEALTH CONCERNS** | | | | | | |
| 42 | | EA | WE | SS | IEQ | MR | |
| 43 | EA | 1.00 | 3.00 | 5.00 | 0.14 | 7.00 | |
| 44 | WE | 0.33 | 1.00 | 3.00 | 0.14 | 7.00 | |
| 45 | SS | 0.20 | 0.33 | 1.00 | 0.11 | 5.00 | |
| 46 | IEQ | 7.00 | 7.00 | 9.00 | 1.00 | 9.00 | |
| 47 | MR | 0.14 | 0.14 | 0.20 | 0.11 | 1.00 | |
| 48 | SUM | 8.68 | 11.48 | 18.20 | 1.51 | 29.00 | |
| 57 | | | | | | | |
| 58 | | EA | WE | SS | IEQ | MR | **WEIGHT** |
| 59 | EA | 0.12 | 0.26 | 0.27 | 0.09 | 0.24 | **20%** |
| 60 | WE | 0.04 | 0.09 | 0.16 | 0.09 | 0.24 | **13%** |
| 61 | SS | 0.02 | 0.03 | 0.05 | 0.07 | 0.17 | **7%** |
| 62 | IEQ | 0.81 | 0.61 | 0.49 | 0.66 | 0.31 | **58%** |
| 63 | MR | 0.02 | 0.01 | 0.01 | 0.07 | 0.03 | **3%** |

*Figure 5:* Normalized and final LEED category weights based on various criteria

| | G | H | I | J | K | L |
|---|---|---|---|---|---|---|
| 65 | | | **FINAL RANKING** | | | |
| 66 | | | CRITERIA | | COMBINED SCORES | |
| 67 | | | ECOSYSTEMS | HEALTH | | |
| 68 | | Crit. Weight | 32% | 68% | | |
| 69 | GREEN BUILDING ASPECTS | EA | 32% | 20% | =I69*$I$68+J69*$J$68 | |
| 70 | | WE | 29% | 13% | 17.9% | |
| 71 | | SS | 16% | 7% | 9.8% | |
| 72 | | IEQ | 2% | 58% | 39.9% | |
| 73 | | MR | 21% | 3% | 8.8% | |

*Figure 6:* Normalized and final LEED category weights based on various criteria

## Conclusion

Authors of this paper have been working on many aspects of customer perception and occupant satisfaction of green buildings. In this paper, an AHP methodology is described in detail as it can be applied in green building market research. The graphics shown regarding the AHP method are developed based on non-representative sample data. The goal of the paper is to illustrate the proposed methodology rather than present rankings of LEED categories. Based on the literature review that the authors have conducted, there are limited results of similar investigations in the building industry. This proposed and conceptualized study is significant, as it will help develop more effective marketing strategies for green buildings. Architecture and construction companies will be able to provide insightful implications when promoting sustainable practices. Understanding the client and the occupants is the first step in the development of responsible, efficient, healthy, and functional projects. It is important for future studies to expand

similar approaches to different populations, thus fill potential gaps of information in the building industry regarding occupant satisfaction.

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