Developing a Decision Model for the Assessment of Sustainable Alternatives

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This study examines the development of a decision model that addresses both first costs and design outcomes in pursuing a United States Green Building Council's (USGBC) Leadership in Environmental and Energy Design (LEED) certification for new commercial construction. The study notes the three greatest drivers determining first costs are project specific LEED credits selected and the degree to which current building standards, experience of the design/construction team, and practices meet those required by the USGBC. The proposed model incorporates a Logical Scoring of Preferences (LSP) method that evaluates decision makers' preferences and cost separately and then combines preference rankings and costs to provide a range of costs and sustainable impacts.

Key Words: LEED, Sustainable, Construction, Decision Model

Introduction

While sustainable design and construction practices continue to grow within the United States, and specifically within the State of Florida, there is continued confusion regarding designed benefits and associated first costs of certified green construction. This void has lead to the need to identify a systematic way for project teams to evaluate sustainable designs in terms of outcomes and costs. The proposed incorporates the United States Green Building Council's (USGBC) Leadership in Energy and Environment Design (LEED) for new construction 2.2 point based building evaluation and certification tool as the basis for sustainable design. Two of the most cited LEED critiques are: 1) LEED costs too much and 2) point mongering becomes the goal of design rather than building the best sustainable building as possible given constraints (Schendler 2005). Too often in consulting sessions the process of selecting credits is based on lowest cost rather than on owner preference, program fit, or credit impact. During these sessions the relationship between project function and point impacts tends to be lost altogether as project teams focus on achievability of "no cost" credits above all other considerations. A need was in place for a decision model that evaluated design attributes or outcomes and cost separately at the initial stage but then brought these two elements back together in a final selection phase. These types of decision processes are often made during schematic design and conceptual estimating and continue as the project program moves through final design.

Problem Statement

Currently there is no model available to evaluate project specific LEED building criteria based on local standards, key decision makers' sustainable preferences and building program, cost, location, and LEED certification level. This research proposes the Decision Model for the

Assessment of Sustainable Construction (DMASC). The DMASC model incorporates a logical scoring system which provides a way to independently evaluate sustainable alternatives based on building performance, environment, social, and occupant health impacts and associated first costs. The tool identifies key factors for successful adaptation from traditional to integrated sustainable design and construction. Decision processes are broken into three phases 1) an initial evaluation stage, 2) a combined preference and cost stage, and 3) a final ranked decision stage to aid in the selection of sustainable alternatives. The main hurdle with regards to adoption of LEED standards continues to be the perception of additional first costs associated with certification. Common cited cost estimates range from potential initial savings to increased costs above 20% of the construction budget. This model demonstrates the three drivers determining initial costs are the extent to which the current building program meets the LEED pre-requisites and credit requirements, the experience of the design and construction team, and which credits are selected to be incorporated in the final building design. The model will allow for the identification of standard, essential, required, and non-applicable credits. It also sums the LEED points being pursued as well as previously identified building outcome totals.

Background

Established in 1998, the USGBC LEED certification process is the predominant sustainability criteria used in evaluating buildings throughout the United States (US). The USGBC program offers certification levels depending on the total amount of credit points certified. It has been adopted by the Government Service Agency (GSA), branches of the US Military, and used in several state- and university-based construction programs. Due to the nature of the LEED scoring system, that is after the completing a set of prerequisites, the final project credits selected are up to the owner and project team. It is difficult to guarantee performance outcomes solely based on certification levels. In order to address the concerns regarding first costs and performance impacts a model was needed to explain how an entity, be it private owner or public institution, transitions from current traditional methods to more sustainable ones. Information regarding integrated sustainable design benefits and costs is widespread across several countries, states, and cities, but little or no information is available in print regarding efforts made in the state of Florida. The basic tenets of sustainable construction are straightforward and stress the importance of human health, energy and water conservation, site planning, and material selection in order to provide a measurable benefit to the inhabitants of the building, the environment, and the community, but how these tenets drive design and cost decisions is less discernable. Although decision makers are willing to embrace the tenets of sustainability they are not willing to fund them blindly. There was need to develop a decision model.

Costing Green

Three main costing studies have been produced over the past five years, one a prescriptive estimating study examining the General Service Administration's (GSA) design program (GSA 2004), another prescriptive study examining cost impacts to the existing Indian Health Service (IHS) building program(IHS 2006), and one post-built study of actual design and construction costs for projects built throughout the US (Morris 2004). The GSA study shows a progression of cost increases through the LEED system from certified to platinum. Essentially, the GSA will increase project funding by 2.5% to cover LEED certification costs. The caveat to this number is that GSA was already performing tasks associated with significant costs in their base program. Items such as commissioning and meeting ASHRAE guidelines were included in their base building. The second study is a 2006 report put together by a team from Seattle that was commissioned by the Division of Engineering Services (DES). The DES is responsible for overseeing all new healthcare facilities for the United States Government Indian Health Services (IHS) Agency. This study examined the cost impact of each applicable LEED credit based to existing IHS program standards. The study also demonstrated Life-Cycle Costs (LCC) for each credit. Additionally, it compared its findings with that of the GSA report. This gives insight to how the LEED process impacts two different building types developed under two different building programs. The third study often cited includes a report produced by the Davis Langdon firm, a design firm that provides "comprehensive cost planning and sustainable design management services to architects and owners (Langdon 2004)." In this study the company reviewed its proprietary cost database to compare green versus non-green buildings on the basis of cost. Individual credits were not assessed. Forty-five library, laboratory, and academic classroom projects designed with some level of LEED certification were selected for comparison with 93 non-LEED projects of the same types. All costs were normalized for location and time of construction. Given the common perception that LEED projects cost more than non-LEED projects, the analysis was striking. The results showed no statistically significant difference between LEED and non-LEED projects. The LEED projects were dispersed through the range of all projects based on cost.

Perceived Sustainable Benefits

Perceived sustainable benefits associated with the built environment generally fall into four broad categories. Building performance strategies that focus on reduced energy and water uses compared to traditional construction methods. Health and productivity benefits emphasize the importance of controllability of systems and indoor air quality during the design, construction, and maintenance phases of a project. Environmental benefits focus on reduced impacts of sustainable construction methods and related savings. Finally, social benefits composed of those impacts that influence the community in which the project is located. Figure 1-1 illustrates the impacts of LEED categories and these broad sustainable benefit areas.

Building Performance Benefits

Energy and Atmosphere credits account for the largest percentage, 24.6 percent, of the USGBC category credits. Savings from energy design strategies are often viewed as having the single most cost-to-benefit ratio as other green strategies. Increased fuel and energy costs will continue to push the envelope of energy saving design. The goal of sustainable design is to reduce the amount of energy used to effectively operate a building. Energy optimization credits account for the largest percentage of points available for one credit under LEED-NC 2.2. Lowering water usage is also a mainstay of green design. Water efficiency credits account for five out of sixty-nine, or 7.4%, possible LEED credits. The USGBC reports commercial buildings use 12.2% of all potable water, or 15 trillion gallons a year during operation(USGBC 2007). Depending on the credits pursued, LEED-designed buildings have an energy savings of 14 to 50% less than conventional buildings. International developer Hines, Inc., is quoted regarding energy star buildings, "Efficiencies gained from its Energy Star buildings are generating $13 million in annual savings, based on 2000 evaluation."

Health and Productivity Benefits

The USGBC reports that the average American spends between 80 and 90% of the day indoors. Addressing concerns of indoor environmental quality helps to ensure a healthy and productive society both in the long and short term. Companies are seeking to improve their competitive edge in terms of employee recruitment and retention. Similar to leasing and tenant issues, marketing the space that an employee will occupy as a healthier (i.e., better indoor air quality and natural lighting) provides support for attracting and keeping employees.

Environmental Benefits

Environmental benefits associated with green design include: resource conservation, waste diversion, material selection, and site selection and management. High performance design stresses reduction in water and electrical needs. These reductions result in less stress imposed upon municipal supplies and less waste generated compared to standard construction. These reductions help to lessen the need for greater infrastructure that supports the buildings and the energy and chemicals used to process waste. Reduction of stormwater runoff and erosion are also key benefits of high performance design. Techniques such as porous pavement, green roofs, green swales, and natural vegetative wetlands help to reduce the amount of stormwater and particles introduced to a municipal waste water system. Reduction of stormwater runoff also helps to reduce the amount of infrastructure used to transfer and process the water.

Social Benefits

Social responsibility or stewardship definitions vary among countries, cultures and communities. The International Organization for Standardization (ISO) Strategic Advisory Group on Social Responsibility (SAG) derived common definition for social responsibility (IISD 2004). SAG found that the common elements or threads running through definitions for social responsibilities include "a balanced approach for organizations to address economic, social, and environmental issues in a way that aims to benefit people, community, and society." Short-term benefits include local jobs during the construction process, community improvements, increase in neighborhood perceived value, and access via public transit for local workers to access new LEED facilities. Examples of long-term benefits of the community might be reduced energy loads of buildings delay the cost associated with new power plants or how reduced waste streams may negate the costs associated with the construction of new land fills. Figure 1-1. illustrates the connections among LEED criteria and building outcomes

Methodology

The Decision Model for the Assessment of Sustainable Construction (DMASC) is a multi-stage model that provides a structure and means for the adoption of more sustainable practices and evaluation of USGBC LEED sustainable criteria. See Figure 1-2 outlining the decision process.

- Phase I – Analysis of current building methods and decision process for moving to the adoption of more sustainable building practices.
- Phase II – The incorporation of Logical Scoring of Preferences (LSP) methods that evaluate objectives of decision makers and initial costs separately. This stage includes an outcome identification phase that incorporates a multi-attribute analysis phase to determine relative outcomes rankings.
- Phase III – The process of reconciling preferences and costs to determine a hierarchy of best fit criteria for a building program.

Multi-attribute Decision Analysis (MADA)

Given the varied nature of the LEED alternatives it was decided to use an Analytic Hierarchy Process (AHP) approach to evaluate the impacts or outcomes for each alternative. Falling under the multi-attribute decision analysis (MADA) category of decision making models (Norris and Marshall 1995), AHP provides methods to evaluate an alternative based on its relative importance to all other alternatives. Originally developed by Saaty (Saaty 1982) in the early 1980s AHP methodology has been used extensively to evaluate data that contains a mix of quantitative, non-financial characteristics that take judgment to monetize, and qualitative impacts that may be impossible or impractical to quantify such as aesthetics or values. AHP formalizes the process of making pairwise comparisons.

Relevant attributes to be considered are building performance, environment, social, and tenant health impacts. The alternatives were rated based on the following judgments:

- Building Performance – How does alternative i compare to alternative j based on providing a higher performing building compared to traditional methods or standards? Energy savings and water conservation measures were affirmed. The general impact assessment which influenced judging was as follows (listed in order of importance):
  - Energy savings
  - Water conservation
- Environment – How does alternative i compare to alternative j based on beneficial environmental impacts, both long-term and short-term? The general impact assessment which influenced judging was as follows (listed in order of importance):
  - Emissions/Energy savings
  - Water conservation
  - Heat island
  - Waste reduction
  - Site selection (one time impact)
  - Material conservation/practices (one time impact)
- Social – How does alternative i compare to alternative j based on short-term social benefits of neighboring residents? This may include aesthetic benefits as well as immediate economic benefits such as employment or access. For purposes of this study, long-term benefits of sustainable practices (i.e., tax savings from not building additional infrastructure) were not addressed. For applying a judgment economic impacts were judged slightly more in favor of aesthetic impacts.

- Health – How does alternative *i* compare to alternative *j* based on the health and well being of building occupants? The general impacts assessment which influenced judging was as follows (listed in order of importance):
    - Air Quality
    - Lighting
    - Thermal comfort

The intensity of importance scores were applied in a matrix of paired comparisons (MPC). The MPC is the tool that captures the decision makers input with regard to the relative importance of the model criteria based on the overriding attribute. This model developed four initial MPC's focusing on performance, environment, occupant health, and social impacts as the overriding attributes. For example, if energy savings is the overriding attribute than the LEED alternative is compared to each other with regard to their role or impact in energy savings.

The matrices provided a mathematical means to identify the criteria impacts for each alternative. The alternatives represented the LEED alternatives listed on the LEED-NC 2.2 scorecard. Since the alternatives were judged based on intent individual credit options were not judged nor were any Innovation and Design alternatives, Prerequisites, or the LEED AP alternative. Innovation and Design alternatives are project specific alternatives awarded for exemplary performance or innovation on a project by project case.

The scores for each MPC were normalized by dividing the each preference ranking by the highest scoring preference ranking in that column. This provided a basis to rank the scores on their relative impact to the scoring criteria. An alternative composite score was then tabulated by summing the normalized value across all four criteria. The ranking of normalized composite score demonstrates the overall balanced impact individual alternatives have across all four preference criteria relative to each other. The outcome at this stage of the model is a balanced score that evaluates alternatives across criteria, or perceived benefits, to determine a relative impact of LEED alternatives.

DMASC Model

The Decision Model for Assessment of Sustainable Construction (DMASC) outlined in Figure 1-2 provides a systematic approach for determining cost impacts associated with adopting sustainable building processes and techniques. As noted previously, the model consists of three main phases. Phase I address the institutional-wide analysis of traditional construction and building methods, institutional resources, and rationales for seeking a change to sustainable methods. Phase II presents the Logical Scoring of Preferences (LSP) portion of the model. Phase III involves the final decision making portion of the model. The model establishes program requirements; in this case USGBC LEED-NC 2.2, then splits the decision processes into separate cost and preference analysis, and finally combines both evaluation methods into a single cost preference analysis phase

Preference Analysis Model

As discussed, this model incorporated Analytical Hierarchical Processes (AHP) as means to determine the LEED alternative impacts. The method of evaluating alternatives against themselves supported previous studies with regard to identifying outcome categories. However, this model proposes identifying outcomes and allowed for credits to be ranked based on preferences which lead to the ability to rank alternatives in terms of relative importance. These impacts scores would then be summed to an overall composite score for each credit that provided a means for ranking credits across four broad sustainable benefits: Building Performance, Environment, Social, and Occupant Health.

Preference weights allow for emphasis placement alternatives as they relate to project outcomes. Ranking LEED alternatives based on outcome criteria allows project team members to evaluate credits in a hierarchical fashion as they relate to certification levels.

Cost Analysis Model

In order to perform initial costing of credits project specific information would be needed to be collected and entered into a conceptual estimating database evaluating each credit option. After project data and LEED specific data was entered three options are given: standard (no additional cost compared to standard construction), required (all prerequisites are hard coded required), and not-applicable. These identifiers do not influence criteria preferences and are solely to aid anyone filling out the scorecard with regard to costs.

Credit or point conceptual estimates of LEED alternatives were conducted. In our study those credits, including each credit option and exemplary credits, falling within the realm of possibility for University of Florida campus projects were estimated for cost. Conceptual estimates were conducted based on very broad terms such as total project budget, total construction budget, and gross square footage area. Each sheet is linked to this scorecard for ease of calculations. It is important to note that costs are based on the existing building standards and local market conditions. The scorecard developed accounts for 106 requirement and credit option takeoffs and two additional takeoffs accounting for registration and soft-costs for a total of 108 conceptual estimates. The cost analysis is designed to allow for takeoffs for each project based on existing standards. The unique part of this method is the ability for project teams to estimate each credit from project to project. The resulting data would be used to track trends and utility of credits over time.

Cost Preference Analysis

The cost preference analysis provides for side-by-side comparison of previously established preferences of ranked credits, low and high conceptual cost estimates, and a final or revised determination of credit preference (i.e., standard, essential, optional, or non-applicable). The cost preference comparison allows for a team to evaluate credits with outcome weighted preferences as guide for prioritizing credit selection. The model allows for the identification of preferences prior to costing, costing of each credit at a conceptual level, and a reconsideration phase that allows the design team to consider preferences, impacts, and costs.

Ranking of Competitive Systems

Ranking of competitive systems is done through the analysis of revised credit identifiers. Costs are summed and categorized by corresponding individual LEED credit identifiers. Summary sheet data is linked to costs and final credit identifiers. Should a team make changes to any of the individual LEED credit takeoff sheets or reassign credit identifiers those changes would automatically be reflected on the summary sheet.

Decision (Selection of Best Alternative)

The selection of best alternative is that which matches cost, preferences to outcome criteria and certification level. The DMASC approach allows the project team to develop various scenarios at the conceptual level to address such constraints as owner preferences and limited budgets.

Transition to More Sustainable Practices (Trend Analysis)

The collection of preference, cost, and credit selection allows for a systematic way to address making changes to building standards that incorporate LEED goals. The University of Florida Facilities Planning Division has informally adopted those credits they deem consistently no-cost from project to project.

Discussion

One key to advancing a topic or research field is the ability to provide accurate and relevant information. Unclear or oversimplified information regarding LEED first costs continues to be a hurdle for expanded acceptance. It is difficult for experienced builders and designers to accept statements such as there is no-cost associated with method, material, and design changes that vary from tradition. The message sounds false to an audience that is stereotypically resistant to change and associated risks.

This proposed model serves to explain the nuances of LEED design and how practitioners at the University of Florida have learned from their experiences. The way in which owners and design teams approach a LEED project plays a significant role in which credits are selected and why. Should first costs be of concern it is rather simple to evaluate the credits based on costs. The uniqueness of this model is that allows owners and project teams to evaluate credit tradeoffs both in terms of cost and building function.

In addition to the evaluation of alternatives via impacts, each LEED credit option applicable to the project is conceptually estimated. These estimates would be broad “back of the envelope” estimates that are the type typically performed at the programming stage of a project. The key to each of the estimates is the flexibility for which cost percentages would be linked predominately to gross square footage or project budgets. In addition providing cost sheets per project is useful in providing a like method to track costs across projects which would allow the tool to be improved over time. This model provides a systematic, applicable, and useful way to address sustainable alternatives.

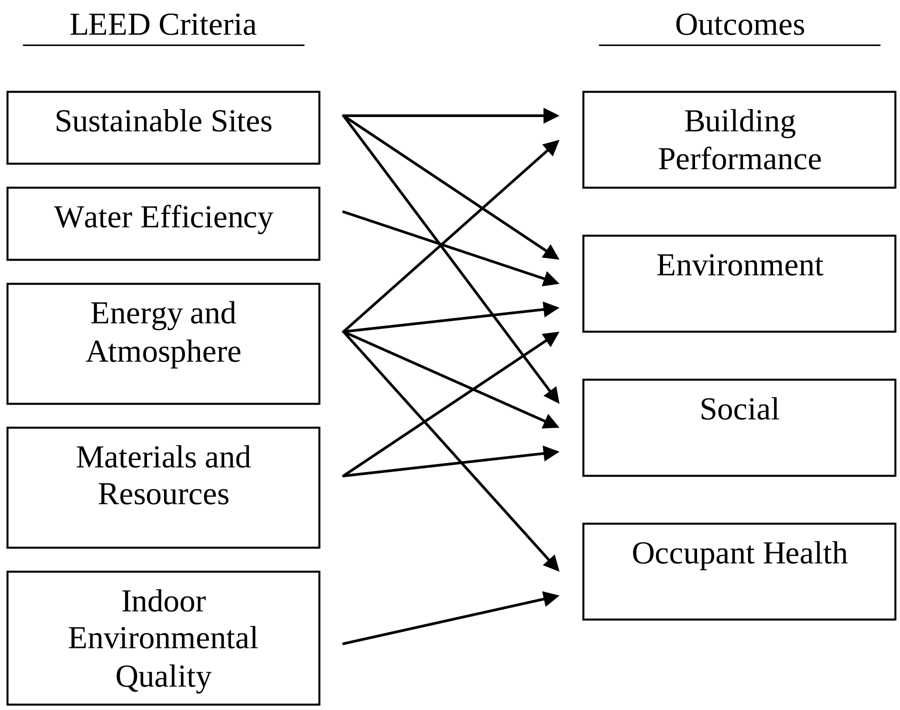

Figure 1-1. Relationships among LEED criteria and building outcomes

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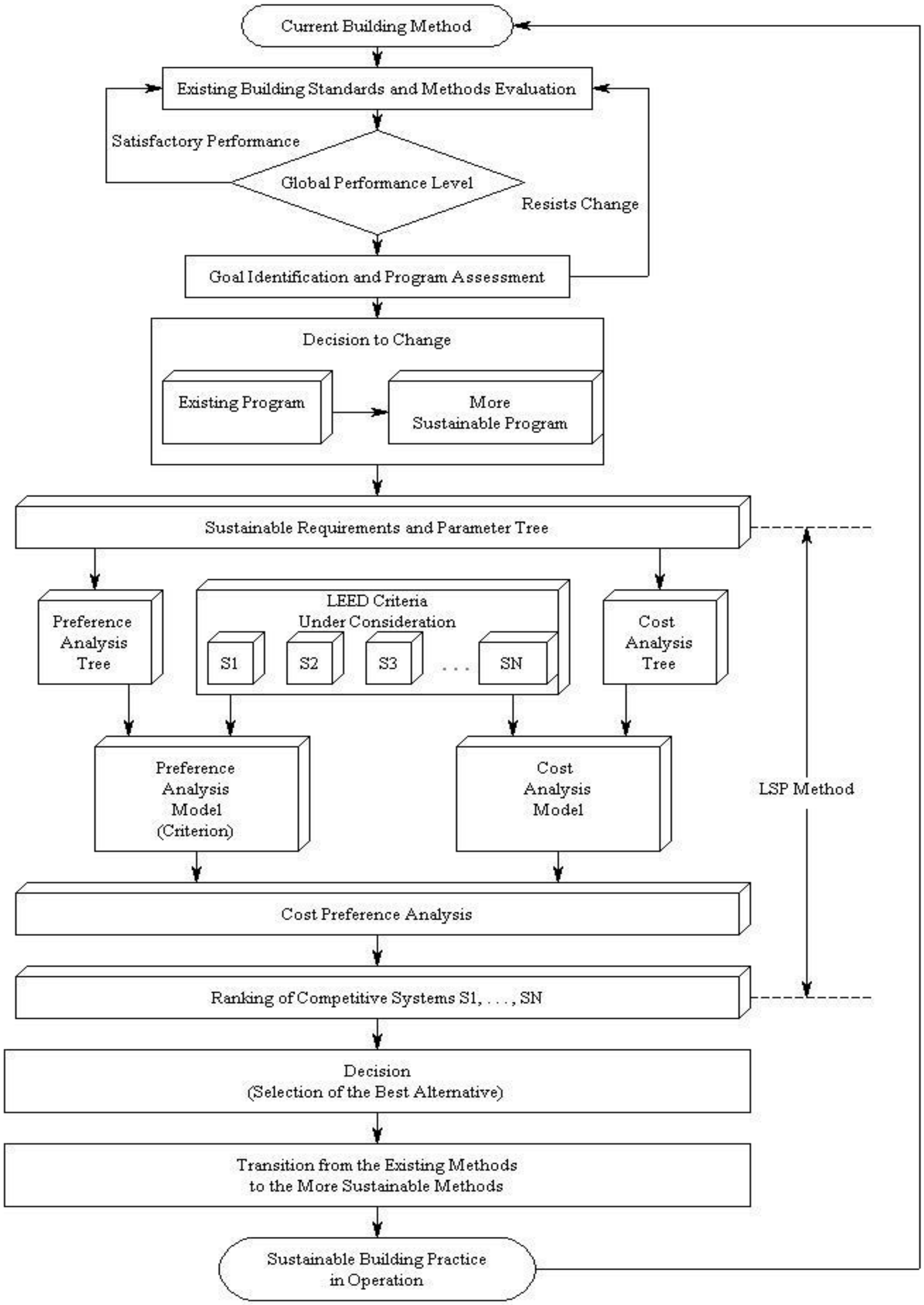

Figure 1-2. Decision Model for the Assessment of Sustainable Construction (DMASC)