

# LEED as a Business Model of Sustainability Commitment

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## ABSTRACT

The Leadership in Energy and Environmental Design (LEED) certification program has become a benchmark for sustainability. Yet most buildings are not LEED certified. The goal of this research study is to assess the LEED certification process as a business model of sustainability for the building market and is based on selected case studies with participatory action research. The case studies involve the LEED certification of 112 projects within the United States from 2004 to 2013 and include ten platinum-level projects. The results of this study determined the percentages and levels of projects which actually attained LEED certification. Seventy-seven of the 112 projects, or 69%, actually achieved LEED certification. Twelve were certified, 32 achieved silver level, 23 reached gold level and another 10 realized platinum level certification. The crucial success factors which facilitated attainment of LEED certification included taking ownership of sustainability, prior LEED project experience, additional training, incorporating LEED goals early, and establishing financial stewardship. One opportunity for improvement of LEED certification is for the rating systems to provide more realistic, consensus-based sustainability goals.

**Keywords:** environment, energy, LEED certification, sustainability, USGBC

## INTRODUCTION

Humanity noticeably conveys its culture, best ideas, and values through the richness of its literature and architecture. Think of all the beautiful buildings and monuments of history—the Egyptian pyramids, Parthenon, Pantheon, Taj Mahal, and many houses of worship are wondrous buildings that provide enduring legacies of the achievements of

past societies throughout the world. Through hymnody or building or mosaic, matter is given a voice (Keselopoulos, 2001, p. 118). The built environment offers a snapshot of the cultural values and technological capabilities of the place and time in which it was created (Eng, 2004, p. 61). A primary goal of environmental stewardship as applied to building is to improve a building's positive impact on the environment and reduce its negative impact. Too many structures diminish humanity because primary design criteria focus on building taller, faster, and cheaper instead of building better (Fedrizzi, 2010, pp. 4-5).

Current buildings may be technologically smart but environmentally unwise because they can damage the environment and waste energy. Some negative environmental consequences include ozone depletion, global warming, loss of habitat for wildlife, and depletion of natural resources. Buildings intended for shelter can harm or even kill occupants through the use of building materials such as asbestos, high volatile organic compounds (VOCs) and formaldehyde. These and other issues exemplify the need for proper environmental stewardship. The buildings we construct today will convey to future generations how well our culture has incorporated the values of environmental stewardship and the ideas of sustainability. Otherwise, the destruction of our environment through improper environmental stewardship will see to it that no one will be around in the future to admire and remember our literature, ideas, and culture. Chief Seattle observed that all things are connected. Whatever befalls the earth befalls the children of the earth (Turner, 2011, p. 5).

In 2001, the Intergovernmental Panel on Climate Change (IPCC) reported that the projected climate change will increase "threats to human health, particularly in lower income populations, predominantly within tropical/subtropical countries" (IPCC, 2001, p. 9) and that the environmental degradation threatens our ability to meet present and future needs (IPCC, 2001, p. 29). Humanity must make an end of climate change or climate change may make an end of humanity as the continual warming of the earth depletes farmland and increases the demand for diminishing natural resources. Unless we change our ways, it is likely that civilization as we know it will disappear (Sarkar, 2010, p. 52). Indeed, the coexistence of man and nature should be placed on the level of friendly relations, not of conflict or oppression of the one by the other (Keselopoulos, 2001, p. 1).

Climate change and global warming are related but distinct phe-

nomena. Climate change is a general term that refers to changes in many climatic factors such as temperature and precipitation. Global warming is the rise in global temperatures due to an increase of heat-trapping carbon emissions in the atmosphere (Sarkar, 2010, p. 19). Climate change is both an environmental and societal problem since the simple truth is that humanity is changing the atmosphere. Every day, we add around 70 million tons of carbon dioxide to the atmosphere, which is the very gas that we know controls the earth's temperature (Sarkar, 2010, p. 52).

When researching the impact of climate change and global warming, one word arises again and again: urgency. The urgency of climate change requires new leadership such that positive improvements concerning the design and energy consumption of buildings may be realized. An urgent need exists to better understand the threats posed by human-induced climate change and to build a consensus on proactive initiative that can help society mitigate and adapt to its impacts (Sarkar, 2010, p. 71). A growing percentage of the population now supports the practice of sustainable design and construction initiatives that focus on environmental stewardship (ASHE, 2010, pp. 13-14). Business as usual is no longer a viable option (Sarkar, 2010, p. 22).

In response to the urgency of climate change, the United States Green Building Council (USGBC) developed the Leadership in Energy and Environmental Design (LEED) certification program to provide the business community with nationally consensus-based tools useful for designing, building, and operating buildings that incorporate sustainable building qualities and practices.

Therefore, LEED was developed in response to the urgency of climate change, and the LEED certification program is presented to the business community as a model of sustainability commitment. The demand for high performance, "green," or sustainable buildings is rapidly emerging as the most significant trend in the building industry (Pulaski, 2005, p. 15). Some buildings are built with permanent materials and are considered sustainable for their long life potential. Other buildings made of impermanent materials as temporary structures are also considered sustainable for their ability to be recycled. Both of these practices are sustainable because of the appropriateness of the design intent. When applied to the built environment, to build appropriately means that a building should be designed to last with the intended use of the building in mind (Eng, 2004, p. 19). Businesses which apply the building qualities and practices as stated by LEED demonstrate a

level of sustainability commitment. But is LEED truly a good model for sustainability commitment for the business community? This study reviews and analyzes selected data from 112 LEED-registered projects to determine the effectiveness of LEED as a model for businesses to follow. This study also provides new knowledge about key elements which helped projects achieve LEED certification and what opportunities there may be to improve the LEED certification program.

## **Background**

The Organization for Economic Cooperation and Development (OECD) and the International Energy Agency (IEA) project that over the next 30 years, global primary energy demand will grow by 1.7% per year from 9.20 billion tons to 15.30 billion tons of oil equivalent and this demand will be met primarily by conventional fossil energy fuels such as oil, natural gas, and coal (Sarkar, 2010, p. 53). In the July 2009 G-8 meeting of the Major Economic Forum (MEF) held in L'Aquila, Italy, leaders from Canada, France, Germany, Italy, Japan, Russia, the United Kingdom, and the United States, agreed to a goal of achieving at least a 50% reduction in global greenhouse gas emissions by 2050 (Sarkar, 2010, p. 76).

Buildings are a significant cause of global greenhouse gas emissions. The USGBC cites a study provided by the Office of Energy Efficiency and Renewable Energy of the Department of Energy (DOE) that "buildings annually consume 39% of the total energy and 74% of the electricity produced annually in the United States" (USGBC, Building Design and Construction, 2009, p. 213). A new construction project in the United States typically will generate up to 2.5 pounds of solid waste per square foot of completed floor space (USGBC, LEED-S, 2007, p. 12). Americans use "3,700 billion gallons per year more than they return to the natural water system to recharge aquifers and other water sources" (USGBC, LEED-S, 2007, p. 127). Thus, the built environment has a "profound impact on our natural environment, economy, health, and productivity" (USGBC, LEED-S, 2007, p. 11). Rendering the built environment more energy efficient and environmentally responsible will logically have a profound positive impact, as the reduction of the energy that buildings use will help offset the projected global primary energy demand.

The USGBC developed the LEED certification program to provide the business community with nationally consensus-based tools useful

for design, construction, and operation of buildings that incorporate sustainable building qualities and practices. This study reviews the roles and effectiveness of the LEED certification program as implemented for projects registered to attain LEED certification.

### **History of LEED**

Energy efficiency is a fundamental component of any carbon reduction strategy (Tidona, 2009, p. 51). Several building-system assessments of environmental qualities and energy efficiency are in use for the United States. Among these are Green Globes, Energy Star, and LEED. The Green Building Initiative (GBI) promotes Green Globes. GBI is an accredited standards developer for the American National Standards Institute (ANSI). Energy Star is a voluntary labeling program jointly sponsored by the U.S. Environmental Protection Agency (EPA) and the Department of Energy.

Once the USGBC was formed in 1993, organization members realized that the sustainable building industry required a system to define and measure green buildings, so the USGBC researched green building metrics and developed rating systems (USGBC, BD+C, 2009, p. xi). A pilot program, LEED version 1.0, was implemented in 1998. After extensive modifications, LEED version 2.0 was issued in March 2000. LEED then evolved to address divergent building types releasing, from 2005 through 2007, the USGBC version 2.2 rating systems for Core and Shell buildings (LEED-CS), Commercial Interiors (LEED-CI), New Construction and Major Renovations (LEED-NC), Existing Buildings (LEED-EB), and K-12 Schools (LEED-S). In 2009, the USGBC authorized version 3.0 for Building Design and Construction (BD&C), Interior Design and Construction (ID&C), and Existing Building Operation and Maintenance (BO&M) (USGBC, Building Design and Construction, 2009, pp. 11-12) and significantly changed the allocation of points compared with previous LEED rating systems. These changes increased the relative emphasis on the reduction of energy consumption and greenhouse gas emissions that are associated with buildings (USGBC, Building Design and Construction, 2009, p. xiii). In 2011, the LEED 2009 rating system for Healthcare New Construction and Major Renovations rating system (LEED-HC) was introduced.

The next version of LEED is LEED V4. LEED V4 is a technical redaction of LEED V3. By way of comparison, the LEED V4 (Building Design and Construction) provides significant changes in comparison

to LEED V3 BD&C. These include updating the referenced standard for energy performance to ASHRAE 90.1-2010 and the provision of new prerequisites and credits as shown by category in Figure 1.

LEED V4 has more options for projects outside the US, compared to LEED 2009, and has been expanded to more market sectors such as data centers, warehouses and distribution centers. LEED V4 is currently being introduced through Beta testing for selected projects. None of the projects researched for this study utilizes the LEED V4 rating system.

Buildings both within and outside of the United States are eligible to achieve LEED certification, and some businesses demonstrate a striking commitment to LEED. For example, PNC Bank now has the most LEED certified buildings (over 100) of any organization on the planet (Fedrizzi, 2010, p. 1).

The LEED 2009 Minimum Project Requirements (MPR) Supplemental Guidance (version 1.0, November 2009) lists the following building criteria requirements:

1. Comply with environmental laws.
2. Complete permanent building or space.
3. Reasonable site boundary.
4. Comply with minimum floor area requirements.
5. Minimum occupancy rates.
6. USGBC access to Whole-building Energy and Water Usage Data (if metered).
7. Comply with minimum building area to site area ratio.

Where meters are cost prohibitive or physically impractical to install, owners such as higher education campuses are not expected to supply energy and/or water usage data (USGBC, LEED 2009 MPR Supplemental Guidance, p. 27).

### **Problem Statement**

The LEED rating system establishes the criteria to evaluate a building's performance so as to provide a "definitive standard for what constitutes a 'green building'" (LEED-S, 2007, p. 14). While the LEED certification program has become a recognized benchmark for sustainability, in reality, most buildings are not LEED certified. The New Buildings

<b>General</b>	
Integrative Process	Encourages early analysis of energy and water systems
<b>Location and Transportation</b>	
LEED-ND Location	Encourages selection of a LEED for Neighborhood Development certified site.
<b>Sustainable Sites</b>	
Site Assessment	Encourages early analysis of site conditions to inform design.
<b>Water Efficiency</b>	
Outdoor Water Use Reduction	Requires reducing landscape water use by 30% using EPA’s WaterSense Water Budget Tool or have no irrigation
Building-Level Water Metering	Requires measuring whole building water use
Water Metering	Rewards projects which submeter at least two water end uses
Cooling Tower Water Use	Encourages projects to analyze water source and maximize water cycles
<b>Energy and Atmosphere</b>	
Building-Level Energy Metering	Requires measuring whole building energy use
Advanced Energy Metering	Rewards projects which submeter energy end uses which comprise at least 10% or more of the total building energy consumption
Demand Response	Encourages projects to participate in a demand response program and includes demand response processes in the commissioning scope
<b>Materials and Resources</b>	
Construction and Demolition Waste Management Planning	Requires setting a project target for waste management and reporting of waste diversion rates.
Building Product Disclosure and Optimization Credits	Rewards the use of products with Environmental Product Declarations
	Rewards the use of local raw materials sourcing
	Rewards the use of optimized local materials ingredients.
<b>Indoor Environmental Quality</b>	
Interior Lighting	Redaction of the “Controlability of Systems – Lighting” credit and adds a lighting quality option.
Acoustic Performance	Rewards usage of sound level requirements (LEED-S and LEED-HC)

Figure 1: LEED V4 New Prerequisites and Credits

Institute (NBI) noted that only 552 new buildings in 2006 were LEED certified (NBI, 2008, p. 1). Therefore, the basic issue is that a low percentage of new buildings attain LEED certification in the United States.

### **Purpose of the Study**

The goal of this study is to assess the LEED certification process as a business model for the building market. The explanatory study is based on a comparison of 112 LEED-registered projects and includes participatory action research with the role of a LEED commissioning agent. The results of this study are intended to determine the level of success regarding how the projects implemented the LEED certification process, underscoring salient critical success factors, and identifying opportunities for the improvement of LEED certification as a credible business model. Langdon has argued that the “goal of ever greener buildings by committed building owners and investors will lead to a greater focus on the life cycle benefits of the technologies and design strategies, assisting the financial evaluation of the various attributes beyond the initial capital cost impacts” (April 2007, p. 3).

### **Significance of the Study**

The significance of this case study is to inform and encourage the leadership of the various sectors of the building market concerning the results of projects which attained LEED certification, some lessons learned, and opportunities for improvement within the current LEED rating system. Higher education plays a specifically critical role “in making a healthy, just, and sustainable society and a stable climate a reality” by preparing the professionals “who develop, lead, manage, teach, work in, and influence society’s institutions” (ACUPCC Institutions, 2009, p. 5).

### **Nature of the Study**

The nature of this study involves a detailed longitudinal examination of the problem of a low percentage of LEED-certified buildings through selected case events—that is, incorporation of sustainability principles for the intended goal of achieving LEED certification with selected data and results that were obtained from 112 LEED registered projects. The LEED rating system defines and interprets the principles of sustainability through the following categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources,



Indoor Environmental Quality, Innovation and Design Processes and Regional Priorities. Prerequisites are met, and credits are earned for satisfying each criterion. There are currently four levels of green building certification: certified, silver, gold, and platinum (USGBC, 2009, *Building Design and Construction*, pp. xix-xxi).

This study primarily draws on the LEED 2007 and 2009 rating systems to identify the sustainability criteria defined by LEED. Comparisons of the LEED 2007 and 2009 versions indicate that the current rating system places greater emphasis on the energy and atmosphere category for energy efficiency, with less emphasis on usage of materials and resources. LEED 2009 rating systems adds a category, Regional Priorities, for sustainability goals that are based on geographic location.

### **Research Questions**

This study considers the following research questions relative to the 112 LEED registered projects in comparison with the case study:

1. What percentage of these buildings have achieved LEED certification?
2. What were project design criteria significant to the achievement of LEED certification?
3. What level of LEED certification was actually achieved?

### **Hypotheses**

The hypotheses investigated in this study are:

1. A low percentage of new buildings achieve LEED certification.
2. Some LEED requirements were relatively easy to implement while others are not.
3. The “first costs” of achieving LEED certification is a principal factor when analyzing the financial impact of LEED certification.

### **Conceptual Framework**

The 112 LEED projects considered for this study are few among the many other LEED certification projects. Currently, the USGBC is certifying over one million square feet of LEED every day and has exceeded one billion square feet of LEED certified space across the globe (Fedrizzi, 2010, p. 2). Over 40,000 projects are currently participating in the commercial and institutional LEED rating systems comprising over 7.9 billion square feet of construction space in all 50 states and 117 countries (USGBC, 2011, p. 1). The most common project type was commercial of-

fice and the American cities most represented in the list were Chicago and Washington, D.C. (USGBC, 2011, p. 2). By comparison, most of the case studies discussed in the research were located in Pennsylvania and New Jersey.

### **Scope of the Study**

The scope of the study focuses on utilizing sustainable design practices defined by the USGBC LEED program. Sustainable design building practices defined by other organizations such as Energy Star, Green Globes Passivhaus/Passive House, and the Commercial Building Energy Consumption Survey (CBECS) are not the primary focus of this study.

### **Summary**

The business model for sustainability is essentially a benchmark through which a company can demonstrate compliance and commitment to defined sustainability goals. The LEED rating systems provide that benchmark. This section identified the parameters of the case study, and selected LEED projects and their relevance to the application of sustainable design practices for the building market. The study reviewed the history of LEED. The goal of the study is to provide new knowledge to those in the building market who are committed to demonstrating sustainable practices by using LEED certification.

## **REVIEW OF LITERATURE**

### **Environmental Stewardship**

Environmental stewardship is the basis of sustainability. If sustainability were a place, it would be a “place so much at home with the world” (Turner, 2010, p. 6). The NASA photograph of Earth as seen from space depicts the serene beauty and the fragility of our planetary home. Earth’s atmosphere protects us from the harsh environment of space. Our planet’s abundant fresh waters and oceans provide a home for countless creatures. Both are essential for life, yet we use our planet’s atmosphere, waters, and oceans as dumping grounds for waste. The literature search reveals an abundance of hard data demonstrative of current interest in developing environmental sustainability and emphasizes the urgency of global climate change. For example, in the

United States, buildings account for 38% of carbon dioxide emissions (EIA, Annual Assumptions to the Annual Energy Outlook, 2010, p. 23). Buildings use 13.6% of all potable water, or 15 trillion gallons per year (USGS, 2000). The challenge of this century will be for society to regain a healthy relationship with our living earth (Sarkar, 2010, p. 52). In other words, it's about a simple, more meaningful, economically secure way of life (Fedrizzi, 2010, p. 6).

The concept of environmental stewardship is not new. The Christian patristic tradition understands environmental stewardship as an expression of the divine economy. Once God creates the world out of nothing, He organizes it, adorns it and preserves it (Keselopoulos, 2001, p. 16). God places man in the world as His representative in order to exercise God's care of the natural world, participate in the continuous act of creation and guide creation to its perfection (Keselopoulos, 2001, p. 62). God's command to care and cultivate the earth (Gen. 2:15) refers to man's rights and obligations towards the environment in which he lives (Keselopoulos, 2001, p. 61). This concept is similarly found among the traditions of indigenous peoples as found in Hawaiian wisdom (Kupuna), "Earth, water, and sea belong to the gods, and people are here to enhance them, not deplete them" (Turner, 2011, p. 5).

Through his physical senses, man sees in the sensible things of the world the ineffable gifts of God (Keselopoulos, 2001, p. 63). Thus, sustainability goals are founded on care and respect through which matter and the environment can potentially be elevated to their original beauty (Keselopoulos, 2001, p. 182).

The current understanding of sustainability was first introduced in 1990 by the British Building Research Establishment Environmental Method (BREEAM). Other models of sustainability have been developed and continue to evolve. Most sustainability systems are structured like LEED (Novitski, 2010, p. 53). Therefore, the LEED certification program merits study because it is the benchmark of sustainability as a "widely recognized indication of sustainable design and construction practices" (ASHE, 2010, p. 14). While the recession has derailed many once popular business trends, 59% of the 3,000 respondents to the Sloan Management Review / Boston Consulting Group 2010 sustainability survey indicated that they were increasing their investment in sustainability and only 3.5% of those surveyed considered themselves to be "true sustainability skeptics" ("Sustainable Gain," 2011, p. 60).

The United States Green Building Council (USGBC) has become

a globally recognized advocate for environmental stewardship and encourages increasing levels of sustainability for the way buildings are designed, constructed, operated and maintained through its Leadership in Energy and Environmental Design (LEED) program. The USGBC Greenbuild International Forum recently was attended by 750 international green building leaders from 73 countries around the world (Fedrizzi, 2010, p. 1).

The USGBC Memorandum which introduced the LEED 2009 version reported that as of May 1, 2008 over 3.5 billion square feet of building projects have been registered to pursue LEED certification (USGBC, May 1, 2008, p. 1). The USGBC website, [www.usgbc.org](http://www.usgbc.org) is a vibrant portrayal of the organization and is regularly updated. The website offers reference guides, online courses, workshops, webinars, study guides and links to related podcasts, research articles, and videos. The LEED Minimum Program Requirements (MPRs) are also regularly updated as necessary to provide additional clarification on the intent and application (LEED 2009 MPR, p. 2). The research reviewed prerequisites and credits of the 2007 and 2009 LEED reference guides for the LEED-CI, LEED-CS, LEED-EB, LEED-NC and LEED-S rating systems.

### **Theory and Research Specific to the Problem**

The sources for the literature review included journals and dissertations, reference and research books, other case studies, periodicals, governing agencies, university libraries, professional engineering and architectural sources, USGBC, and GBCI. Governing agencies included building codes and standards, particularly ASHRAE/ANSI/IES Standard 90.1.

The LEED certification scorecards for each of the case studies available to members of the project team were reviewed. In addition, other related documentation publicly available through the USGBC website was examined.

### **Optimized Energy Performance**

Energy efficiency is distinct from optimized energy performance. The intent of LEED's optimized energy performance requirements is to recognize the minimum energy-efficient requirements and then mandate increasing levels of energy efficiency beyond the standard. ASHRAE Standard 90.1, as it is commonly known, provides the minimum energy-efficient requirements for the design, construction, and

plan of operation and maintenance for new buildings and their systems, as well as new systems and equipment in existing buildings (ASHRAE 90.1, 2010, p. 4). ASHRAE Standard 90.1 details heating, cooling, and ventilation of spaces, building envelope and equipment-performance requirements, interior lighting power allowances, and other design criteria. ASHRAE Standard 90.1 includes tables that list U.S. climate zones and climatic data for other countries. The ASHRAE Standard 90.1 incorporates minimum energy performance metrics for a building which is used as the baseline when calculating the whole building energy simulation model (LEED 2009 BD+C, p. 257). Some consider that the characteristic energy usage is a comparison of the measured energy use after implementation of energy efficiency interventions with what was before energy efficiency implementation (Grober, 2010, p. 25). However, to measure the optimized energy performance, LEED considers the ASHRAE Standard 90.1 with its minimum energy efficiency requirements as the baseline before additional energy efficiency methodologies are implemented.

### **Existing Building Case Studies**

One case study in the literature involved the retrofit of the Boeing Bay Area Boulevard building in Houston. The only major retrofits were the installation of a DDC control system with lighting controls, replacing the original outside air-handling units and exhaust with energy recovery units and the replacement of one chiller (Tom, 2010, p. 72). In addition, tower isolation valves were installed in the cooling tower system so that each of the three tower sections could be operated independently. Previously, if one chiller was running, all three tower sections and all three cooling tower fans had to run to meet the needs of this one chiller (Tom, 2010, p. 66).

Most of the energy initiative involved refining control sequences, and repairing or re-commissioning existing systems. With these changes, Boeing reduced energy use by 35%, earned a LEED-EB gold level certification, and brought up the building's energy star rating from 42 in 2006 to 81 in 2009 (Tom, 2010, p. 73). The energy savings Boeing achieved at its Houston facility resulted in a reduction of 3,415 metric tons of carbon dioxide emissions, which is equivalent to the annual greenhouse gas emissions resulting from 640 passenger vehicles or the consumption of 396,413 gallons of gasoline or the electricity used by 484 homes (Tom, 2010, p. 70).

Another case study in the literature which utilized both retro-commissioning and continuous commissioning also earned LEED-EB gold level certification. The project team applied retro-commissioning as a “return to plans and specs” (McCown, 2011, p. 44). All items requiring corrective actions were immediately fixed, allowing immediate realization of energy savings of 6% after the first year (McCown, 2011, p. 48). Continuous commissioning allowed the commissioning team to have more time to study building systems operation, and overall energy savings was improved by 14% (McCown, 2011, p. 51). Ongoing commissioning is also recommended for the Department of General Services for the State of California (Kats, 2003, p. 103).

### **Environmental Performance Metrics**

Many international agencies are developing and harmonizing credible, science-based environmental performance metrics. These include the United Nations Environmental Programme and Society for Environmental Toxicology and Chemistry (UNEP/SETAC), the European Union Joint Research Center, the USGBC, and others (NSTC, 2008, p. 17). The New Buildings Institute (NBI) prepared for the USGBC a study of the energy performance of 121 LEED new-construction buildings (NBI, 2008). This study served as a basis for part of the current research. Their data suggest that continued improvements to the LEED program are necessary (NBI, 2008, p. 32). The NBI study also compared the energy use intensity (EUI) of these buildings to a national survey of building energy characteristics from the Commercial Building Energy Consumption Survey (CBECS) completed every four years by the Energy Information Administration (EIA). The NBI study argued that the median measured EUI is 24% below or better than the CBECS national average for all commercial buildings (NBI 2008, p. 2). The NBI study used data from the CBECS buildings which date from as early as 1920; whereas the sample of LEED buildings of the NBI study were built or renovated after 2000 (NBI 2008, p. 36). Therefore, the NBI study is considered flawed since the LEED sample consists of buildings constructed or renovated according to post-2000 energy-saving building practices, and with materials such as modern lighting fixtures, cooling equipment, and insulation which are not necessarily attributable to LEED elements (Gifford v. USGBC, 2010). The NBI study underscores the need for a better building performance evaluation methodology to comprehensively account for actual building conditions (Dahl, 2008, p. 42).

### **Energy Management Strategies**

Various proven technologies found in the literature and also the case studies are now used to improve the energy performance of building systems. The benefits of building green include cost savings from reduced energy, water, and waste; lower operations and maintenance costs; and enhanced occupant productivity and health (Kats, 2003, p. 11). Some of the energy management strategies are described below (Tom 2010, pp. 62-63 and Vorwald, 2011, pp. 20-21).

### **Learning Adaptive Optimal Start**

When a building is unoccupied, the HVAC systems are scheduled to turn off through broader temperature ranges. The systems are only energized for a brief period whenever the building becomes too hot or too cold. Through learning adaptive optimal start, the DDC system is constantly monitoring the outdoor and indoor air conditions and calculating how long it will take the system to bring the rooms back to comfortable conditions. The system will remain off for as long as possible and automatically turn on just in time to bring the space temperature to the programmed setpoint by the time the space is scheduled to be occupied. An example of implementation is usage of a wireless meter control system that downloads optimal control patterns to smart thermostats for individual zones as weather and building use patterns change (Kramer, 2010, p. 52).

### **Demand Control Ventilation**

The outside air dampers are modulated to ensure that enough outdoor air is brought into the building based on measured carbon dioxide levels. Energy consumption is minimized by not bringing in more outside air requiring heating or cooling than what is needed. However, extra outside air is brought in each morning to purge the building of cleaning chemicals used during the previous night. Using carbon dioxide sensors permits further refinements to determine low level occupancy under various conditions (Kramer, 2010, p. 72).

### **VAV Static Pressure Reset**

To save fan energy, reduce losses through duct leakage, and reduce noise, the DDC system monitors the position of all VAV dampers and modulates the static pressure setpoint so that the “worst case” box is 85% open.

### **Chilled Water Differential Pressure Reset**

To save pump energy when the demand for cooling is low, the DDC system monitors the position of the chilled water valves. The DDC system modulates the differential pressure setpoint of the chilled water pumps to keep the “worst-case” valve 90% open.

### **Geothermal Heat Pump Systems**

Taking advantage of the year-round stability of ground temperature to heat and cool buildings, geothermal heat pump systems extract warmth from the ground during the heating season and cooling from the ground during the cooling season, to heat or cool air used to maintain temperature conditions within a building.

### **Daylighting**

Daylighting uses natural light to illuminate building spaces, reducing electrical lighting during daylight hours.

### **Combined Heat and Power**

Combined heat and power (CHP), also known as cogeneration, involves the simultaneous generation from one source for electric and heat energy forms. CHP captures the heat generated by electricity produced through fossil fuels and redirects it for heating needs in a building. Other benefits include reductions in peak demand, the release of electrical grid system capacity, and reductions in overall electrical system transmission and distribution losses (LEED 2009 BD+C, p. 266). According to one study, all U.S. conventional power plants together convert only one third of their fuel into electricity, shedding the other two thirds as waste heat. This is equivalent to Japan’s the total energy use of (Ottinger, 2010, p. 35).

### **Business Community and Government Partnerships**

Sustainable development requires that the business community partner with government (McDonald, 2005, p. 57). Corporations are pressing for government action regarding environmental standards. Through the Global Roundtable on Climate Change, executives from a range of industries including air transport, energy, and technology have called on governments to set targets for greenhouse gases and carbon dioxide emissions. The group includes more than 100 of the world’s largest corporations, including Ford, General Electric, Toyota, Alcoa, Goldman Sachs, and Wal-Mart (Langdon, April 2007, p. 5). The federal



new-construction environment requires LEED certification (Smith, 2010, p. 52). Compliance with LEED standards is now required or encouraged in 22 states and 75 municipalities including Seattle and Boston (Gifford v. USGBC, 2010). The U.S. government considers that a more effective environmental stewardship contributes to the security, environmental sustainability, and economic well-being of the nation (NSTC, 2008, p. 5). Through executive order 13423, the federal government mandates a 30% reduction of energy use by 2015, including roughly three billion square feet of building area (Seidl, 2010, p. 2). Various states provide tax credits for a building that achieves LEED silver level certification. California has become the first state to adopt a statewide green building code (Fedrizzi, 2010, p. 2). Other incentives by policymakers include increased building valuation, reduced financing fees, lower taxes and insurance premiums, and special considerations in the permitting and review process (NSTC, 2008, p. 54).

Sustainable development makes good business sense because the responsible development is in line with growing community expectations and complies with emerging socially responsible investor requirements (Langdon, April 2007, p. 7). Specific business communities such as colleges and universities have also embraced sustainable design strategies as outlined by LEED. The American College and University Presidents Climate Commitment (ACUPCC) established a policy to require that all new campus construction be built to at least the LEED silver standard or equivalent (ACUPCC, 2009, Signature Letter, p. 2).

### **Limitations of LEED Certification**

Nonetheless, LEED certification has its limitations. For some researchers, no building is environmentally upright. All are downright wicked such that, even if every building were a LEED platinum level building, they still would have a negative impact on the environment (McDonald, 2005, p. 27). Every energy source pollutes; some do so badly and some not so badly (Turner, 2011, p. 5). Buildings displace habitat and are tremendous consumers of resources and generators of waste (Harrigan, 2004, p. 36). Construction, demolition, and renovation of buildings create waste (Tétrault, 2008, p. 5). An achievable, long-term plan for sustainable construction practices of the built environment is necessary (Fee, 2005, p. 13).

Failed LEED projects are starting to wash up in court. With more buildings pursuing LEED certification, the greater exposure of LEED

has increased the number of LEED critics and opponents (Fee, 2005, p. 79). One developer sued the builder after its \$7.5 million condominium project failed to achieve LEED silver certification. The developer claimed that it lost \$635,000 in state tax credits (Buckley, 2009, p. 50). Another lawsuit alleges that the LEED rating system's promise to reduce energy usage is unproven and is supplanting building codes in many jurisdictions, undermining marketplace competition, and obscuring other building standards which actually do reduce energy use (Gifford v. USGBC, 2010).

Furthermore, a LEED rating system by itself does not ensure superior energy efficiency (ASHE, 2010, p. 15) nor is it the only means for improving energy efficiency. Energy is required to heat, cool, ventilate, and light a building. The greenest energy is that which is not used. Building-energy consumption can be reduced by 30-50% by using a broad array of currently accessible and cost-effective technologies such as *in situ* performance metrics, embedded intelligence, and high performance building envelope systems and components to manage thermal loads (NSTC, 2008, pp. 18, 22, 25). It is noted that "high performance" and "green" buildings are terms used synonymously. However, high performance buildings differ from green buildings by achieving exemplary levels of sustainability while improving traditional project performance measures such as cost and schedule (Pulaski, 2007, p. 23).

Commissioning, a prerequisite of most of the LEED rating systems, is one vehicle by which a building's energy performance is improved. The intent of commissioning is to verify that the project's energy-related systems are installed, calibrated and perform according to the owner's project requirements, basis of design, and construction documents (LEED 2009 BD+C, p. 217). Commissioning an existing building retrospectively (retro-commissioning) can significantly reduce annual energy costs. Through retro-commissioning, one hospital reduced its annual energy costs by more than 40% without compromising thermal comfort, infection control, and reliability (ASHE, 2010, p. 74). One study reported that nearly one third of all buildings have problematic economizers and that successful commissioning of buildings for control-related problems must address deficiencies in this and other categories (Ardehali, 2009, p. 41).

### **Barriers to Energy Saving Strategies**

A variety of barriers to implementation of energy savings strategies have been observed. For implementation of CHPs, these include

hostile utility policies, excessively onerous environmental permit requirements, lack of regulatory recognition of the benefits of CHP implementation, and unfavorable tax treatment (Ottinger, 2010, p. 35). Concerning installation of PV arrays, some argue that the utilities will find their business model significantly impacted as they produce a lower percentage of required electricity and become more involved in grid management (Turner, 2011, p. 5).

### **Summary**

Among the 112 LEED certification projects surveyed for the research, 77 projects have achieved LEED certification. The original NBI study (2008) investigated 121 LEED certification case studies and served as a basis for part of the current research. The results of the NBI study are being challenged as fraudulent through litigation (*Gifford v. US-GBC*, 2010).

Hanby (2004) provides an excellent study of barriers to LEED certification:

1. Acceptance of LEED values
2. Knowledge of the LEED process
3. Process time
4. Upfront and hidden financial costs

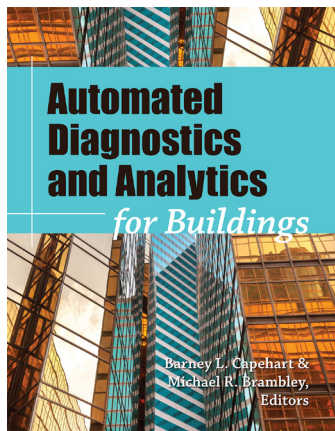
This study examines these barriers as applied to the case studies to discuss opportunities for improvement of the LEED certification program. The case studies themselves indicate other barriers to LEED certification. First, the geographic location affected the success or failure of the LEED certification program. Projects located in urban areas benefited from some easily attainable credits compared to projects located outside an urban environment, without brownfield sites and public transportation. Second, team members who possessed specialized LEED training, accreditation, and experience contributed to the successful completion of LEED certification. Third, the quality of the building envelope and the efficiencies of the mechanical, electrical, and plumbing systems affected the level of LEED certification that was attained.

Feedback from survey and interview participants varied. Some perceived that the LEED rating systems had become radicalized; that is, the current rating systems were architecturally driven and did not truly represent realistic and consensus-based sustainability. Others believed that the LEED certification program was well suited as a model



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Edited by Barney L. Capehart, Ph.D.,  
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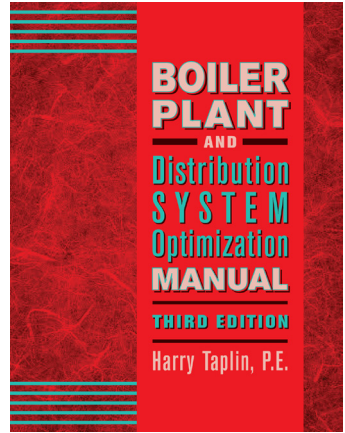
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of sustainability for the business community. The cost of pursuing LEED certification was generally estimated to be 2% to 4% of the total construction cost. This estimate lies within the USGBC's estimate that initial costs are increased from an average of 2% to 7%, depending on the design and extent of added features (USGBC, 2003, p.1). Concerning these costs, Harrigan reasons that it is possible to do well financially and still do the right thing environmentally because well executed green development projects perform extremely well financially. A minimal upfront investment of 2% of the construction costs typically yields a life cycle savings of more than ten times the initial investment (2004, p. 42).

By comparison, Langdon initially reports that such a wide variation in cost per square foot between buildings on a regular basis, even without taking sustainable design into account, contributed to the lack of statistically significant differences between the LEED-seeking and non-LEED buildings (July 2007, p. 10). However, this same study analyzes the individual additional costs of each LEED category and concludes there are a number of factors which can have a significant impact on both the ability to achieve specific LEED points and on the cost to build a sustainable building (July 2007, p. 23).

### **Contributions of the Study**

This study provides new knowledge about the roles and effectiveness of the LEED certification program as implemented for 112 projects registered to attain LEED certification. The research proposes several improvements to overcome barriers to successful achievement of LEED certification. In other words, what worked and did not work was examined so that the lessons learned can become a useful model for those in the building market who wish to achieve LEED certification.

### **RESEARCH METHODOLOGY**

The research methodology used a mixed-methods design of qualitative and quantitative research data. The LEED scorecards for each of the 112 LEED certification projects and level of LEED certification (certified, silver, gold, platinum) were used as primary quantitative data. The qualitative method was used to analyze the results of the LEED certification projects—whether or not the project achieved LEED certification. The author of this embedded-cases study served as the commissioning agent for each case study and provided formal presentations to vari-

ous professional organizations for four of the cases. Interviews of key stakeholders were also conducted for selected case studies. Interviews were conducted so as to convince subjects that what they had to say was important (Berg, 2008, p. 139).

The excellent research conducted by Hanby concerning the barriers to LEED certification projects in Oregon (2004) was the basis for the current research as well as the NBI study (2008). Data were gathered from the case studies and organized into two subgroups. The two subgroups included those case studies which attained LEED certification and those which did not. The LEED certification subgroup was further divided by level of LEED certification that was attained. The levels of LEED certification are certified, silver, gold, and platinum as recorded on each project's scorecard. However, each project scorecard is treated as confidential (Berg, 2008, p. 92). A suitable quota-sampling function of prerequisites and credits was systematically selected, to demonstrate "lessons learned" for the attainment of LEED certification. The quota-sampling approach assumed that the variations of the characteristics would ultimately result in a representative sample (Brewerton & Millward, 2008, p. 117).

The survey instrument was initially based on the fourth annual green building survey (2010) of the Constructive Technologies Group (CTG). The survey instrument was then compared with a construction practices survey (Fee, 2005, p. 94), reworked and substantially redeveloped to suit the research purposes of this article.

The survey instrument also incorporates personal insights and new ideas gained through experience with LEED projects and through the following professional criteria:

1. Through the U. S. Green Building Council (USGBC), the author is a LEED Accredited Professional (LEED AP).
2. The author served as a subject matter expert for the USGBC for the development of the LEED AP exam.
3. Through the Association of Energy Engineers (AEE), the author is a Certified Sustainable Design Professional (CSDP), a Certified Building Commissioning Professional (CBCP) and an Existing Building Commissioning Professional (EBCP).

The qualitative portion consisted of informal interviews with the same participants on the same topics covered in the written question-

naire. The professional business relationship with those interviewed enabled a candid discussion of the LEED rating systems and attainment of LEED certification.

### **Variables**

Independent variables were the number and type of credits pursued for each case study and whether or not the project achieved LEED certification. Dependent variables included the geographic location of the project, rating system, building type, quality of building envelope and systems, and team members.

### **Sample**

Among the 112 projects surveyed for the research, the author participated as the commissioning agent (CA) for every case study. Other team members included the project champion who may be the owner or owner representative, the optional sustainability consultant, the engineer of record, architect, construction manager, and contractors. Participants were encouraged to be candid and reflective.

### **Instrumentation**

This study utilized interviews, questionnaires, personal observations, and reviews of project-independent and project-dependent variables. Interview participants were asked what worked and what did not work for the particular case study. Also, survey participants were asked to provide basic cost data and to consider possible improvements to the LEED rating systems. The literature review provided sources of information for some of the questions. The NBI report for LEED-NC buildings (NBI, 2008) was used as a benchmark for some of the data.

### **Procedures**

To determine the availability of projects and people and relevance of the data, informal discussions were conducted with key project team members before the study was commenced. Finally, the research included interviews based on a case study that incorporated sustainable principles but did not pursue LEED certification.

### **Data Analysis**

The data were analyzed to answer the research questions, validate the hypotheses, and discover opportunities for improvement. The data collected from the questionnaires were recorded on a spreadsheet to en-



able descriptive analysis and final comparisons of the achievements and levels of LEED certification with each applicable rating system. A structure based on the LEED criteria was developed to present the results in a logical and meaningful structure (Brewerton & Millward, 2008, p. 173). The summary of results is found in the appendices. The results are based on the performance data provided by the project scorecards.

### **Reliability and Validity**

The internal validity of the data was related to the level of LEED certification and whether or not LEED certification was actually achieved. The collected data also provided possible solutions and opportunities for the improvement of LEED certification. The performance/outcome of the levels of LEED certification based on the rating systems specified by the USGBC was subjected to the following critical analysis (Brewerton & Millward, 2008, p. 124):

1. Objectivity—the criterion score is the same whoever measures it.
2. Reliability/validity—the score is related to the performance alone.
3. Discriminability—the criterion score discriminates fairly between different levels of performance.
4. Accessibility—the criterion score should be readily available and accessible.

### **Limitations of the Study**

The projects actually registered for LEED certification with the USGBC during the years 2004 through 2013 were considered as primary case studies. An “actually registered” project was defined as a project whose stakeholder paid the registration fee to the USGBC, to have the project considered for LEED certification. In addition, one major construction project which incorporated sustainable design strategies including commissioning, but did not pursue LEED certification, was considered in the research. This major construction project was valued at more than \$36 million. Personal interviews with key stakeholders were conducted to determine whether LEED certification was considered and if so, why LEED certification was not pursued.

A “LEED certification” project was determined to be a project that was to pursue LEED certification following the Commercial Interiors (LEED-CI), Core and Shell (LEED-CS), Existing Building (LEED-EB),

New Construction (LEED-NC) or Schools (LEED-S) rating systems from 2004 to 2013. Other projects utilizing other LEED rating systems such as Homes, Neighborhood Development, Retail or Healthcare were not part of the research. A project that actually achieved LEED certification by the USGBC was awarded a certified, silver, gold, or platinum level certification.

The LEED certification projects considered as case studies were those in which the author was assigned the role as the LEED commissioning agent. This study also is encumbered by the following limitations:

1. This study is limited to the members of the LEED project team who agree to participate voluntarily in the surveys and interviews.
2. This study is limited by the amount of time available to conduct the study for the purposes of this research study.
3. This study is confined to tracking the developments and decision making by the project team required for the LEED certification of the 112 case studies.
4. The scope of the study focuses on utilizing sustainable design practices defined by the USGBC LEED program. Sustainable design building practices defined by other organizations such as Energy Star, Green Globes and the Commercial Building Energy Consumption Survey (CBECS) are not the primary the focus of this study.

### **Summary of the Methodology**

The barriers listed by Hanby (2004) were found to be applicable for the case studies, but in varying degrees. Other barriers were uncovered. These include geographic location, LEED training and experience of primary team members, and the quality of the building envelope and systems.

The research suggests that opportunities exist for the improvement of the LEED certification program. One improvement is that the current rating systems need to become more faithful toward a realistic, consensus-based sustainability. For team members, the opportunities which enabled the successful attainment of LEED certification include:

1. Taking ownership of the greater goals of sustainability.
2. Including team members who know the ways of LEED certification.

3. Providing sustainability and LEED training to others on the project team.
4. Incorporating LEED goals early.
5. Establishing financial stewardship.

## RESULTS

The case studies included core and shell buildings constructed by various developers committed to sustainability. The core and shell buildings usually provided commercial interior spaces for tenant fit-outs for offices and other business operations, and some of the tenant fit-outs were among the case studies. Several large new construction projects for colleges and universities comprised additional case studies, including a campus center and buildings for the studies of sustainability, nursing, law, and science, technology, engineering and mathematics (STEM) specialties. Other projects were for educational centers, a church, an arboretum, condominiums, transitional housing, senior living, schools, social services, manufacturing, banks, corporate headquarters, data centers, government facilities, laboratories, hospitals, medical office buildings, retail stores, a beauty salon and even a fast-food drive-in.

The project size varied greatly, from less than 3,000 square feet to more than 200,000 square feet. The majority of the projects which achieved LEED certification were located in either Pennsylvania or New Jersey. The rest of the projects were located in Arizona, Delaware, District of Columbia, Florida, North Carolina, Maryland, Massachusetts, and Virginia.

Each case study included the following proprietary, basic criteria required for LEED certification:

1. LEED scorecard
2. Owner project requirements
3. Basis of design
4. Engineering design or construction level drawings
5. Commissioning master plan

The LEED scorecard provided information concerning the rating system to be utilized, applicable version, and target score. The Owner Project Requirements (OPR) summarized the sustainability goals for the project (LEED-NC 2009, p. 222). The Basis of Design (BOD) and

associated mechanical, electrical and plumbing/fire protection (MEP) drawings described the engineering design criteria required to achieve the sustainability goals (LEED-NC 2009, p. 223). The Commissioning Master Plan documented the measures and practices to be used for the commissioning of the active building systems (LEED-NC 2009, p. 224). Commissioning is a systematic process undertaken to verify that critical building energy systems perform interactively according to the contract documents, design intent and owner intent (LEED-NC 2009, p. 217).

### **Percentages of Buildings Not Achieving LEED Certification**

One hundred twelve case studies were researched. Thirty-five projects or 31% of the total case studies did not achieve LEED certification. Of the projects that did not achieved LEED certification, seven (20%) were placed on hold due to funding; eight (23%) were on hold but have now restarted; ten (29%) are in the beginning stages of development; five (14%) were finished but did not complete LEED certification due to cost; and five (14%) remain open pending completion of all assigned prerequisites, credits, and final action by the LEED review team.

### **Percentages of Buildings Achieving LEED Certification**

Figures 2 through 12 provide the LEED certification results by rating system and by district/state. The levels of LEED certification are certified, silver, gold and platinum. a platinum level project.

### **Design Criteria Significant for Achieving LEED Certification**

Familiarity of project team members with the LEED process was one positive factor that enabled achievement of LEED certification. Two criteria for LEED expertise included experience with past LEED projects and individuals who were LEED Accredited Professionals (LEED APs). The project team for each case study included people serving as:

1. Owner
2. Architect
3. Engineer of record
4. Construction manager
5. Commissioning agent

All LEED platinum and gold projects had LEED APs serving in at least three different team member roles. In addition, all LEED platinum and gold projects were served by three or more people who had previously completed at least five LEED projects.

An additional optional member of the project team was the sustainability consultant who was always a LEED AP. The case studies generally benefited from hiring a specialty sustainability consultant to handle the LEED certification process. A sustainability consultancy firm manages the LEED scorecard, guides team members to help achieve assigned prerequisites, and serves as a champion for the project when it is being evaluated by the LEED review team. Inclusion of a sustainability consultant on the project team, however, did not guarantee gold or platinum level certification.

Early planning for LEED certification was another factor that contributed to the success of achieving LEED certification. Sustainable objectives are often poorly integrated into project requirements (Pulaski, 2005, p. 140). All platinum and gold level projects specifically included LEED certification as a project goal early in the development phase. Early planning resulted in actions that were perceived to be favorable to the LEED certification process. A budget was established for architectural and engineering design optimizations and LEED certification. People who had previous LEED experience were assigned, and training was provided for those who did not have previous LEED experience. Construction activities were planned to ensure adherence to LEED criteria and overall sustainability goals.

Location was another significant factor influencing the level of LEED certification achieved. Eight of the ten platinum level projects and 11 of the 23 gold level projects were located within a city or nearby suburb. Projects located within a city or nearby suburb were more likely to achieve a number of credits such as community connectivity (SSc.2), brownfield redevelopment (SSc.3), alternative transportation (SS4), and regional materials (MRc5). Conversely, three projects located along the Atlantic shoreline had greater difficulty achieving the regional materials credit, as half the circumference of the project boundary extended well into the Atlantic Ocean.

The efficiencies of the mechanical, electrical and plumbing systems designed for controls, lighting, heating and cooling a building along with an improved building envelope also affected the level of LEED certification. These results collaborate the findings of Dahl who argued that the design of the mechanical system is critically important to the sustainability of buildings, and project teams must closely control this aspect of design to deliver a successfully sustainable project (2008, p. 168). Others also have observed that energy management and control systems

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI					
8	6	7	2	1	24
LEED-CS					
10	0	10	8	3	31
LEED-EB					
1	1	2	0	1	5
LEED-NC					
14	5	12	11	5	47
LEED-S					
2	0	1	2	0	5
Totals					
35	12	32	23	10	112
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
31%	11%	29%	20%	9%	69%
Percentages of LEED Certified Projects in Comparison to Total LEED Certified Projects (77) in Study					
---	15%	42%	30%	13%	---

State/District	Total
Arizona	1
Delaware	1
District of Columbia	1
Florida	1
Maryland	0
Massachusetts	0
North Carolina	0
New Jersey	13
Pennsylvania	56
Virginia	4
Total	77

**Figure 2b: LEED Certification Results by State**

**Left: Figure 2a: LEED Certification Results by Level**

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, CS, EB, S					
0	0	0	0	0	0
LEED-NC					
0	0	0	1	0	1
Totals					
0	0	0	1	0	1
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
0%	0%	0%	<1%	<1%	<1%

**Figure 3: LEED Certification, Arizona**

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, CS, EB, S					
0	0	0	0	0	0
LEED-NC					
0	0	0	0	1	1
Totals					
0	0	0	0	1	1
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
0%	0%	0%	0%	<1%	<1%

**Figure 4: LEED Certification, Delaware**

(EMCS) can enhance the performance of building systems so that the highest operational efficiency can be realized (Ardehali, 2009, p. 34).

All platinum and gold level projects utilized sophisticated energy saving strategies such as building automation system (BAS) controls, daylighting and occupancy sensors, energy recovery, geothermal wells, air-side and water-side economizers, demand control ventilation, optimized building morning warm-up/cool down, variable frequency drives and high efficiency motors. One large hospital project case study

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, CS, EB					
0	0	0	0	0	0
LEED-NC					
1	0	0	0	0	1
LEED-S					
2	0	1	0	0	3
Totals					
3	0	1	0	0	4
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
3%	0%	<1%	0%	0%	4%

**Figure 5: LEED Certification, District of Columbia**

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, EB, S					
0	0	0	0	0	0
LEED-CS					
1	0	0	0	0	1
LEED-NC					
0	1	0	0	0	1
Totals					
1	1	0	0	0	2
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
<1%	2%	0%	0%	0%	2%

**Figure 6: LEED Certification, Florida**



Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CS, EB, NC, S					
0	0	0	0	0	0
LEED-CI					
1	0	0	0	0	0
Totals					
1	0	0	0	0	1
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
<1%	0%	0%	0%	0%	<1%

**Figure 7: LEED Certification Results, Maryland**

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, CS, EB, S					
0	0	0	0	0	0
LEED-NC					
1	0	0	0	0	0
Totals					
1	0	0	0	0	1
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
<1%	0%	0%	0%	0%	<1%

**Figure 8: LEED Certification, Massachusetts**

that achieved gold level certification utilized combined heat and power (CHP), otherwise known as cogeneration. Usage of BAS controls concurs with the NSTC recommendation for embedded intelligent controls (2008, p. 18). Two platinum level projects even utilized underfloor airflow distribution (UFAD) and air towers. All platinum and gold level projects included improvements to the building envelope such as increased insulation, selection of higher quality glazing, solar light shelves or deep overhangs, and building orientation. An optimized

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, EB, NC, S					
0	0	0	0	0	0
LEED-CS					
1	0	0	0	0	0
Totals					
1	0	0	0	0	1
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
<1%	0%	0%	0%	0%	<1%

**Figure 9: LEED Certification, North Carolina**

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-EB, S					
0	0	0	0	0	0
LEED-CI					
0	1	1	0	0	2
LEED-CS					
2	0	1	1	0	4
LEED-NC					
6	3	4	2	0	15
Totals					
8	4	6	3	0	21
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
7%	4%	5%	3%	0%	18%

**Figure 10: LEED Certification, New Jersey**

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI					
7	5	6	2	1	21
LEED-CS					
6	0	9	5	3	23
LEED-EB					
1	1	0	0	1	3
LEED-NC					
5	1	8	8	4	26
LEED-S					
0	0	0	2	0	2
Totals					
19	7	23	17	9	75
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
17%	6%	20%	15%	8%	67%

**Figure 11: LEED Certification, Pennsylvania**

building orientation for one gold level project reduced the building's cooling requirements by four tons.

All platinum level projects pursued the green power credit (EAc.6) and purchased renewable energy certificates (RECs) for the development of off-site renewable energy programs such as wind farms. RECs are tradable commodities representing proof that a unit of electricity was generated from a renewable source. Two platinum level projects, one gold level project and three silver level projects installed a photovoltaic (PV) system for generation of on-site renewable energy. Thirty (39%) of the 77 projects achieving LEED certification included the enhanced commissioning credit (EAc.3) for the project goals. All platinum level projects achieved a 30% reduction of water usage or greater (WEc.3).

One project which achieved a platinum level LEED certification has installed a rainwater harvesting system to satisfy the requirements of the innovative wastewaters technology credit (WEc.2). However, the

Unrated	Certified	Silver	Gold	Platinum	Total
LEED-CI, S					
0	0	0	0	0	0
LEED-CS					
0	0	0	2	0	2
LEED-EB					
0	0	2	0	0	2
LEED-NC					
1	0	0	0	0	1
Totals					
1	0	2	2	0	5
Percentages of LEED Certified Projects in Comparison to Total Projects (112) in Study					
<1%	0%	1%	1%	0%	<1%

**Figure 12: LEED Certification, Virginia**

local municipality required the project to install a water meter to track usage of the rainwater harvesting system. The municipality intends to charge the building owner for the harvested non-potable water usage, which would then be discharged to the sewage system, thus reducing cost savings through water use reduction via the rainwater harvesting system.

**Cost Savings for LEED Certification Projects**

Energy cost savings varied greatly among LEED certified projects due to a number of factors. One primary factor is the project’s baseline energy criteria which varied depending on the rating system and version. The baseline building energy criteria for the energy optimization credit (EAc.1) for new construction or major renovations (LEED-CI, LEED-CS, LEED-NC, LEED-S) are based on increasingly vigorous ASHRAE 90.1 standards (1999, 2004 and 2007) distributed throughout the versions of the LEED rating systems and in force when the building was constructed. Appendix G of the ASHRAE 90.1 standard provides a Building Performance Rating Method through which the energy cost

savings is calculated (ASHRAE 90.1, 2010, pp. 209-221). Thus, a LEED project registered with the USGBC before 2004 followed ASHRAE 1999 as a baseline. A LEED registered project before 2007 used ASHRAE 2004 as a baseline. LEED registered projects from 2007 to 2010 followed ASHRAE 2007 as the baseline. An exception is that the LEED-EB rating system measures a building's energy performance using the Energy Star program of the Department of Energy as a baseline.

Whole building energy simulation programs used to determine projected energy savings include Carrier's Hourly Analysis Program (HAP-E20 II), DOE-2/eQuest (eQuest), Trane Trace™ 700 and others (LEED 2009 BD+C, p. 277). These programs are used to analyze input data of energy conservation measures (Sclafani, 2010, p. 19). The appendices provide a sample of input data regarding the building shell and mechanical systems, and the projected building energy savings (over 25%). It is noted that projected and actual building energy savings may vary due to a number of factors such as EMCS hardware and software failures, and human factor problems. Human factor problems include intentional or unintentional control changes, operator unawareness due to inadequate training, and even apathy (Ardehali, 2009, pp. 40-41). Others have found that conducting energy studies and projecting energy savings using energy modeling is an inherently inaccurate methodology (Siedl, 2010, p. 9).

### **Energy Consumption**

The varieties of building size and usage affected energy consumption. For example, a small office space usually consumed energy in a predictable manner following schedules of occupied times and unoccupied periods in which lighting and mechanical equipment were scheduled off or reduced in operating times. In comparison, critical building operations such as hospitals and data centers operate 24 hours a day, seven days a week, so the majority of lighting and mechanical systems are operating all the time, with redundant systems scheduled for lead/lag operation. These buildings also used greater process energy to power computer, medical and other equipment and required specialized cooling and ventilation strategies.

The following gives the Energy Star rating of the ten LEED platinum level projects as determined by the Department of Energy. The listed energy cost savings are proposed, not actual. Except in the case of the LEED-EB project, actual energy cost savings were not measured and

may turn out to be different from the proposed energy savings (NBI, 2008, p. 24).

- Project one (LEED-EB), achieved a rating of 81 (the building's energy performance was better than 81% of similar buildings).
- Project two (LEED-NC)—38.5% (ASHRAE 2004).
- Project three (LEED-NC)—42% (ASHRAE 2004).
- Project four (LEED-CS)—50% (ASHRAE 1999).
- Project five (LEED-NC)—31.5% (ASHRAE 2007).
- Project six (LEED-NC)—35% (ASHRAE 2004).
- Project seven—44.5% (ASHRAE 2007).
- Project eight—42% (ASHRAE 2004).
- Project nine—30.35% (ASHRAE 2007).
- Project ten—26.7% (ASHRAE 2007).

A more tangible determination of cost savings has been gained through the internal costs of commissioning and the positive impact of commissioning for actual energy savings. Completion of successive commissioning projects from 2004 to 2010 has provided a cost reduction between 3% and 5% for similar sized projects. This cost reduction was attained through streamlining the document development process and functional testing criteria. The reduced production cost enables provision of a more competitive fee for commissioning, which in turn transfers cost savings for the project while enhancing a competitive edge when providing bids for LEED commissioning. As previously mentioned, through retro-commissioning, one hospital reduced its annual energy costs by more than 40 percent without compromising thermal comfort, infection control, and reliability (ASHE, 2010, p. 74). Other studies on the cost benefits of building commissioning show that commissioning implementation results in an average annual savings of 15% in energy costs (Shakoorian, 2006, p. 17).

### **Surveys and Interviews**

Thirty surveys were sent out randomly to members of the primary project team of the case studies. The primary project team was comprised of the following people (with the addition of the sustainability consultant as applicable):

1. Owner/owner representative
2. Engineering design team

3. Architect
4. Construction team
5. Commissioning agent

Fifteen of those surveyed responded, and each respondent was subsequently interviewed. Ten respondents were LEED Accredited Professionals (LEED APs) and ten respondents worked on at least five LEED projects. Every respondent acknowledged that sustainable elements were very important. All respondents assumed that energy costs would continue to increase in the future. All respondents considered cost to be a major concern when considering LEED certification. All respondents estimated that LEED projects added two to four percent to the total construction costs of a project.

For the LEED-EB platinum level project, the respondent representing the owner indicated a total cost of \$198,000 to pursue LEED-EB certification and estimated a three-year return on investment (ROI). Twelve respondents reported that the knowledge gained from previous LEED projects enabled them to better contribute to the success of another LEED project. This finding collaborates with Fee's contention that the awareness of LEED guidelines and increased participation with LEED-certified projects can give contractors an edge in the competitive construction industry (2005, p. 15). However, seven respondents agreed that the LEED rating systems had become "radicalized" and no longer a truly representative consensus of sustainability for businesses. Two respondents considered that "raising the bar" through tougher LEED criteria was appropriate. One respondent who was an owner representative for a LEED-S project strongly objected to the minimum acoustical performance (IEQp3) prerequisite, asking, "Have you ever been in a quiet school, especially one with open classrooms?" The owner representative argued that the educational community was most qualified to define suitable teaching environments, not LEED.

Additional interviews were conducted with three members of a project team that incorporated sustainable design strategies but did not pursue LEED certification for a new construction project totaling approximately \$36 million. The sustainable design strategies for this project included improvements to the building envelope, building controls, and optimized electrical and mechanical systems with energy recovery wheels. The three people enthusiastically supported implementation of sustainable design strategies and energy savings, but they did not like

the LEED certification process. LEED certification was perceived to be useful as a guide but excessive and intrusive in implementation. LEED requirements were viewed as unreliable because the basis rested on the consensus of only those active in the USGBC organizations, not the general business community. In summary, one person responded, "Screw LEED. We can build an energy efficient, environmentally friendly building without them." Nonetheless, all three participants were open to pursuing LEED certification for a future project.

One engineer observed that LEED's impact on the built environment has been to foster integration of architectural and engineering design considerations. LEED's impact also motivates building owners to consider energy efficiencies and environmental stewardship as the expected business practice for the building market. For example, an architect and engineer now will discuss the impacts of glazing, insulation, and selection of efficient lighting fixtures in relation to mechanical and electrical systems selection. Also, the predicted energy usage derived through computer energy modeling simulation programs may utilize data that eventually become unrelated to actual energy usage once the building is occupied. This insight collaborates Forrester's observation that some computer models are naïve and are conceptually inconsistent with the nature of actual systems (1995, p. 5).

### **Summary of Results**

Among the 112 projects surveyed for the research, 77 achieved LEED certification. The barriers listed by Hanby (2004) were found to be applicable for the case studies, but in varying degrees. Elements supportive of LEED certification were uncovered. These include qualifications of the primary project team, geographic location, quality of the building envelope, and efficiencies of the mechanical and electrical systems. The research suggests that opportunities exist for the improvement of the LEED certification program. One improvement is that the current rating systems need to become more faithful toward a realistic, consensus-based sustainability that is inclusive of those who are not active in USGBC organizations but who are committed to the overall goals of sustainability. For team members, the opportunities for improvement include:

1. Taking ownership of the greater goals of sustainability.
2. Including team members who know the ways of LEED certification.
3. Providing sustainability training to other project members.



4. Incorporating LEED goals early in the project.
5. Establishing financial stewardship.

## CONCLUSIONS

The basic issue considered for this study was that a low percentage of new buildings attain LEED certification in the United States. However, the results of the research indicated that 69% of the case studies achieved LEED certification. The crucial success factors which facilitated attainment of LEED certification included taking ownership of sustainability, prior LEED project experience, additional training, incorporating LEED goals early and establishing financial stewardship. One opportunity for improvement of LEED certification is for the rating systems to provide more realistic, consensus-based sustainability goals. For some, the attainment of LEED certification by 69% of the case studies represents a very good batting average, but for others, more is never enough given the urgency of global climate change. The trained eye that views America's skylines will see uninspiring buildings that are hemorrhaging our resources (Fedrizzi, 2010, p. 4).

### **Initial Hypotheses**

The hypotheses investigated in this study are as follows:

1. A low percentage of new buildings achieved LEED certification.
2. Some LEED requirements were relatively easy to implement while others were not.
3. The "first costs" of achieving LEED certification is a principal factor when analyzing the financial impact of LEED certification.

The research indicated that the first hypothesis was unfounded but the second hypothesis was substantiated. The third hypothesis was inconclusive since the research indicates that the financial impact of LEED certification is even disputed in court.

Does pursuit of LEED certification make sense as a business model for sustainability? Yes and no—the research suggests that LEED certification is a useful vehicle for sustainability and that the business model which incorporates sustainability goals has become an expected and even mandated norm. LEED has defined tangible, quantifiable sustainability goals for sustainable sites, materials and resources, water

efficiency, energy and atmosphere, indoor environmental quality and innovation. Through these goals the projects were encouraged to redevelop existing habitats and mitigate negative impacts on other habitats. Water usage was reduced, recycling was encouraged, and indoor environmental quality was improved through the usage of low-emitting materials. Indeed, I and others have found that LEED buildings provide open spaces conducive for worker productivity and are refreshingly devoid of the smells of high VOC paints and adhesives as well as new building material typically found in general construction. Elements supportive of the achievement of LEED certification included qualifications of the primary project team, geographic location, quality of the building envelope, and the efficiencies of the mechanical and electrical systems.

LEED, however, is limited, and other vehicles for sustainability exist. Some will argue, perhaps unfairly, that it's not so much that LEED buildings are so good as that other buildings are so bad. There is enough bad building stock out there (Fedrizzi, 2010, p. 4). Others may judge LEED as just another social system for conformance and thus flawed given there are no utopias in social systems (Forrester, 1995, p. 23). In addition, the disparity of proposed and actual energy savings continues to be a sore point regarding LEED requirements and has even been challenged in court. Then there is the rating system itself. For some of those interviewed, disagreements exist between what LEED and others consider as sustainability goals and what is consensus-based and market driven. However, the research suggests that opportunities exist for the improvement of the LEED certification program, which implies that LEED need not be thrown out but renewed, recycled, and reused.

### **Recommendations for Future Research**

Comparisons of the usefulness between the LEED certification program and other sustainability programs need to be investigated. Also, the long-term impact of any sustainability program in regard to energy efficiency, environmental stewardship and even societal acceptance requires further study. Other studies, similar in nature to this research may be conducted to compare the results of this study with future projects and future LEED rating systems. Further study of the financial impact of LEED certification certainly is needed including the relationship between carbon reduction through energy efficiency and cost implications for the emerging carbon market. To further explain,

in a carbon constrained world where one metric ton of carbon dioxide has the same impact on global warming anywhere on the planet, the price for emitting that ton will be closely related to the cost of removing it from the atmosphere or preventing it from being released into the atmosphere in the first place (Tidona, 2009, p. 56). Also, an examination is merited as to the truthfulness of what LEED and other programs consider to be sustainability goals.

Climate change may be mitigated but may not be reversed in the near future. Therefore, the adaptation of the engineering design intent relative to the impact of climate change merits further study. Design objectives and strategies to help adapt to inevitable climate change may address the following criteria: (Wilson, 2009, p. 28):

1. Power outages by incorporating passive survivability.
2. Warmer temperatures by raising the cooling design temperature and incorporating more robust cooling-load avoidance strategies.
3. More intense storms, flooding and rising sea levels by building on higher ground, increasing stormwater capacity, specifying materials that can survive wetting, and more robust structures.
4. Drought by planting drought-resistant plants, using graywater systems and avoiding development of the driest areas.
5. Wildfires by following fire-safe practices and avoiding fire-prone areas which are expanding.

### **Summary**

Considering the urgency of environmental stewardship and the buildings' negative consequences on the environment, it is therefore reasonable that the LEED certification program continue for some time as a vehicle for sustainability. Humanity's survival rests in part on environmental stewardship. Years ago, colleagues in the engineering community often lamented that the opportunities for energy efficiency and environmental stewardship that were learned in school and through experience were thrown away through the practice of "value engineering" that focused only on a building project's first costs. This is no longer the case. Energy efficiency and environmental stewardship are now elements for expected business practice. Theodore Roosevelt observed that the credit belongs to the man who is actually in the arena and who strives valiantly (1910). The LEED certification program has entered

into the arena of sustainability and was found to have 77 successes. If LEED has failed for some, then it at least fails while daring greatly so that its place is not with those timid souls on the sidelines who know neither victory nor defeat.

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#### ABOUT THE AUTHOR

**Dr. Daniel Tisak**, Director of Commissioning and Validation for more than 18 years at Bala Consulting Engineers, King of Prussia, Pennsylvania, is an associate of one of the top 100 engineering firms in the USA and enjoys diverse sustainable design achievements as a LEED™ Accredited Professional (LEED AP), a Certified Building Commissioning Professional (CBCP), a Certified Sustainable Design Professional (CSDP), and an Existing Building Commissioning Professional (EBCP). Dan has served as a subject matter expert for the United States Green Building Council (USGBC) and presented at the 2006 Greenbuild event in Denver. Dan is a member of the Delaware Valley Green Building Council (DVGBC) and has served on its committees for schools and education. Dan also is a member of the Association of Energy Engineers (AEE) and is a member of and has presented for two data center organizations (7 x 24 Exchange and AFCOM) and has been a member for 20 years and presenter for the International Society of Pharmaceutical Engineers (ISPE).

He has completed various commissioning engineering projects globally as well as throughout the United States and Puerto Rico. These include projects for Brazil, Canada, Colombia, Germany, Japan, Kuwait, the People's Republic of China and other countries.

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