# COMPARISON OF A SAMPLE OF GREEN HOSPITALS WITH NON-GREEN HOSPITALS WITH RESPECT TO OPERATING EXPENSES AND PATIENT REVENUE

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## ABSTRACT

*Concerns regarding the environmental impacts of hospitals have made the healthcare sector one of the most prominent settings for the green building movement. Despite these environmental concerns, the number of studies that document the benefits of sustainable healthcare facilities is limited. In this study, the authors used the Medicare and Medicaid cost report data to compare the financial performance of 14 Leadership in Energy and Environmental Design (LEED) certified hospitals against the average performance of non-green facilities. In line with studies conducted in other settings, the authors found that there are low and high performers among green hospitals. For this study, green hospitals had higher facility operating expenses than an average non-green hospital and spent more on plant operations. While green hospitals included in this study generated more revenue, the incomes were not high enough to validate the high operating expenses.*

## KEYWORDS

LEED-certified hospitals, financial performance, hospital cost report, Center for Medicare and Medicaid Services

## INTRODUCTION

According to the Center for American Progress, with $2.8 trillion in annual expenditure, health care has been the largest and fastest growing sector of the economy in the United States (Center for American Progress 2010). Experts suggest that between 2012 and 2016, the United States will spend more than $230 billion on health care construction, achieving a growth rate of 10% by 2016, with construction project costs that could exceed $52 billion per year (Giggard 2012).

Growth of the health care construction sector is in part a response to the need for replacing aging 1970's hospitals with new facilities capable of adopting new medical practices and emerging technologies. Besides the need for modern facilities, new trends such as consumer-driven and patient-centric health care constantly challenge owners and operators of hospitals to improve the quality of care and reduce operational costs.

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As far as operational costs are considered, unique characteristics of hospitals, including 24/7 operations, energy and water consumption intensity, widespread usage of hazardous and toxic materials, strict code regulations, and infection control requirements need to be addressed (Houghton et al. 2009). Leadership in Energy and Environmental Design (LEED), developed by the United States Green Building Council (USGBC), is one of the new approaches for addressing these issues without compromising the satisfaction of patients and their families. With nearly nine billion square feet of building space using this framework, LEED has been the leading program for rating the design, construction and operation of green buildings (Katz 2012).

In general, green buildings are designed to create healthy and productive indoor environments for occupants, and provide long-term financial and ecological benefits by promoting energy, water, and material efficiencies (Kibert 2008). As for financial benefits, several studies from the green building literature demonstrate the benefits of LEED certification. However, these studies often measure a single metric, such as energy efficiency or water conservation, and the number of studies that cover a range of performance indicators is limited. As Fowler et al. (2008) note, to fully measure the operational impact of sustainably designed buildings, other than energy usage, multiple occupant and operational measures need to be considered. Compiling data from a national database that provides industry benchmarks, this study empirically compares a sample of LEED-certified/registered hospitals with non-LEED hospitals of comparable size and location based on financial performance.

## BACKGROUND

Studies show that hospitals have massive ecological impacts. According to the United States Environmental Protection Agency (EPA), in 2003, hospitals made a 9% contribution to the total energy consumption in the Unites States (EIA 2012). As Joseph et al. (2010) note, health care facilities are the second largest source of carbon dioxide pollution in the Unites States. Additionally, hospitals generate about 6,600 tons of waste daily and fall within the top ten consumers of water in the community by using between 40 to 350 gallons per day per capita (Center for American Progress 2010, Practice Greenhealth 2012, U.S. Department of Energy July 2011). Rising concerns regarding the negative environmental impacts of hospitals has made the health care sector a model setting for an escalation of the green building movement. As a result, several organizations are promoting environmental sustainability programs for health facilities. In 1998, Health Care Without Harm (HCWH) launched a program to advance pollution prevention efforts in health care facilities (Practice Greenhealth 2012). In 2004, after two years of collaboration, HCWH and Center for Maximum Potential Building Systems (CMPBS) published Green Guide for Health Care (GGHC) (Center for Maximum Potential Building Systems 2007). Finally, after seven years of close collaboration between GGHC and USGBC, a health care–specific rating system was published by USGBC in 2009.

USGBC provides independent, third-party verifications and certifies projects with Certified, Silver, Gold, or Platinum designation, depending on the number of credits achieved. Project may earn credits from five categories, including sustainable site (SS), water efficiency (WE), energy and atmosphere (EA), materials and resources (MR), and indoor environmental quality (IEQ). Additionally, under the Innovation & Design Process (ID) category, projects can achieve credits for exceptional performance or by showing innovation in design (USGBC 2012). After extensive modifications, USGBC released LEED v2 in March 2000. LEED v3

was released in 2009, consisting of rating systems for different types of buildings, including homes, schools, office buildings, recreational facilities, manufacturing plants, and health care facilities (USGBC 2012e).

The most common rating system in the LEED product suit is LEED for New Construction and Major Renovation (LEED-NC). In addition to new projects, this rating system can be used to certify major modification or renovation of the mechanical system or building structure and envelope. Existing buildings may apply for LEED for Existing Buildings: Operations & Maintenance (LEED-EB: O&M) certification. LEED-Health care was released as a part of LEED v3 product suite and USGBC opened registration of project for health care certification in November 2010 (USGBC 2012b). Before 2010, health care facilities generally used LEED-NC.

The purpose of this paper is to compare the financial performance of a sample of LEED-certified hospitals with the average performance of non-LEED facilities across the United States.

## LITERATURE REVIEW

Green buildings are designed to create healthy and productive indoor environments for occupants and provide long-term financial and ecological benefits by promoting energy, water, and material efficiencies (National Institute of Building Sciences 2003). This section reviews studies that address financial benefits of green buildings provided by energy, water, and material efficiency. The authors conducted a mixed-method systemic review of the literature to identify studies that show a relationship between LEED certification and financial performance of facilities. Comprehensive searches of peer-reviewed publications from the Web of Science, MEDLINE, PsycINFO, ABI/INFORM, PubMED, EBSCO, AGRICOLA, and AGRIS were included in the literature search. Search parameters included the following: health care, healthcare, hospital, patient revenue, revenue, income, facility cost, operation cost, operating cost, operation expense, operating expense, profit, profitability, LEED, USGBC, performance, outcome, energy, water, and savings. The authors supplemented the literature review with a report on benchmarking, surveys, case studies, and systemic reviews conducted in healthcare and on health care settings.

In a comprehensive study of 33 LEED-rated office and school projects, Kats and Alevantis (2003) investigated costs and financial benefits of LEED projects and found that the total financial benefits of green buildings are over ten times the average initial investment required to design and construct them. This study also showed that energy savings alone exceed the average increased cost associated with building green. According to Kats and Alevantis (2003), green building energy savings primarily come from reduced electricity purchases, with secondary benefits from reduced peak energy demand.

In another multi-facility study, Fowler et al. (2008) collected data on the aggregate operational cost of 12 LEED-certified projects owned by the U.S. General Services Administration (GSA). The aggregate operating cost in their study included water utilities, energy utilities, general maintenance, grounds maintenance, waste and recycling, and janitorial costs. Fowler et al. (2008) found that except for three sites, the aggregate operational cost was lower than the comparative industry baseline for office buildings. They also concluded that for the sample of 12 GSA buildings, energy performance and waste costs were better than those of an average baseline building.

Another study that addresses the benefits of LEED certification is the benefit-cost analysis conducted by S. B. W. Consulting Inc. (2003). This analysis evaluated the feasibility of LEED-Silver certification for two municipal facilities, and concluded that LEED-Silver certification requirements yield significant energy efficiency and occupant productivity benefits. The analysis demonstrated that with a discount rate of 5%, the estimated benefit-cost ratios for these two projects were 1.19 and 1.72 when examined for a period of 25 years.

Additionally, in a post-occupancy analysis of 25 LEED projects representing a variety of building activities in Illinois, the USGBC Chicago regional chapter found that as far as annual energy use intensity is considered, many Illinois LEED projects perform better than conventional commercial interiors and buildings (Center for Neighborhood Technology 2009). One key conclusion of this study was that, similar to conventional buildings, there is a wide variation in measured performance among 25 LEED projects included in the study. The study also suggested that to evaluate a building's environmental impacts and efficiency, ongoing measurement and analysis over its lifecycle is critical.

A review of studies on facility performance in health care settings shows that improvement efforts in hospitals mostly focus on energy efficiency. This seems plausible as many energy intensive activities such as medical and lab equipment use, sterilization, computer and server use, laundry, food service, and refrigeration take place in these facilities. A survey conducted by Health Facilities Management (HFM) and American Society of Health Engineers (ASHE) in 2011 indicated that 28% of 691 hospital executives who participated in the study reported that estimated annual energy costs per square foot in their facility is between $3.01 to $4.00 and 21% of respondents reported that it can be as high as $5.01 to $6.00. Only 12% reported less 2.5 $/sq. ft. of annual energy cost. Another survey conducted in 2010-2011 by Corporate Realty, Design & Management Institute and the Healthcare Institute of International Facility Management Association (IFMA) indicated that given a 4% total margin, saving $1 in energy equals $25 in revenue (Whitson and Fischer 2012). Despite the growing awareness toward the green building movement, minimal justification regarding a wide range of benefits that green facilities may offer exists for the health care sector. In one study, Matthiessen et al. (2007) included green ambulatory care facilities in a study of the feasibility and cost impact of sustainable design in different settings. They compared nine LEED-certified ambulatory care hospitals with eight non-LEED ambulatory care projects and found that LEED facilities do not cluster in the upper range of cost per square foot when compared with non-green facilities. Matthiessen et al. (2007) also pointed to the high variation in green buildings costs and concluded that there are low-cost and high-cost green facilities as there are low-cost and high-cost non-green buildings.

As long as overall operational costs are considered, in a study of first-cost premiums in health care, Houghton et al. (2009) concluded that "research suggests that the benefits derived from direct operational cost savings (e.g., energy, water), productivity, and health gains more than offset the modest first-cost premium required to build green health care facilities"(page 23). The authors found a health services organization located in the Northeastern region of the United States as an example for achieving such operational benefits. This organization runs 37 community practice sites, and the USGBC directory of LEED projects indicates that of these 37 facilities, one is LEED-Gold and three are LEED-Silver facilities. In 2010, the Website of this organization reported that its green efforts had resulted in annual savings approaching $5 million.

Besides operational cost savings resulting from energy and water efficiency, LEED certification also provides opportunities for using governmental incentives and tax credits (USGBC, 2012). For example, Yudelson (2005) reports that the Center for Health and Healing, a LEED-Platinum certified project at the Oregon Health and Science University in Portland, received about $1.5 million in incentives and tax credits by implementing energy efficiency, water efficiency, and renewable energy strategies.

In addition to the cost savings discussed above, health care environmental studies suggest that adopting green building solutions, specifically improving the indoor environment, might increase revenues associated with patient care. Sadler et al. (2008) note that the physical environment in which patients are cared for and caregivers work has a measurable and quantifiable impact on them. Additionally, a benefit-cost study by Sadler et al. (2011) shows that there is a business case that supports improvement in the physical environment of health care facilities. This study—among others—demonstrates how the improvement in indoor air quality, reducing noise levels, and providing natural light and views may increase patient revenue by reducing the rate of hospital-acquired infections and medical errors, as well as decreasing patient length of stay. In addition to increase in patient revenue, a number of green building case studies argue that LEED certification also promise branding advantages, as it sends a message that the facility provides patients with high-performance health care surroundings that are environmentally responsive, resource efficient and community sensitive (Swift 2011). As far as non-patient revenue is considered, case studies also suggest that LEED certification plays an important role in increasing philanthropic contributions to the hospital (Robeznieks 2010). Higher patient and philanthropic revenues, as well as receiving incentives and tax credits suggest that LEED hospitals may have greater profitability.

In summary, existing evidence covered in the literature review suggest that implementing green building solutions included in LEED rating systems, such as improving energy efficiency and reducing water consumption will reduce facility operation costs. However, a number of studies exist in the literature where analyses do not support premises regarding the improved performance of LEED facilities, specifically in terms of energy consumption. One of the most comprehensive such studies is conducted by New Building Institute (NBI) for USGBC, in which measured energy performance for 121 LEED-NC buildings certified through 2006 are analyzed to understand the link between intention and outcome for LEED projects. The study found that 15% of facilities used more energy per square foot than at least 70 percent of comparable buildings and one-quarter of the buildings certified demonstrated energy performance that was below the national average (Truner and Frankel, 2008). Moreover, as Murphy (2009) states, LEED programs have received criticism because of the lack of life cycle analysis and actual performance requirements. Furthermore, the entire process relies entirely on paperwork with no actual inspection of the facility. Certification requirements have received criticism because they are based entirely on design and do not take into account how the building will be used and operated (Murphy 2009). Finally, the survey conducted by Corporate Realty, Design & Management Institute and the Healthcare Institute of IFMA suggested that owners and builders are skeptical of certificate programs for healthcare facilities. About 70% of 1,251 participants indicated appointing a sustainability manager is the most important step in retooling a hospital for sustainability and would produce better results than creating a committee or relying on participation in Energy Star or LEED (Whitson and Fischer 2012). Note that according to USGBC, LEED v4 will improve previous versions by

incorporating new credit categories focusing on integrated design, life cycle analysis of materials, and an increased emphasis on measurement and performance (USGBC 2012d).

To better understand financial benefits of achieving LEED certification, this study will empirically compare a sample of LEED hospitals with the average performance of non-LEED hospitals at national and state levels. In comparison with using *internal metrics* for tracking improvements in performance of a single LEED facility over time, access to a large, national database of facilities can help determine improvement levels relative to industry norms. Moreover, identifying high and low performers within the sample of LEED hospitals and discussing their performance provide additional opportunities to investigate how those organizations achieved, or failed to achieve, their performance level. However, this study does not attempt to evaluate the LEED certification program or generalize the impact of LEED certification on financial performance of hospitals. This study is one of the few efforts of its kind conducted in healthcare settings, and is intended as a starting point for future studies. Directions for future research are provided in the conclusion section where applicable limitations of the study are discussed.

## METHODOLOGY

This study compared the financial performance of a sample of LEED hospitals with the average performance of a large group of non-LEED hospitals. The comparison was based on the following financial indicators:

1. Annual operation of plant costs ($/sq. ft.)
2. Annual inpatient revenue ($/bed)
3. Annual plant cost ratio

Equation 1 was used to calculate *plant cost ratio* (i.e., the percentage of total operating expenses that go toward running the plant):

$$\text{Plant Cost Ratio} = \frac{\text{Operation of Plant (\$)}}{\text{Total Operating Expenses (\$)}} \times 100 \quad (1)$$

Moreover, in the analysis of worst and best performers in the sample of LEED hospitals, the authors also included a *profitability index* (i.e., money earned per each dollar spent), to understand whether owning and running a LEED-certified facility contributes to the overall financial well-being of the organization. *Profitability index* was calculated using Equation 2:

$$\text{Profitability Index} = \frac{\text{Total Inpatient Revenues (\$)} + \text{Total Outpatient Revenues (\$)}}{\text{Total Operating Expenses (\$)}} \quad (2)$$

Evaluating the financial performance of LEED hospitals in this study focused mainly on patient revenues and plant operation costs. The other two indicators, as well as total operating expenses ($/sq. ft.), were used to support further discussions regarding the best and worst performers among LEED hospitals included in this study. Because philanthropic gifts are independent of services that a hospital provides, they were not included in the calculation of the *profitability index*.

In line with recommendations made by Shoemaker (2009) and Cimasi (2008) regarding characteristics of evaluation metrics in health care studies, the authors used the indicators listed above as they are broad based (i.e., applicable to diverse situations) and require minimal

manipulation or normalization. Moreover, previous studies, such as the report by the International Facility Management Association (IFMA) on operations and maintenance benchmarks for health care facilities published in 2010, used annual cost and revenue to account for cyclical changes in health care demand and occupancy rate over a year. It is also common to perform the comparison and present the results in different levels. For example, Kahn (2009) notes it is important to include as many projects from diverse regions as possible to provide more statistically significant data and then apply finer filtering and more accurate comparisons. The authors performed three levels of analysis as follows:

- Level-One Analysis: Comparison of each LEED facility with the national average regardless of type, size, and location of the facility.
- Level-Two Analysis: Comparison of each LEED facility with the national and state average of same type facilities.
- Level-Three Analysis: Comparison of each LEED facility with facilities of the same type and size at national and state level.

Note that level two accounts for differences in types of services and regional variations caused by factors such as facility type, location, climatic conditions, governmental regulations, and union strength (Kahn, 2009). Additionally, level-three analysis accounts for economies of scale. Bed number and square footage were used to determine the comparison group for level-three analysis. For example, one of the LEED hospitals in this study was a 238,764 square-foot facility in Tennessee with 91 beds. The comparison group for this facility includes acute care facilities with square footages between 180,000 and 300,000 and bed numbers between 70 and 110. 185 acute care facilities across the United States and five facilities in Tennessee met these inclusion criteria.

## *Data*

Two different sources of data to perform the comparison explained above were used. All the data utilized in this study was obtained from publicly available sources.

### *Financial Records*

Financial data for this study was collected from the website of the Centers for Medicare & Medicaid Services (CMS). CMS has an online platform for keeping records of Medicare and Medicaid costs reported to the Health Care Cost Report Information System (HCRIS). In this information system data files containing a breakdown of general service costs and patient revenues, as well as facility information, such as bed numbers and square footage of the facility are stored. Each type of provider is required to complete a certain cost report form consisting of a collection of several worksheets. All hospital-based sub providers use the form CMS-2552-96 referred to as Hospitals and Health Care Complexes.

Hospitals complete cost report forms annually according to their individual reporting years. CMS updates the HCRIS database quarterly. The Medicare and Medicaid cost report is the primary means for the federal government to monitor hospital costs, and CMS makes a reasonable effort to ensure that data available through HCRIS are accurate, complete, and comprehensive. Cost report data for more than 6,000 hospitals are stored in three separate files and can be downloaded in a relational database format (CMS 2012). These three data files need to be linked together to extract cost report line items, referred to as cost accounts, or variables of interest. Table 1 shows cost accounts used in this study and the corresponding worksheets in CMS-2552-96 form.

**TABLE 1.** Cost accounts used in this study and the corresponding worksheets.

| Cost Report Item | Location in Form CMS-2552-96 |
|---|---|
| Inpatient Revenue | Worksheet G-2, part I, line 25, Column 1 |
| Outpatient Revenue | Worksheet G-2, part I, line 25, Column 2 |
| Total Operating Expense | Worksheet G-2, Part II, line 40 |
| Operation of Plant (Salaries) and (Other) | Worksheet A, line 8, Columns 1 and 2 |
| Inpatient Beds | Worksheet S-3, line12, Part 1, Column 1 |
| Square Footage of the Facility | Worksheet B-1, Line 8, Column 8 |



More information about line items included in each cost account may be found in Chapters 12 and 36 of The Provider Reimbursement Manual 15-2, published by CMS (CMS 2012). As far as *operation of plant* is considered, this cost center contains the direct expenses incurred in the operation of the plant (i.e., electrical services, HVAC services, plumbing services, power plant operation) and equipment, maintaining general cleanliness and plant sanitation, protecting employees, visitors, and properties. The care or cleaning of the interior physical plant, including the floors, walls, ceilings, partitions, windows, fixtures and furnishings, and emptying of trash containers is also included in this cost center. Maintenance of grounds such as landscape and paved areas, streets on the property, sidewalk, fencing, external recreation areas and parking facilities are part of this cost center as well. Costs of similar services purchased from an outside organization are included in this cost center.

Hospitals with the fiscal year start date of August 1, 2009, and end date of September 30, 2010, were analyzed. Financial records for 3,522 hospitals were available in the CMS database. All variables were approximately normally distributed. The authors used the data labeling rule (Hoaglin and Iglewicz 1987; Hoaglin et al. 1986) to identify and remove outliers. To calculate total costs associated with the *operation of plant*, the line items "other" and "salaries" were summed, and only included the hospitals that reported both costs. This resulted in 2,357 useable plant operation records.

### *Green Building Data*

The list of LEED-certified projects extracted from the USGBC LEED project directory (USGBC 2012c), included 13,873 projects which were listed in the directory as of August 8, 2012, 208 of which were identified as health care facilities. Of these 208 LEED projects, six received Platinum designation, 62 achieved Gold designation, 75 received Silver designation, and 65 held the Certified status. The average number of LEED credits achieved by these 208 facilities is 34.57 with a standard deviation of 7.05 points. Among these 208 projects, 170 have LEED-NC certification.

The authors used the project title and address provided in the LEED directory to find common records between the CMS database and LEED directory of certified projects. 40 projects in the LEED directory were labeled as confidential and were automatically removed as the project title and address were not available. 53 LEED projects were found in the CMS database. The authors verified the project titles and addresses to make sure hospitals' names and addresses are similar in the two databases. After verifying addresses and titles, the authors found that only 15 out of 53 projects had LEED certification for the whole facility and decided to limit the analysis to these 15 sites. One LEED site was removed later, because the

square footage reported in the CMS database did not match with the square footage shown in the LEED directory. Accordingly, the final sample size of LEED projects for this study was14. These 14 sites had identical Provider ID, name, and address in the two databases. Table 2 summarizes type, location, size, and LEED certification information for each facility.

Table 3 shows the credits achieved by each project with direct or indirect impacts on energy and water efficiency. Maximizing open space may increase the cost of landscaping while it moderates the heat island effect (Los Alamos National Laboratory 2002). Reducing the heat island effect decreases air conditioning loads and peak power demand. Increasing energy efficiency and decreasing water consumption reduces water and electricity bills (EPA 2000, EPA 2008). Likewise, introduction of daylight into regularly occupied spaces will further reduce power demand from electric lights (Deru et al. 2005; National Renewable Energy Laboratory 2002). On the other hand, increased mechanical ventilation may raise energy consumption (EPA 2001). Lastly, commissioning before the operation phase ensures that design objectives and performance targets are met (National Institute of Building Sciences 2012), while measurement and verification during operation ensures timely detection of deficiencies in building systems (Los Alamos National Laboratory 2002).

Note that cost report data obtained from the CMS database cannot be associated with a specific design feature. Accordingly, it is not possible to investigate the true relationship between LEED credits and facility performance. However, as Cimasi (2008) notes, comparative studies commonly follow identification of nonstandard performance and anomalies by further evaluations to determine the underlying causes of these anomalies. Accordingly, the authors used the information provided in Table 2 and performed further analysis to discover possible underlying relationships between LEED green building solutions and the performance of LEED hospitals.

Also note that Site 1 has achieved LEED for Existing Buildings (LEED-EB) certification and Site 11 has achieved LEED for Core and Shell Certification. LEED certification type (New versus Existing Building) mostly impacts credits in the "Materials & Resources" category, that addresses the construction phase and does not impact facility performance. However, these two types of certification are similar to LEED for New Construction (LEED-NC) in terms of credits included in categories shown in Table 3 and they both require the same levels of performance for a project to achieve the available points. For example, Site 1 received a LEED-EB certification and achieved credits for energy efficiency of 25% above the national average, 30% reduction in water consumption, and 50% reduction in water efficient landscaping. Similarly, Site 3 that received a LEED-NC certification achieved credits for energy efficiency of 20% above the national average, 30% reduction in water consumption, and 50% reduction in water efficient landscaping. Because performance levels (e.g., levels of energy efficiency) are used to compare LEED facilities in this study, certification type did not impact the results of the comparison. Accordingly, the authors decided to include these two sites in the sample of LEED projects as the analysis focuses on the level of performance achieved by LEED-facilities.

Another important confounding factor in comparing the performance of different hospitals is the discrepancy in the age of facilities. One may argue that the effectiveness of the facility operation and maintenance programs increase over time, and only facilities with similar ages should be compared with each other. Unfortunately, there is no way for verifying the age of healthcare facilities constituting the national and state samples in this study, and the authors acknowledge that as one of the limitations of this study. However, note that

**TABLE 2.** Background information about LEED hospitals of the study

| Site Number | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Acute Care | OH | 451 | 901,000 | Certified | Existing Buildings | 34 | 3 | 2010 |
| 2 | Acute Care | MI | 208 | 69,224 | Certified | New Construction v2.1 | 26 | 9 | 2008 |
| 3 | Acute Care | CO | 171 | 153,773 | Silver | New Construction v2.0 | 33 | 10 | 2003 |
| 4 | Acute Care | CA | 805 | 508,414 | Silver | New Constructionv2.1 | 31 | 2 | 2010 |
| 5 | Acute Care | OR | 40 | 176,000 | Gold | New Construction v2.1 | 39 | 9 | 2006 |
| 6 | Acute Care | VA | 238 | 680,000 | Gold | New Construction v2.1 | 38 | 11 | 2010 |
| 7 | Acute Care | TN | 91 | 238,764 | Silver | New Construction v2.2 | 37 | 12 | 2010 |
| 8 | Acute Care | PA | 845 | 327,605 | Certified | New Construction v2.2 | 30 | 12 | 2008 |
| 9 | Acute Care | CO | 136 | 570,400 | Gold | New Construction v2.2 | 39 | 13 | 2009 |
| 10 | Acute Care | OK | 15 | 95,636 | Gold | New Construction v2.2 | 41 | 7 | 2009 |
| 11 | Children's | MN | 202 | 160,500 | Gold | Core and Shell v2.0 | 35 | 7 | 2010 |
| 12 | Children's | CA | 272 | 272,274 | Certified | New Construction v2.1 | 27 | 10 | 2011 |
| 13 | Children's | TX | 167 | 473,000 | Platinum | New Construction v2.1 | 52 | 11 | 2009 |
| 14 | Psychiatric | WI | 100 | 100,491 | Gold | New Construction v2.2 | 43 | 12 | 2010 |

Columns headings are as follows: (1) Type of Facility; (2) State; (3) Number of Beds; (4) Square Footage; (5) Certification level; (6) Certification Type; (7) Total LEED Credits Achieved; (8) Number of Credits Achieved for Indoor Environmental Quality Year Certification Achieved

**TABLE 3.** LEED credits with direct and indirect influence on operational costs achieved by each site.

| | SS | | | WE | | | EA | | IEQ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
| Site 1 | ✓ | ✓ | ✓ | 30% | 50% | - | 25% | - | - | - |
| Site 2 | - | ✓ | ✓ | - | 50% | - | - | ✓ | - | - |
| Site 3 | - | - | ✓ | - | 50% | - | 30% | ✓ | - | ✓ |
| Site 4 | - | - | ✓ | - | - | - | 30% | - | 90% | ✓ |
| Site 5 | - | - | ✓ | 30% | 50% | ✓ | 20% | ✓ | - | - |
| Site 6 | - | - | ✓ | 30% | - | - | 55% | ✓ | - | ✓ |
| Site 7 | ✓ | - | ✓ | 30% | 50% | - | 14% | ✓ | - | ✓ |
| Site 8 | - | - | ✓ | - | 50% | ✓ | - | ✓ | 75% | ✓ |
| Site 9 | ✓ | - | - | 30% | 50% | - | 14% | ✓ | 90% | ✓ |
| Site 10 | ✓ | ✓ | ✓ | 20% | 50% | - | 17.5% | - | - | - |
| Site 11 | ✓ | - | - | 30% | 50% | - | 17.5% | ✓ | - | ✓ |
| Site 12 | - | ✓ | ✓ | - | 50% | - | 20% | ✓ | - | - |
| Site 13 | - | ✓ | ✓ | 30% | 50% | ✓ | 60% | ✓ | 75% | - |
| Site 14 | ✓ | - | - | 30% | 50% | ✓ | 28% | ✓ | - | ✓ |

Columns headings are as follows: (1) Protect Or Restore Open Space; (2) Heat Island Effect Roof; (3) Heat Island Effect Non-Roof; (4) Indoor Water Consumption; (5) Landscaping Water Consumption; (6) Measurement and Verification; (7) Energy Efficiency; (8) Advanced Commissioning; (9) Daylight and View; (10) Increased Ventilation

hospitals normally have several buildings of various ages on their campus and older buildings might have newer HVAC systems. This becomes even more complicated, as previous studies have shown that the facility performance declines as the building ages, and then picks up as the buildings are renovated. Accordingly, with regards to the large sample size at the national and state levels, the authors believe that this limitation does not invalidate the findings of this study.

All financial data was normalized to make a reasonable comparison between LEED and non-LEED facilities. The square footage of the facility was used for normalizing cost data (i.e., *operation of plant*) and number of inpatient beds was used for normalizing inpatient revenues. Additionally, to compare the performance of LEED facilities with the average performance of non-LEED facilities at the state and national levels, the performance difference in percentage using Equation 3 was calculated:

$$\text{Percentage Difference} = \frac{\text{value for the LEED facility–national (state) average}}{\text{national (state)average} \times 100} \quad (3)$$

Equation 3 is used for all financial indicators except for plant cost ratio, for which the absolute difference was employed.

As noted in Matthiessen et al. (2007), because of the large variations in building characteristics, comparing average cost per square foot between two groups does not provide any meaningful data for the assessment of any individual facility. Accordingly, to understand

where LEED facilities stand in comparison with non-LEED facilities, the percentile rank of facilities using Equation 4 was calculated:

$$\text{Percentile Rank} = \frac{\text{number of cases with the same or lower value}}{\text{total number of records}} \times 100 \qquad (4)$$

For example, Site 3 had *inpatient revenue* per bed of $1,926,958, which was higher than *inpatient revenue* of 1,627 out of 1,961 short-term acute care facilities across the United States. Using Equation 4, the national percentile rank of Site 3 on this indicator was 82.96. For cost indicators, a low percentile rank indicated a good performance, while for revenue and profitability indicators, a high percentile rank was preferred. As stated previously, the financial indicators explained above were used to perform three levels of analysis. Results of the analysis are available in Appendices I and II. Blank cells in the tables indicate missing values for LEED facilities. Because of missing values for non-LEED facilities, the sample size of the comparison group is different across indicators as well. For instance, for Site 7 the comparison group for *profitability index* had 177 hospitals, while the comparison group for *operation of plant* had a sample size of 133. Also, some of the cost values reported for LEED hospitals were identified as outliers. The authors decided to use these outliers in the analysis as they provide valuable information regarding the performance of LEED facilities.

## RESULTS

Figure 1 shows the result of level-one analysis, which is the comparison of LEED projects with the national average. It also shows the comparison of LEED facilities with one another.

**FIGURE 1.** Comparison of financial performance of LEED facilities with national average.

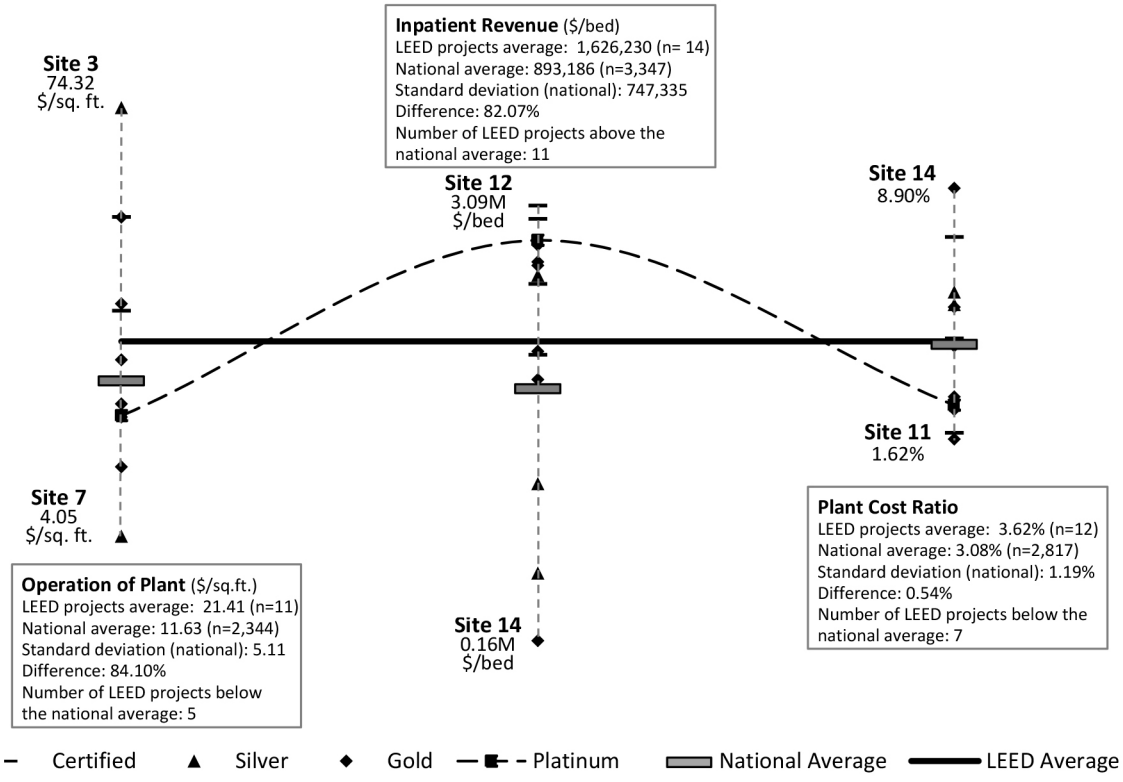


Figure 1 shows that on average, the sample of 14 LEED facilities spent about 84% more on *operation of plant* compared with an average non-LEED facility. While *operation of plant* expenses were higher in the sample of 14 LEED facilities, average *inpatient revenue* per bed was also 82% higher than the national average, and 11 out of 14 LEED projects stood above the national average on this indicator. However, incomes generated by LEED hospitals of this study were not high enough to compensate higher operating costs. Figure 1 also shows that on average, the percentage of total operating expenditures going to running the facility (i.e., plant cost ratio) was slightly higher in the sample of 14 LEED facilities.

To compare the financial performance of LEED projects with non-LEED projects, three levels of analysis were performed. Appendix I and Appendix II show the detailed results of the second and third levels of analysis. The results of the level-three analysis, where the performance of LEED projects with non-LEED facilities of the same type and size are compared and discussed below.

### *Operation of Plant*

Figure 2 compares the performance of each LEED facility in relation to the average performance of non-LEED facilities of the same type and size at national and state levels.

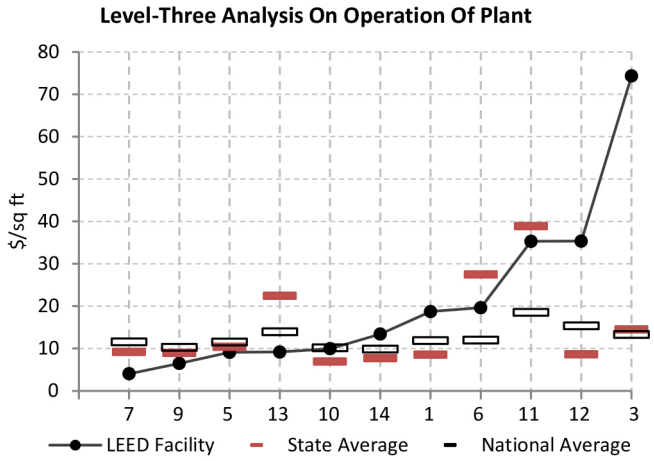


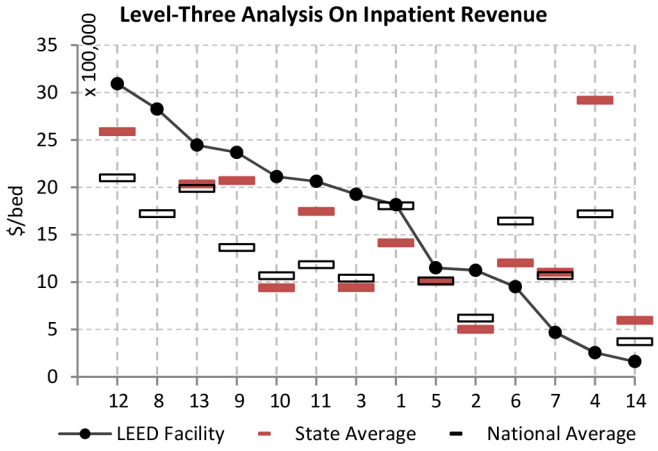

**FIGURE 2.** Comparison of LEED facilities with national and state average of plant operation cost in non-LEED facilities of the same type and size. Horizontal axis represents LEED facilities ordered from lowest to highest values.

Figure 2 shows that among the facilities of the same type and size, six out of 11 LEED projects had plant operation cost lower than the corresponding state average. The largest positive difference was 413.33% (Site 3), and the largest negative difference was -56.01% (Site 7). Additionally, five out of 11 LEED projects stood below the national average. The largest positive difference was 459.64% (Site 3), and the largest negative difference was -64.92% (Site 7). Although the level-three analysis shows more than half of the hospitals included in the sample of LEED facilities performed better than their corresponding state averages, Figure 2 shows that positive cost differences (i.e., where LEED hospitals performs better) were small, while negative cost differences (i.e., where LEED hospitals performs worse) were large.

### *Inpatient Revenue*

Figure 3 compares the performance of each LEED facility with national and state averages of non-LEED facilities of the same type and size.

**FIGURE 3.** Comparison of LEED facilities with national and state averages of inpatient revenue in non-LEED facilities of the same type and size. Horizontal axis represents LEED facilities ordered from highest to lowest values.




As Figure 3 shows, nine out of 13 LEED projects had higher *inpatient revenue* than the corresponding state average (there is no comparable facility for Site 8 in Pennsylvania). The largest positive difference was 125.34% (Site 10), and the largest negative difference was -91.25% (Site 4). Additionally, 10 out of 14 LEED projects had higher *inpatient revenue* than the national average. The largest positive difference was 98.27% (Site 10), and the largest negative difference was -85.14% (Site 4). In summary, similar to the level-one analysis, results of level-three analysis were also in favor of LEED facilities identified in this study.

### *Plant Cost Ratio*

Figure 4 shows the performance of each LEED facility in comparison with national and state averages of non-LEED facilities of the same type and size.

**FIGURE 4.** Comparison of LEED facilities with national and state averages of plant cost ratio in non-LEED facilities of the same type and size. Horizontal axis represents LEED facilities ordered from lowest to highest values.

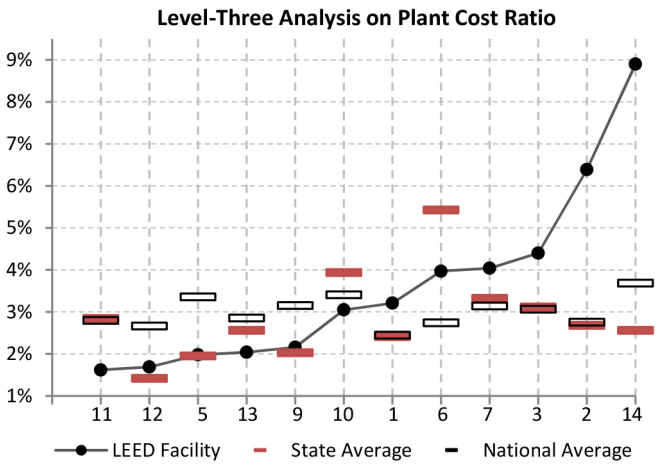



Figure 4 shows that five out of 12 LEED projects had *plant cost ratio* lower than the corresponding state average. The largest absolute positive difference was 6.34% (Site 14), and the largest absolute negative difference was -1.45% (Site 6). Additionally, six out of 12 LEED projects stood below the national average. The largest positive difference was 5.22% (Site 14), and the largest negative difference was -1.37% (Site 5).

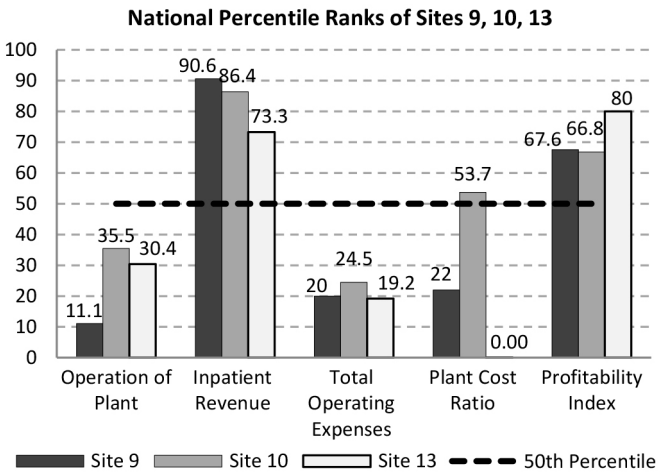



**FIGURE 5.** National percentile ranks of Sites 9, 10, and 13 on each financial indicator. Site 9 and Site 11 have a better performance than at least 50% of non-LEED facilities of the same type on all financial indicators. However, because the distribution associated with plant cost ratio is slightly positively skewed, Site 10 stands in the 53.7th percentile. The values in parentheses represent ranking of each site among LEED facilities.

As far as the performance of individual projects is considered, Sites 9, 10, and 13 had better performance on all indicators compared with the average performance of non-LEED facilities across the nation. Sites 9 and 10 are acute care facilities and have achieved Gold certification. Site 13 is a children's hospital and has a Platinum certification. Level-two analysis, shown in Appendix I, indicated that these three sites also had a better performance on all indicators when compared with non-LEED facilities of the same type. Figure 5 shows national percentile ranks of Sites 9, 10, and 13 among non-LEED facilities of the same type. Discussions regarding these three sites, as well as the results of the analyses presented in this section are presented next. The discussion follows the same order presented in the previous section.

## DISCUSSION

Comparing LEED facilities with the average performance of non-LEED facilities shown in Figure 1 did not suggest that LEED hospitals in this study have better financial performance. The sample of LEED hospitals in this study had higher *inpatient revenue*, but it came with the cost of higher operating expenses. Operating expenses can be higher because healthcare providers may decide to place their operationally intensive medical devices and other operations in their LEED facility. On the other hand, providers generally charge more for services involving use of operationally intensive medical devices and operations. Accordingly, one could argue that the *profitability index* should be higher in LEED facilities as well. However, this was not the case for the sample of LEED hospitals in this study (only three projects had *profitability index* higher than their corresponding state average). Note that level-two and level-three analyses, where facility type, size, and location were considered, indicated results similar to level-one analysis. For example, Appendix I showed Site 12 had the highest *inpatient revenue* among LEED facilities, but because its *operation of plant* costs were 179% higher than the national average, it had a low *profitability index*. In summary, the analysis did not find that LEED certification guaranties superior financial performance in the 14 LEED facilities included in this study.

This finding should be interpreted with caution, because this study only documents the financial performance of hospitals for a period of one year and the sample size is small. To accurately evaluate the impact of LEED certification, multiple years of data should be

analyzed to track changes in the facility performance. Furthermore the literature on high-performance facilities suggests that every building is unique in its use and occupancy. Even at the individual facility level, occupancy rate may vary from time to time (Center for Neighborhood Technology 2009).

### *Comparison Based on Certification Level*

As far as different certification levels are considered, Figure 1 shows that the highest and lowest *operation of plant* costs belonged to two LEED-Silver facilities. Additionally, a LEED-Certified facility had the highest revenue. The highest and lowest *plant cost ratios* belonged to LEED-Gold projects. Moreover, a LEED-Gold site had the lowest *profitability index*, while the highest *profitability index* was achieved by a LEED-Silver facility. Figure 1 also indicates that Site 13, the Platinum-certified facility, was not the best performer on any of the three performance indicators. In summary, comparison of the LEED facilities associated with this study did not provide any evidence to support the premise that LEED facilities perform better with higher certification levels. This is in line with the findings of the study by Menassa et al. (2012), where they concluded energy savings were not closely related to the number of points received in the Energy and Atmosphere section of the LEED certification process. However, this finding should be interpreted with caution. A report by the David and Lucille Packard Foundation (2002) argues that with each increasing levels of LEED certification, estimated short-term costs increase while estimated long-term costs decrease dramatically. All LEED hospitals included in this study, except for Sites 3 and 5, are new and multiple years of data is needed to analyze changes in long term costs.

### *Comparison Based on Inpatient Revenue*

The level-three analysis shown in Figure 3 indicated that most of the LEED hospitals of this study had higher patient revenue compared with non-LEED facilities of same size and type in their state. This is in line with the evidence provided in health care environmental studies discussed in the review of literate. However, the relationship between patient revenue and the number of LEED credits achieved by each hospital under indoor environmental quality category is not strong. As Table 2 shows, Site 12 with the highest *inpatient revenue* has achieved 10 credits, while Site 14 with the lowest *inpatient revenue* has achieved 12 credits. It should be noted that the patient revenue of a hospital depends on several other factors independent of green building features. For example, hospitals provide different types of medical procedures and medical tests. They might also have different charges for the services they provide. Note that to account for variability in patient services, level-two and level-three analyses only included hospitals of the same type located in the same state. However, the authors believe there is still variability in types of services provided by hospitals, specifically within acute care facilities.

### *Comparison Based on Operation of Plant costs*

LEED hospitals in this study had higher *operation of plant* costs. The authors believe higher costs associated with operating the plant in the sample of LEED hospitals might not be directly related to obtaining LEED certification. As mentioned before, in addition to cost items directly influenced by green building features, such as the operation of HVAC and plumbing systems, CMS includes a wide range of other cost items, including facility cleanliness or safety of people and facilities, which are not covered by the LEED rating system. For

example, hospitals might use different methods for cleaning and disinfection of patient rooms with different levels of complexity and cost effectiveness.

Additionally, employees' salaries are also included in this cost accounts, causing additional variation not accounted for by building features. For example, a hospital might have a lower number of Full Time Equivalents (FTE) involved in the operation of facility; however, because of higher payment rates labor costs might be higher than those of a similar facility with the same number of FTEs. A study conducted by International Facility Management Association and American Society for Healthcare Engineering (2010) found that labor is the major component of plant operation cost and any change in salaries can affect the overall cost of plant operation significantly. In summary, the authors believe that despite the higher operation of plant cost in the sample of LEED project, because of the small sample size and other limitations explained above, higher operating costs are not necessarily associated with LEED features.

### *Facility-Level Comparison within LEED Projects*

Level-three analysis presented in Figure 3 through Figure 5 suggests that a good performance on one indicator does not necessarily mean a good performance on other indicators. While Sites 9, 10, and 13 stood above the national average across all financial indicators, rankings of these three sites among other LEED facilities, shown in Figure 8, indicate that these sites are not among the best performers on any financial indicator.

Moreover, a comparison of Sites 9, 10, and 13 shows that achieving more credits does not guaranty the better financial performance of a facility. Table 2 shows that Site 9 had the lowest total number of credits among these three sites. Additionally, improvement of energy efficiency in Site 9 is 14%, which is the lowest improvement among LEED projects of this study. Moreover, no effort is implemented to reduce the heat island effect in Site 9. Despite these factors, Site 9 had lower *operation of plant* costs, lower total operating expenses, and higher *inpatient revenue* than Site 10 and Site 13.

Comparing Site 9 with other Gold-certified acute care facilities (i.e., Sites 5, 6, and 10), also shows the superior performance of this facility. Appendix I (level-two analysis) indicates that compared with the other Gold-certified hospitals, Site 9 had a better performance on *operation of plant* cost, *inpatient revenue*, total operating expenses, and *profitability index*. Only Site 5 had a slightly better performance on *plant cost ratio*. Once again, Sites 5, 6, and 10 all had higher energy efficiency than Site 9 and have achieved the same level of indoor water savings. In summary, comparing Site 9 with other LEED hospitals of this study indicated a facility does not necessarily need to be designed to obtain more LEED credits to achieve a higher building performance.

### *Worst Performers within LEED Projects*

Figure 1 shows that among the sample of 14 LEED projects, Site 14 was the worst performer on *inpatient revenue*, *plant cost ratio*, and *profitability index*. Appendix II (level-three analysis) indicates that Site 14 also had a poor financial performance compared with non-LEED facilities of the same type and size. This comparison can be summarized as follows:

- Site 14 had the highest *plant cost ratio* compared with 19 non-LEED psychiatric facilities of similar size across the United States.
- As far as *operation of plant* cost is considered, Site 14 stood on the 89.5th percentile among non-LEED facilities of the same size in the United States.

- As Appendix II (level-three analysis) shows, there was one non-LEED psychiatric hospital of similar size in Wisconsin (Site 14 is 100,491 sq. ft. and has 100 beds and the non-LEED facility is a 105,142 square foot psychiatric hospital with 68 beds). CMS data show that Site 14 spent 73.96% more on plant operation.
- Conversely, Appendix II (level-three analysis) indicates that despite high operation of plant cost, with national percentile rank of 8.7, Site 14 had a notable performance in lowering *total operating expenses*.

Small total operating expense and high *plant cost ratio* suggest that a great opportunity existed for Site 14 to increase the *profitability index* by cutting *operation of plant* costs. However, CMS data for the fiscal year of 2009-2010 suggest that this cost saving was not accomplished despite achieving Gold certification. As Table 3 shows, several LEED credits with potentially high influence on operating costs were implemented in Site 14. For example, Site 14 had an increased energy efficiency of up to 28% and achieved reduction in indoor and landscaping water consumption by 30% and 50% respectively. Advanced commissioning was performed on this site as well to verify that the building's systems operate as intended. Despite implementing green building solutions explained above, Site 14 had the smallest *profitability index* among 19 non-LEED psychiatric hospitals of similar size in the United States.

Other than the LEED projects discussed above, Figure 1 shows that Site 3 had the highest *operation of plant* costs among LEED projects. Appendix II (level-three analysis) shows that Site 3 also had the highest *operation of plant* cost compared with non-LEED acute care facilities of the same size in the United States. As far as *plant cost ratio* is considered, 4.4% of total operating expenses for Site 3 go to the operation of plant. Appendix II (level-three analysis) shows that 4.4% *plant cost ratio* of Site 3 was higher than *plant cost ratio* of the other four non-LEED acute care facilities of similar size in Colorado, and higher than 90.2% of 143 non-LEED acute care facilities of similar size in the nation. High *plant operating* costs and large *plant cost ratio* suggest that costs associated with running the plant play a major role in increasing total operating expenses for Site 3. In other words, there was a great opportunity for Site 3 to reduce the total operating expenses and improve its profitability by cutting facility costs. Once again, CMS data for the fiscal year of 2009-2010 suggest that this has not been achieved for Site 3 and *plant operating* costs for this site were 513% higher than the national average. This is despite the fact that by achieving energy efficiency of 30% and performing advanced commissioning, *plant operating* costs for Site 3 should be lower than the national average. Note as an example that Sites 7 and 9 had energy efficiency of 14%, and as Appendix I (Level-two analysis) shows, operation of plant cost in these two sites were 66.61% and 46.48% lower than the national average respectively. In summary, similar to Site 14, despite achieving LEED certification, Site 3 had high *plant cost ratios* which adversely affected its profitability.

The limitations discussed in previous sections also apply to the discussions regarding financial performance of Site 3 and Site 14. For example, high *operation of plant* costs reported for these two facilities can be associated with other cost items included in this cost center. Additionally, another important consideration is that as Torcellini et al. (2006) and Lawrence Berkeley National Laboratory (2006) note, energy modeling used for LEED certification is performed during the design phase and it does not always accurately predict actual performance of a facility during the operation phase. Actual post-occupancy energy usage data are needed to verify the actual energy efficiency achieved by Site 14 and Site 3. Also, the data obtained from the CMS website are not associated with any specific design feature.

Accordingly, the authors are only able to make speculation regarding the connection between the design intent and building performance in the discussion of individual facilities.

### *Best Performer among LEED projects*

Figure 1 shows that among LEED facilities, Site 7 had the best performance on *operation of plant* and *profitability index*. Comparing Site 7 with other 45 non-LEED acute care facilities in Tennessee, shown in appendix I (level-two analysis), indicated that Site 7 had the lowest *operation of plant* costs and the lowest total operating expenses. An average, non-LEED acute care facility of similar size spent $12.12 /sq. ft. on plant operation, while for Site 7 plant cost was as low as $4.05 /sq. ft. This suggests that implementing green building solutions, such as reducing heat island effect, increasing energy efficiency up to 14%, performing advanced commissioning, and reducing water consumption made it possible for Site 7 to save about 65% on *operation of plant*, as compared with other similar facilities in Tennessee.

The positive influence of this significant savings can be seen in other performance indicators for Site 7. For example, total operating expenses in Site 7 was 78.19% lower than the national average, which was smaller than operating expenses of all other 178 non-LEED acute care facilities of same size across the United States (level-three analysis). Appendix II (level-three analysis) also shows that *plant cost ratio* in Site 7 was larger than 81.8% of other 132 non-LEED short term acute care facilities of the same size in the nation. Because the percentage of overall costs that goes to the *operation of plant* was large, the 65% cost savings in plant operating cost was one of the important contributing factors to lowering total operating expenses. This study suggest these cost savings also helped site 7 to have outstanding profitability, which was higher than 92.1% of other 38 non-LEED acute care facilities in Tennessee. Appendix I (level-two analysis) shows that *inpatient revenue* for Site 7 is -44.85% less than the state average and did not contribute to the improvement in *profitability index*. In summary, CMS data suggests that unlike Site 3 and 14, Site 7 has managed to improve its profitability in the fiscal year of 2009-2010 by reducing *operation of plant* costs.

One important consideration regarding profitability of Site 7 bears repeating. As Equation 2 demonstrates, outpatient revenue was also included in calculating *profitability index*. Because outpatient revenue for Site 7 was only 1.44 times that of inpatient revenue, it was not large enough to have a significant contribution to the profitability of Site 7.

## CONCLUSION

This study used Medicare and Medicaid cost report data of hospitals for the fiscal year August 2009 to September 2010. The authors performed three different levels of analysis in which cyclical changes in health care demand and occupancy rate over a year, as well as regional variations caused by factors such as facility type, location, climatic conditions, governmental regulations, and union strength are considered. Analyzing the financial performance of 14 LEED hospitals indicated that on average, LEED projects in this study had higher operating expenses than the national average and they spent more on *operation of the plant*. LEED hospitals made more *inpatient revenue* on average; however, incomes were not high enough to compensate higher operating costs. The study found that only three projects in the sample of 14 LEED projects performed better than an average non-LEED facility on all four financial indicators. However, these three sites were not among the best performers within the sample of 14 LEED facilities. Comparing LEED hospitals of this study based on certification level

showed that financial performance was not necessarily better in hospitals with higher certification levels and achieving more credits did not guaranty the better financial performance of a facility. In summary, in line with studies of LEED facilities in other settings, this study found that similar to hospitals with no LEED certification, there are low and high performers among LEED hospitals.

Because of the small sample size, generalization should be done with care. Moreover, multiple years of data are needed to track changes in the performance of LEED facilities. More importantly, full value, monetary or otherwise, of building LEED hospitals might not be conveyed in the revenue section of CMS cost report. There are several other factors that influence financial performance of hospitals, some of those were discussed in this study. Based on the findings of the literature review and data analyses, the following considerations are proposed for future research:

- The literature review suggested healthcare executives and facility design and operation professionals are aware of the importance of improving energy inefficiency for reducing operating expenses. It is expected that many hospitals that do not seek LEED certification also implement solutions for achieving energy efficiency beyond the baseline building performance rating specified by design standards used in the LEED rating system (e.g., ANSI/ASHRAE/IESNA Standard 90.1-2007). If this is proved to be true in future studies (i.e., hospitals generally achieve some levels of energy efficiency), then to guarantee higher energy performance of LEED-certified hospitals, LEED for Healthcare should increase the minimum level of energy efficiency that a healthcare facility must achieve to be eligible for LEED certification (LEED rating systems currently require 10% improvement in the proposed building performance rating for new buildings as a minimum level of energy efficiency).
- In line with the previous recommendation, future studies of green buildings in healthcare settings should investigate how LEED for Healthcare may respond to specific characteristics of healthcare facilities by incorporating new design and operation credit categories other than improving energy efficiency (e.g., improved staff and patient safety by minimizing risks of hospital-acquired infections through improving indoor air quality and cleanliness and maintenance methods).

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Appendix I: Comparison of LEED facilities with state and national average of non-LEED facilities of the same type

| | Short Term Acute Care | | | | | | | | | | Children's | | | Psychiatric |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 19 | Site 10 | Site 11 | Site 12 | Site 13 | Site 14 |
| | Certified | Certified | Silver | Silver | Gold | Gold | Silver | Certified | Gold | Gold | Gold | Certified | Platinum | Gold |
| | OH | MI | CO | CA | OR | VA | TN | PA | CO | OK | MN | CA | TX | WI |
| **Annual Operation of Plant ($/sq. ft.)** | | | | | | | | | | | | | | |
| LEED Facility | 18.71 | - | 74.32 | - | 9.10 | 19.62 | 4.05 | - | 6.49 | 9.95 | 35.30 | 35.34 | 9.17 | 13.41 |
| State Average | 10.89 | - | 12.95* | - | 12.14 | 10.86 | 10.48 | - | 12.95 | 9.82 | 11.80 | 8.63 | 14.03 | 9.45 |
| Sample Size | 60 | - | 20 | - | 16 | 42 | 40 | - | 20 | 32 | 1 | 1 | 1 | 2 |
| Percent Difference | 71.81% | - | 474.10% | - | -25.07% | 80.69% | -61.39% | - | -49.91% | 1.28% | 199.19% | 309.53% | -34.62% | 41.92% |
| Percentile Rank | 90.0% | - | 100.0% | - | 31.3% | 88.1% | 0.0% | - | 5.0% | 50.0% | 0** | 0** | 1** | 0** |
| National Average | 12.12 | - | 12.12 | - | 12.12 | 12.12 | 12.12 | - | 12.12 | 12.12 | 12.65 | 12.65 | 12.65 | 10.64 |
| Sample Size | 1461 | - | 1461 | - | 1461 | 1461 | 1461 | - | 1461 | 1461 | 23 | 23 | 23 | 125 |
| Percent Difference | 54.37% | - | 513.23% | - | -24.95% | 61.91% | -66.61% | - | -46.48% | -17.94% | 179.09% | 179.39% | -27.48% | 26.05% |
| Percentile Rank | 88.6% | - | 99.9% | - | 26.8% | 90.9% | 5.7% | - | 11.1% | 35.5% | 95.7% | 95.7% | 30.4% | 76.8% |
| **Annual Inpatient Revenue ($/bed)** | | | | | | | | | | | | | | |
| LEED Facility | 1,817,126 | 1,124,316 | 1,926,958 | 255,444 | 1,150,682 | 950,767 | 468,686 | 2,826,263 | 2,368,940 | 2,113,451 | 2,063,496 | 3,093,317 | 2,446,286 | 161,484 |
| State Average | 970,465 | 938,601 | 1,493,157 | 1,953,539 | 1,335,370 | 964,119 | 849,906 | 1,499,474 | 1,493,157 | 838,442 | 2,048,054 | 2,586,498 | 2,450,061 | 294,184 |
| Sample Size | 103 | 50 | 24 | 120 | 23 | 49 | 45 | 11 | 24 | 38 | 2 | 2 | 3 | 7 |
| Percent Difference | 87.24% | 19.79% | 29.05% | -86.92% | -13.83% | -1.38% | -44.85% | 88.48% | 58.65% | 152.07% | 0.75% | 19.59% | -0.15% | -45.11% |
| Percentile Rank | 93.2% | 70.0% | 83.3% | 0.8% | 26.1% | 100.0% | 40.0% | 90.9% | 87.5% | 94.7% | 1** | 1** | 1** | 4** |
| National Average | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,185,243 | 1,766,274 | 1,766,274 | 1,766,274 | 368,403 |
| Sample Size | 1961 | 1961 | 1961 | 1961 | 1961 | 1961 | 1961 | 1961 | 1961 | 1961 | 30 | 30 | 30 | 203 |
| Percent Difference | 53.31% | -5.14% | 62.58% | -78.45% | -2.92% | -19.78% | -60.46% | 138.45% | 99.87% | 78.31% | 16.83% | 75.13% | 38.50% | -56.17% |
| Percentile Rank | 80.4% | 53.7% | 83.0% | 7.3% | 55.1% | 45.3% | 19.0% | 95.7% | 90.6% | 86.4% | 56.7% | 93.3% | 73.3% | 8.9% |
| **Annual Total Operating Expenses ($/sq. ft.)** | | | | | | | | | | | | | | |
| LEED Facility | 584 | 3,784* | 1,688* | 379 | 459 | 494 | 100 | 2,746* | 301 | 326 | 2,184* | 2,093* | 451 | 151 |
| State Average | 399 | 429 | 466 | 675 | 570 | 444 | 331 | 389.00 | 466 | 407 | 2,121 | 609 | 639 | 230 |
| Sample Size | 100 | 42 | 24 | 124 | 19 | 47 | 45 | 12 | 24 | 40 | 2 | 1 | 2 | 5 |
| Percent Difference | 46.35% | 782.71% | 262.16% | -43.87% | -19.56% | 11.26% | -69.67% | 606.02% | -35.47% | -19.83% | 2.96% | 243.64% | -29.42% | -34.49% |
| Percentile Rank | 92.0% | 100.0% | 100.0% | 7.3% | 21.1% | 70.2% | 0.0% | 100.0% | 8.3% | 35.0% | 1** | 0** | 1** | 3** |
| National Average | 459.70 | 459.70 | 459.70 | 459.70 | 459.70 | 459.70 | 459.70 | 459.70 | 459.70 | 459.70 | 685.91 | 685.91 | 685.91 | 320.08 |
| Sample Size | 1914 | 1914 | 1914 | 1914 | 1914 | 1914 | 1914 | 1914 | 1914 | 1914 | 26 | 26 | 26 | 192 |
| Percent Difference | 26.99% | 723.19% | 267.17% | -17.57% | -0.21% | 7.44% | -78.19% | 497.43% | -34.57% | -29.10% | 218.36% | 205.10% | -34.28% | -52.92% |
| Percentile Rank | 77.6% | 99.9% | 99.9% | 88.0% | 56.9% | 63.7% | 2.0% | 99.9% | 20.0% | 24.5% | 96.2% | 96.2% | 19.2% | 6.8% |

| | Short Term Acute Care | | | | | | | | | | Children's | | | Psychiatric |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 3 | Site 4 | Site 5 | Site 6 | Site 7 | Site 8 | Site 19 | Site 10 | Site 11 | Site 12 | Site 13 | Site 14 |
| | Certified | Certified | Silver | Silver | Gold | Gold | Silver | Certified | Gold | Gold | Gold | Certified | Platinum | Gold |
| | OH | MI | CO | CA | OR | VA | TN | PA | CO | OK | MN | CA | TX | WI |
| **Annual Plant Cost Ratio** | | | | | | | | | | | | | | |
| LEED Facility | 3.21% | 6.39% | 4.40% | - | 1.98% | 3.97% | 4.04% | - | 2.16% | 3.05% | 1.62% | 1.69% | 2.04% | 8.90% |
| State Average | 2.83% | 3.03% | 3.23% | - | 2.80% | 3.18% | 3.27% | - | 3.23% | 3.04% | 2.35% | 4.50% | 3.98% | 3.65% |
| Sample Size | 60 | 30 | 17 | - | 13 | 34 | 29 | - | 17 | 22 | 1 | 2 | 1 | 6 |
| Absolute Difference | 0.38% | 3.36% | 1.17% | - | -0.82% | 0.79% | 0.77% | - | -1.07% | 0.01% | -0.73% | -2.81% | -1.94% | 5.25% |
| Percentile Rank | 65.0% | 100.0% | 94.1% | - | 23.1% | 76.5% | 72.4% | - | 11.8% | 59.1% | 1** | 2** | 1** | 0** |
| National Average | 3.40% | 3.40% | 3.40% | - | 3.40% | 3.40% | 3.02% | - | 3.40% | 3.40% | 3.88% | 3.88% | 3.88% | 3.26% |
| Sample Size | 1299 | 1299 | 1299 | - | 1299 | 1299 | 1299 | - | 1299 | 1299 | 16 | 16 | 16 | 133 |
| Absolute Difference | -0.19% | 2.99% | 1.00% | - | -1.42% | 0.57% | 1.02% | - | -1.24% | -0.35% | -2.26% | -2.19% | -1.84% | 5.64% |
| Percentile Rank | 59.7% | 99.9% | 89.3% | - | 18.7% | 80.4% | 82.6% | - | 22.0% | 53.7% | 0.0% | 0.0% | 0.0% | 99.2% |
| **Annual Profitability Index** | | | | | | | | | | | | | | |
| LEED Facility | 2.71 | 1.95 | 2.88 | 1.09 | 1.99 | 1.70 | 4.36 | 3.94 | 2.72 | 2.70 | 1.76 | 2.34 | 3.34 | 1.08 |
| State Average | 2.32 | 2.14 | 2.42 | 2.56 | 2.51 | 2.73 | 2.54 | 3.12 | 2.42 | 2.34 | 1.06 | 2.25 | 2.72 | 2.12 |
| Sample Size | 74 | 41 | 17 | 145 | 21 | 43 | 38 | 9 | 17 | 31 | 1 | 2 | 2 | 7 |
| Absolute Difference | 16.81% | -8.88% | 19.01% | -57.42% | -20.72% | -37.73% | 71.65% | 26.28% | 12.40% | 15.38% | 66.04% | 4.00% | 22.79% | -49.06% |
| Percentile Rank | 70.3% | 51.2% | 82.4% | 1.4% | 47.6% | 18.6% | 92.1% | 3** | 76.5% | 64.5% | 0** | 1** | 1** | 7** |
| National Average | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.46 | 2.61 | 2.61 | 2.61 | 2.47 |
| Sample Size | 1727 | 1727 | 1727 | 1727 | 1727 | 1727 | 1727 | 1727 | 1727 | 1727 | 20 | 20 | 20 | 146 |
| Absolute Difference | 10.16% | -20.73% | 17.07% | -55.69% | -19.11% | -30.89% | 77.24% | 60.16% | 10.57% | 9.76% | -32.57% | -10.34% | 27.97% | -56.28% |
| Percentile Rank | 67.2% | 36.5% | 72.2% | 4.1% | 37.5% | 23.9% | 93.7% | 89.4% | 67.6% | 66.8% | 20.0% | 40.0% | 80.0% | 3.4% |

* Identified as outlier

** For comparison groups with the number of facilities smaller than 10, instead of percentile rank, the number of non-LEED hospitals that stand above the LEED facility is reported

Appendix II: Comparison of LEED facilities with state and national average of non-LEED facilities of the same type and size

| | Short Term Acute Care | | | | | | | | | | Children's | | | Psychiatric |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site 1 Certified OH | Site 2 Certified MI | Site 3 Silver CO | Site 4 Silver CA | Site 5 Gold OR | Site 6 Gold VA | Site 7 Silver TN | Site 8 Certified PA | Site 19 Gold CO | Site 10 Gold OK | Site 11 Gold MN | Site 12 Certified CA | Site 13 Platinum TX | Site 14 Gold WI |
| **Annual Operation of Plant ($/sq. ft.)** | | | | | | | | | | | | | | |
| LEED Facility | 18.71 | - | 74.32* | - | 9.10 | 19.62 | 4.05 | - | 6.49 | 9.95 | 35.30 | 35.34 | 9.17 | 13.41 |
| State Average | 8.53 | - | 14.48 | - | 10.39 | 27.48 | 9.20 | - | 8.97 | 6.93 | 38.88 | 8.63 | 22.42 | 7.71 |
| Sample Size | 10 | - | 5 | - | 3 | 3 | 5 | - | 4 | 2 | 1 | 1 | 1 | 1 |
| Percent Difference | 119.43% | - | 413.33% | - | -12.43% | -28.59% | -56.01% | - | -27.65% | 43.53% | -9.20% | 309.55% | -59.09% | 73.96% |
| Percentile Rank | 1** | - | 0** | - | 1** | 1** | 5** | - | 2** | 0** | 1** | 0** | 0** | 0** |
| National Average | 11.84 | - | 13.28 | - | 11.50 | 11.94 | 11.54 | - | 10.23 | 10.15 | 18.50 | 15.33 | 13.90 | 9.84 |
| Sample Size | 65 | - | 152 | - | 57 | 105 | 133 | - | 41 | 16 | 3 | 4 | 5 | 19 |
| Percent Difference | 58.01% | - | 459.64% | - | -20.87% | 64.34% | -64.92% | - | -36.58% | -1.99% | 90.87% | 130.49% | -34.01% | 36.25% |
| Percentile Rank | 89.2% | - | 100.0% | - | 28.1% | 92.4% | 0.8% | - | 17.1% | 50.0% | 0** | 0** | 3** | 89.5% |
| **Annual Inpatient Revenue ($/bed)** | | | | | | | | | | | | | | |
| LEED Facility | 1,817,126 | 1,124,316 | 1,926,958 | 255,444 | 1,150,682 | 950,767 | 468,686 | 2,826,263 | 2,368,940 | 2,113,451 | 2,063,496 | 3,093,317 | 2,446,286 | 161,484 |
| State Average | 1,412,393 | 499,615 | 940,203 | 2,918,028 | 1,005,542 | 1,201,762 | 1,103,268 | - | 2,068,746 | 937,889 | 1,744,145 | 2,586,498 | 2,034,770 | 594,651 |
| Sample Size | 15 | 2 | 5 | 2 | 3 | 4 | 5 | 0 | 4 | 2 | 1 | 3 | 1 | 1 |
| Percent Difference | 28.66% | 125.04% | 104.95% | -91.25% | 14.43% | -20.89% | -57.52% | - | 14.51% | 125.34% | 18.31% | 19.59% | 20.22% | -72.84% |
| Percentile Rank | 73.3% | 0** | 1** | 2** | 0** | 2** | 4** | - | 1** | 0** | 0** | 1** | 0** | 1** |
| National Average | 1,803,511 | 618,205 | 1,039,534 | 1,719,311 | 1,011,296 | 1,643,176 | 1,066,848 | 1,721,492 | 1,363,700 | 1,065,921 | 1,181,635 | 2,098,605 | 1,987,060 | 369,938 |
| Sample Size | 78 | 30 | 207 | 8 | 77 | 108 | 175 | 3 | 46 | 27 | 3 | 4 | 8 | 23 |
| Percent Difference | 0.75% | 81.87% | 85.37% | -85.14% | 13.78% | -42.14% | -56.07% | 64.18% | 73.71% | 98.27% | 74.63% | 47.40% | 23.11% | -56.35% |
| Percentile Rank | 62.8% | 86.7% | 86.5% | 8** | 70.1% | 4.6% | 8.6% | 0** | 91.3% | 88.9% | 0** | 1** | 1** | 8.7% |
| **Annual Total Operating Expenses ($/sq. ft.)** | | | | | | | | | | | | | | |
| LEED Facility | 584 | 3,784* | 1,688* | 379 | 459 | 494 | 100 | 2,746* | 301 | 326 | 2,184* | 2,093* | 451 | 151 |
| State Average | 404 | 1,689 | 406 | 1,141 | 530 | 447 | 311 | - | 449 | 224 | 1,369 | 959 | 877 | 216 |
| Sample Size | 15 | 2 | 5 | 2 | 3 | 4 | 5 | 0 | 4 | 2 | 1 | 2 | 1 | 1 |
| Percent Difference | 44.40% | 124.05% | 315.66% | -66.79% | -13.42% | 10.45% | -67.77% | - | -33.02% | 45.64% | 59.51% | 118.27% | -48.58% | -30.17% |
| Percentile Rank | 100.0% | 0** | 0** | 2** | 3** | 1** | 5** | 0** | 4** | 1** | 1** | 0** | 0** | 1** |
| National Average | 513.17 | 541.21 | 481.03 | 746.01 | 388.53 | 451.12 | 403.00 | 726.26 | 364.85 | 401.34 | 718.83 | 761.99 | 592.39 | 287.95 |
| Sample Size | 81 | 28 | 200 | 6 | 77 | 121 | 178 | 3 | 48 | 27 | 3 | 3 | 7 | 23 |
| Percent Difference | 13.76% | 599.21% | 250.89% | -49.20% | 18.07% | 9.49% | -75.12% | 278.16% | -17.56% | -18.79% | 203.79% | 174.64% | -23.91% | -47.67% |
| Percentile Rank | 64.2% | 100.0% | 100.0% | 6** | 71.4% | 66.9% | 0.0% | 2** | 37.5% | 40.7% | 0** | 0** | 4** | 8.7% |

| | Short Term Acute Care | | | | | | | | | | Children's | | | Psychiatric |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Site 1 Certified OH | Site 2 Certified MI | Site 3 Silver CO | Site 4 Silver CA | Site 5 Gold OR | Site 6 Gold VA | Site 7 Silver TN | Site 8 Certified PA | Site 19 Gold CO | Site 10 Gold OK | Site 11 Gold MN | Site 12 Certified CA | Site 13 Platinum TX | Site 14 Gold WI |
| | **Annual Plant Cost Ratio** | | | | | | | | | | | | | |
| LEED Facility | 3.21% | 6.39% | 4.40% | - | 1.98% | 3.97% | 4.04% | - | 2.16% | 3.05% | 1.62% | 1.69% | 2.04% | 8.90% |
| State Average | 2.41% | 2.68% | 3.11% | - | 1.95% | 5.42% | 3.32% | - | 2.03% | 3.93% | 2.84% | 1.41% | 2.56% | 3.57% |
| Sample Size | 15 | 2 | 4 | - | 3 | 3 | 5 | - | 4 | 2 | 1 | 1 | 1 | 1 |
| Absolute Difference | 0.80% | 3.71% | 1.29% | - | 0.03% | -1.45% | 0.72% | - | 0.13% | -0.88% | -1.22% | -0.42% | -0.52% | 5.33% |
| Percentile Rank | 93.3% | 0** | 0** | - | 2** | 1** | 1** | - | 2** | 1** | 1** | 1** | 0** | 0** |
| National Average | 2.44% | 2.75% | 3.06% | - | 3.35% | 2.74% | 3.14% | - | 3.15% | 3.40% | 2.79% | 2.66% | 2.85% | 3.68% |
| Sample Size | 65 | 18 | 143 | - | 57 | 103 | 132 | - | 41 | 16 | 3 | 3 | 5 | 19 |
| Absolute Difference | 0.76% | 3.64% | 1.34% | - | -1.37% | 1.24% | 0.90% | - | -0.99% | -0.35% | -1.18% | -0.97% | -0.82% | 5.22% |
| Percentile Rank | 81.5% | 100.0% | 90.2% | - | 14.0% | 86.4% | 81.8% | - | 17.1% | 56.3% | 3** | 3** | 3** | 100.0% |
| | **Annual Profitability Index** | | | | | | | | | | | | | |
| LEED Facility | 2.71 | 1.95 | 2.88 | 1.09 | 1.99 | 1.70 | 4.36 | - | 2.72 | 2.70 | 1.76 | 2.34 | 3.34 | 1.08 |
| State Average | 3.01 | 2.19 | 2.62 | 3.92 | 2.08 | 3.23 | 3.85 | - | 3.40 | 3.36 | 1.81 | 2.46 | 2.05 | 2.89 |
| Sample Size | 15 | 2 | 5 | 2 | 3 | 4 | 5 | 0 | 4 | 2 | 1 | 2 | 1 | 1 |
| Percent Difference | -9.84% | -10.93% | 9.92% | -72.19% | -4.41% | -47.42% | 13.18% | - | -19.92% | -19.75% | -2.72% | -4.97% | 62.93% | -62.63% |
| Percentile Rank | 33.3% | 2** | 1** | 2** | 3** | 4** | 2** | - | 2** | 2** | 1** | 1** | 0** | 1** |
| National Average | 3.21 | 2.69 | 3.39 | 4.12 | 2.50 | 3.26 | 2.85 | 4.88 | 2.97 | 2.61 | 2.81 | 3.16 | 2.31 | 2.15 |
| Sample Size | 79 | 30 | 209 | 8 | 77 | 121 | 177 | 4 | 48 | 26 | 4 | 5 | 2 | 18 |
| Percent Difference | -15.59% | -27.49% | -15.06% | -73.53% | -20.51% | -47.88% | 52.97% | -19.23% | -8.29% | 3.58% | -37.31% | -25.87% | 44.28% | -49.77% |
| Percentile Rank | 31.6% | 36.7% | 40.7% | 8** | 31.2% | 1.7% | 90.4% | 3** | 60.4% | 57.7% | 2** | 3** | 7** | 0.0% |

* Identified as outlier

** For comparison groups with the number of facilities smaller than 10, the number of non-LEED hospitals that stand above the LEED facility is reported instead of percentile rank