Exploring the Business Case for LEED EBOM Certification of a "Mixed Use" Facility

By

Brendan J. Carroll

B.S. Civil Engineering
United States Military Academy, 2001

SUBMITTED TO THE MIT SLOAN SCHOOL OF MANAGEMENT AND THE DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREES OF

MASTER OF BUSINESS ADMINISTRATION
AND
MASTER OF SCIENCE IN CIVIL & ENVIRONMENTAL ENGINEERING

IN CONJUNCTION WITH THE LEADERS FOR GLOBAL OPERATIONS PROGRAM AT THE
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

JUNE 2013

Signature of Author: _____
MIT Sloan School of Management, Department of Civil & Environmental Engineering
May 10, 2013

Certified By: _____
John Ochsendorf, Thesis Supervisor
Professor of Building Technology

Certified By: _____
John Sterman, Thesis Supervisor
Director, MIT System Dynamics Group

Accepted By: _____
Heidi M. Nepf, Chair, Departmental Committee for Graduate Students
Department of Civil & Environmental Engineering

Accepted By: _____
Maura Herson, Director of MIT Sloan MBA Program
MIT Sloan School of Management

[Page intentionally left blank]

Exploring the Business Case for LEED EBOM Certification of a "Mixed Use" Facility

By

Brendan J. Carroll

Submitted to the MIT Sloan School of Management on May 10, 2013 in partial fulfillment of the requirements for the degrees of Master of Business Administration and Master of Science in Civil & Environmental Engineering

Abstract

Many buildings are highly inefficient in terms of energy and water use and lack features important to a productive and healthy work environment. While many companies have established sustainability goals to ensure new buildings conform to "green standards," these same companies fail to realize the commercial, environmental, and social benefits from improving existing buildings. Here we examine the benefits of and barriers to greening existing buildings at Raytheon Space and Airborne Systems (SAS) in El Segundo, CA. We use the Leadership in Energy and Environmental Design (LEED) Existing Buildings: Operations and Maintenance (EBOM) framework to explore the business case for pursuing LEED EBOM certification.

Because some of the buildings in this study are "mixed use," meaning they house multiple space types within the same building envelope, we must first determine if the LEED framework applies. After benchmarking the energy and water efficiency of each building, we use interviews, surveys, and audits to discover the applicable benefits of greening these buildings. Furthermore, we explore whether companies can realize these benefits with more optimal methods versus pursuing LEED certification. Additionally, the barriers to greening existing buildings are discussed to discover why some companies fail to take advantage of immense savings opportunities.

Key results are that companies can realize significant financial savings opportunities by first conducting water and energy audits and then by implementing no to low cost efficiency projects. While LEED certification is not necessary to realize financial and environmental benefits, the recognition LEED certification provides allows companies to realize "soft benefits." These benefits consist of certification's attractiveness to customers, its benefit to brand image, and its ability to attract and retain talent. Common barriers include acceptance issues, business financing practices, and possessing the capacity to implement projects. We conclude there is a business case for the Raytheon SAS to pursue LEED EBOM certification as a pilot project to validate the benefits of LEED.

Thesis Supervisor: John A Ochsendorf
Title: Professor of Building Technology

Thesis Supervisor: John Sterman
Title: Director, MIT System Dynamics Group

[Page intentionally left blank]

Acknowledgements

The author wishes to acknowledge the Leaders for Global Operations Program for its support of this work. I would also like to thank everyone at Raytheon SAS who assisted with this project, both directly and indirectly. A big thank you goes to my mentors at Raytheon SAS: my supervisor, Suzelle Moss and my project champion, Bob Chatterson, as well as Lincoln Sise and John Zedro. I would also like to thank Chris Cumming for his contributions and support. Furthermore, I would like to thank my advisors, Dr. John Ochsendorf and Dr. John Sterman, for their guidance. I would also like to thank my wife, Liberty, and son, Tegan as well as the rest of my family and friends for their support. Finally, I would like to give a special thanks to Dimitri Shanin from Raytheon SAS for providing me with support and guidance, which greatly assisted me during this study.

[Page intentionally left blank]

Table of Contents

List of Figures

[Page intentionally left blank]

1 Introduction

Buildings and building activities have a significant effect on the environment and the health and well-being of the people who live and work in them. Most of the structures we inhabit are highly inefficient in terms of energy and water usage. According to the U.S. Environmental Protection Agency (2013), activities in buildings account for 36% of total energy use, consume 65% of electricity, account for 30% of the country's greenhouse gas emissions, use over 10% of our potable water, and contribute 30% to our waste output. In addition, buildings with poor ventilation systems often recirculate air polluted by human use and by chemical off-gassing from paints and other materials, making indoor air quality sometimes worse than the air outside (Montoya 2010). Poor air quality can increase absenteeism, aggravate health problems, and reduce productivity. Finally, many buildings today were not built to foster social interactions, connect with natural spaces, or ensure proper lighting and thermal settings; all features important to a productive and healthy work environment (Montoya 2010).

As humans have become more aware of the implications of their activities, many have sought ways to make their actions more efficient and sustainable. Founded with the mission "to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life," the United States Green Building Council (USGBC 2009) developed the Leadership in Energy and Environmental Design (LEED) system as a way to define and measure "green" buildings.

Many corporations now realize that becoming more sustainable makes good business sense. In addition to the financial advantages, mitigating the adverse effects of business practices creates a positive public effect; companies can demonstrate they are good corporate citizens. Not only has this practice been the right thing to do, it has allowed some organizations to remain competitive (Yudelson 2010). Consequently, focusing on the economic, social, and environmental impact of business practices now motivates some companies to analyze actions along the "triple bottom line." LEED is one framework for companies to assess the triple bottom line as they seek to make their buildings sustainable.

While many companies have established sustainability goals to ensure new buildings conform to "green standards," these same companies have failed to realize the commercial, environmental, and social benefits from improving existing buildings.

LEED for existing buildings: operations and maintenance (EBOM) is a framework designed to address this issue. It does this by focusing on major aspects of ongoing building operations such as exterior building site maintenance, water and energy use, environmentally preferred practices for cleaning and alterations, sustainable purchasing policies, waste stream management, and indoor environmental quality (USGBC 2009). The intent is to encourage building operators to implement sustainable practices and to minimize the environmental impact of their buildings.

In this study we examine the benefits of and barriers to greening existing buildings utilizing the LEED EBOM framework and the buildings at Raytheon Space and Airborne Systems (SAS) in El Segundo, CA. We ask whether the LEED EBOM framework makes sense for this industry, what the applicable benefits of greening existing buildings are, what are some of the common barriers to implementing improvements, and what is the best method to implement improvements to maximize benefits. Specifically, we seek to determine if there is a business case for Raytheon SAS to pursue LEED EBOM certification.

1.1 Statement of the Problem

Is the LEED EBOM framework an applicable, effective, and optimal method for companies to realize the financial, environmental, and social benefits of greening existing buildings?

For LEED EBOM certification to make sense, it must be applicable to a company's facilities. While all buildings meeting standard building codes can be assessed using the LEED EBOM framework, most certifications result from building space types categorized by Portfolio Manager, an interactive energy management tool developed by the Environmental Protection Agency and the Department of Energy (Energy Star 2013). For a complete discussion of Portfolio Manager, please refer to Appendix A.

Unfortunately, some of Raytheon SAS's facilities are "mixed use," consisting of space types such as laboratories, hi-tech manufacturing, offices, and warehouses, all within the same building envelope, in

proportions that make them ineligible for an energy performance rating from Portfolio Manager. This presents a unique problem since we must first find a LEED EBOM compatible method to measure the energy efficiency of these buildings before determining if each meets a strict LEED EBOM energy and atmosphere prerequisite.

Achieving LEED EBOM certification may also not be practical. Compared to new construction projects where cost effective, green solutions are built into a building, achieving LEED certification for an existing building is more difficult. Under this system, building owners and operators may sometimes need to incorporate new policies, purchase new equipment, or conduct major renovations to be sustainable and efficient enough to achieve certification. Besides financial considerations, companies may also find it difficult to overcome the organizational dynamics that hinder certification. Consequently, businesses may not want to pursue certification if they believe the effort to be too great.

Finally, from an environmental and economic perspective, achieving LEED EBOM certification may not be optimal; it may make more sense for a company to prioritize energy and water efficiency projects over pursuing certification. Furthermore, a company may be able to realize a greater return on investment just by meeting many of the standards outlined by the LEED EBOM methodology versus actually spending the time and money required to secure LEED EBOM certification. Only by analyzing a company's current status and determining the specific benefits of certification can we answer this question.

1.2 Research Goals

The research hypothesis of this study is: the LEED EBOM method is an optimal way to green existing buildings and the benefits of certification outweigh the costs. To support this hypothesis, we will determine not only the financial and environmental benefits from certification, but also its "soft benefits," such as its benefit to a company's brand image, its attractiveness to customers with sustainability requirements, and its ability to attract and retain top talent. Furthermore, we will evaluate Raytheon SAS's buildings in terms of possible LEED credits to better understand the costs associated with attaining

enough credits to achieve certification. In addition, we will evaluate if a company can attain the financial, environmental, and social benefits of greening existing buildings without pursuing LEED EBOM certification to determine if there are options offering a greater return on investment. Finally, if there is a business case for pursuing certification, we would like to establish an optimum methodology for assessing buildings and potential projects to make the LEED EBOM process scalable.

2 Literature Review

The LEED system has emerged as one of the leading green building rating systems. Designed to encourage the implementation of practical and measurable green building solutions, the LEED framework provides building owners with steps to achieve significant benefits. However, the system is not without criticism, and the barriers to certification can be considerable.

2.1 Benefits of LEED Certification

While economic benefits are usually the biggest factor when evaluating the case to pursue LEED certification, others include the increased productivity and morale of employees, better public relations and marketing, and the ability to attract and retain top talent (Yudelson 2010).

2.1.1 Economic Benefits

Usually the easiest justification for greening an existing building is the economic benefit from reduced operating costs. Higher energy and water efficiency levels can lead to long-term savings. A building that has achieved LEED EBOM certification has proven it meets or exceeds rigorous water and energy efficiency standards (USGBC 2009). Furthermore, efficiency projects offer a building owner a low-risk opportunity for significant return. Before any project, a building owner can reference the company's past utility usage and the known consumption rates of any water or energy retrofits to predict the costs and benefits of different projects. By knowing the expected annual savings of different projects, a building owner can choose to implement only those projects with a positive net present value (NPV).

2.1.2 Increased Worker Morale and Productivity Gains

With the average American spending 90% of his or her time indoors, the space in which a worker finds himself directly affects his health, morale, and the company's bottom line. Poor lighting, harsh acoustics, and a lack of connection to natural spaces all hinder how a person performs his job. Buildings with inadequate ventilation and poor air quality have been known to cause headaches, fatigue, and dizziness and aggravate conditions such as asthma. This leads to increased absenteeism, higher healthcare costs, and lower productivity (Karolides 2002).

Improving indoor environmental quality can mitigate these negative effects. In one study, Martin Melaver and Phyllis Mueller (2009) reported productivity to be 2% to 18% higher in LEED certified buildings. Dr. Norm Miller et al. (2009) found healthier buildings reduced sick time by 2.88 days per worker per year and dramatically increased productivity with the value added for owner-occupied buildings approaching $100 per square foot. Finally, in a compilation of 11 studies by Carnegie-Mellon University (2004), researchers found that improved lighting designs led to median productivity gains of 3.2% or $1600 per employee per year. Altogether, these factors bring tangible value to companies and easily outweigh the costs of creating a healthier environment for workers.

2.1.3 Public Relations, Marketing, and Brand Image

Essential to all businesses, marketing and public relations are used by many to maximize their brand equity. Becoming LEED certified allows businesses to reveal to customers, company shareholders, and the public a concern for the long-term health of the planet and an emphasis on social responsibility. Receiving third party verification also ensures that a project team has been rigorous in implementing LEED EBOM standards. Furthermore, certification provides building owners with a concrete, nationally recognized symbol to exhibit their sustainability commitments and success. Finally, for corporations who issue sustainability reports each year, earning certification not only shows that a company is willing to "walk the walk," but also that it is able to focus its resources to accomplish a difficult goal (Yudelson 2010).

2.1.4 Recruitment and Retention

Most organizations experience 10% to 20% turnover per year. Some estimates put the cost of losing a good employee at 150% the employee's annual salary (Yudelson 2008). Green buildings may have an effect on motivating someone to join or stay with an organization. In one report (2003), Greg Kats et al. noted that two business units from PNC Realty Services experienced 83% and 57% reductions in voluntary terminations shortly after moving into a newly LEED Silver certified facility. Because some people leave an organization due to a poor physical environment, if the healthy conditions of a LEED EBOM certified building reduce employee turnover by even 5 percent, that value alone is enough to justify the costs associated with most improvement projects.

It is estimated that workers 55 and older will make up 34% of the workforce in 2014. This is a 10% increase from 2005 (Yudelson 2008). As more and more of these employees retire, companies will be hard-pressed to recruit and train new hires to backfill key positions. One aspect that could set companies apart from their competition, enabling them to recruit top candidates, is having green buildings. In a survey of green building owners by Deloitte (2008), 40% of respondents indicated that performing green retrofits had significantly increased their ability to attract talented employees. Not only does a LEED certified building display a company's values to prospective hires, it may be the key to convincing new generations of employees, especially ones interested in environmental issues, to join a business.

2.2 Criticisms of LEED

One of the biggest criticisms of LEED certification is that companies can realize many of the benefits of LEED without actually achieving certification. For example, by implementing efficiency projects, a company can receive the same economic and environmental benefits without the effort and investment required for certification. In addition, a company could use the LEED EBOM framework to improve the health and productivity of its workers regardless of whether the USGBC is involved. This leads some to believe that the greatest advantage from LEED is the third party verification it provides, certifying a building has met certain standards, enabling a company to take advantage of the recognition.

Another criticism of LEED is that there is a discrepancy between the level of effort needed to earn certain credits and the benefits those credits provide. In one study, Scheuer and Keoleian (2002) discovered that, "in many cases the economic basis of the calculations directly led to results in which the specific measured environmental impacts did not align with the LEED rating method." To put it another way, the study concluded that some credits, which are easy to earn and do not offer significant environmental benefits, are given the same value as credits which provide significant environmental benefits, but may be more difficult to earn. This gives building owners an incentive to pursue credits solely for the purpose of certification versus implementing improvements with the most positive impact on sustainability. The same study expressed this final belief, "while LEED appears to be accomplishing the goals of an eco-labeling program that is used as a marketing and policy tool it is not as successful at being a comprehensive methodology for assessment of environmental impacts."

Finally, some argue that LEED certified buildings are no more energy efficient than non-LEED certified buildings. Scofield (2009) found, from an analysis of energy consumption data compiled by the *New Building Institute*, that LEED-certified commercial buildings did not show any significant energy savings over comparable non-LEED buildings and, therefore, no associated reduction in greenhouse gas emission. Furthermore, Carol Menassa et al. (2012) determined that the energy savings from 11 LEED-certified United States Navy buildings were not closely related to the number of points received in the Energy and Atmosphere section of the LEED certification process.

2.3 Barriers to LEED Certification

While upfront costs can be the largest barrier to certification, others include team inexperience, staff time requirements, and the certification process; and capacity concerns and acceptance issues.

2.3.1 Cost Barriers

Some owners believe the price to green existing buildings will be greater than the life-cycle benefits. While the upfront costs in registration, certification, consulting fees, and efficiency upgrades are tangible,

it is difficult for these owners to see the long-term value of their investments. To overcome this, companies should assess projects based on net present value. Most projects are low risk and will provide significant savings in the long run; they should be funded as such. To assist with this assessment, project champions should provide stakeholders with a detailed analysis of the costs of doing nothing. In the face of rising energy prices, even a small reduction in energy use could have a significant effect over time. Finally, project champions could use case studies to demonstrate the "soft benefits" of LEED certification. A combination of these approaches should demonstrate to stakeholders that a company can achieve high performing buildings, not only at reasonable costs, but also with additional, non-financial, benefits (Yudelson 2010).

Because the level of effort required to coordinate and document all LEED aspects is significant, a business may seek the aid of an outside consultant. Depending on the size of a building and level of assistance needed, this could easily increase a project's cost by $15,000 to $50,000. However, in the long run, a consultant may be worth the cost as one could relatively easily accomplish tasks that may take a company's staff considerable time just to understand. Based on a business's situation, paying consultant fees could actually lead to a less expensive result overall (Yudelson 2010).

2.3.2 Team Inexperience, Time Requirements, and the Certification Process

Inexperience with the LEED process is a large obstacle for many project teams. Due to the documentation and time required and because many requirements are difficult to understand, certification can be overwhelming for those new to the process. Furthermore, in order to keep costs down and avoid an extensive review cycle in the event LEED reviewers reject documentation, a project team must spend considerable staff time and effort to ensure requirements are correct from the beginning. Not being familiar with this process might cause some teams to waste time on relatively simple things while failing on more important ones (Yudelson 2010). Furthermore, since project teams are cross-functional, representing many divisions within an organization, additional time and resources may be needed to coordinate and facilitate project registration workflow.

While inexperience and the effort required can deter some companies from pursuing LEED, it is important to note that it is usually only the first project that confuses new teams. Once a team has worked through the process once, it may make more sense and be easier on future endeavors. For later projects, teams with experience may have learned the best methods, developed shortcuts, or compiled written standard policies applicable across entire building portfolios (Yudelson 2010).

2.3.3 Company Capacity Concerns and Acceptance Issues

Even if a company concludes it has a business case for pursuing LEED certification, it may decide it does not have the capacity to implement improvements. Due to limited time or personnel, a company may find itself stuck in a vicious cycle where its maintenance personnel are reactive to building issues instead of proactive. As maintenance personnel rush around "firefighting" problems, even less time is available for preventative maintenance, leading to fewer defects fixed, more breakdowns, a greater amount of reactive work, and money wasted (Repenning and Sterman 2001, 2002). To break this cycle, a company must invest in areas that allow it to get out ahead of necessary maintenance. This may include hiring additional personnel. While this might appear as an unreasonable expense at first, additional personnel would provide the resources to implement efficiency projects and conduct maintenance, saving a company more money in the long run (Lyneis 2012). Pursuing LEED EBOM certification could be a method to spur proactive investment. Attempting to implement the requirements of the LEED process would allow a company to gauge where its capacity lies and, if necessary, take steps to allow maintenance teams to be more productive over the long term. Furthermore, achieving LEED certification may create a beneficial cycle as the proactive steps done to meet requirements, to include continuous commissioning, reduce future defects at an even higher rate, leading to even more time for proactive work.

Another difficult barrier to certification is that of acceptance. Because LEED EBOM requires a considerable investment from company personnel, they may not want to expend the effort or fully commit to the project if they believe LEED is not worth the effort or will not be a priority for the company through completion (Capuzzi 2010). Overcoming the acceptance barrier requires a clear message from

upper management that LEED certification is a priority for the company (Capuzzi 2010). In addition, an organization should appoint a "LEED Champion" with authority over stakeholders crucial to a project. This leader can implement a vision and push to ensure a project stays on track.

2.3.4 Cumulative Cost of LEED EBOM Certification

Despite the level of interest in LEED certification, there have been very few studies outlining the cumulative cost of these barriers. One study conducted by the Leonardo Academy (2008) attempted to quantify these costs. Analyzing such "costs" as staff time, energy modeling, registration fees, LEED documentation efforts, and efficiency projects, the study determined the total cost of certification per square foot to be between $0.02 and $5.01, with an average of $1.58. However, this cost range included all levels of certification and was based on an earlier edition of LEED EBOM requirements; one with more prerequisites. For Silver Certification, the study found the cost to range from $0.24 to $2.05 with a median cost of $1.29. While not perfect, this study provides building owners with an idea of the costs associated with LEED EBOM certification.

3 Methodology

As a key determinant when evaluating the difficulty associated with achieving LEED certification and as the first consideration when evaluating the financial and environmental benefits of sustainability projects, a benchmark of each building's current energy efficiency became our first goal in assessing the business case for pursuing LEED EBOM certification.

Benchmarking energy efficiency allowed us to discover which buildings are least efficient, possessing the most potential for return, and which are most efficient, distinguishing them as perhaps relatively simple LEED certification candidates. Furthermore, this step allowed us to determine candidates for energy audits. Audits enabled us to verify our efficiency results as well as analyze the benefits exclusively from efficiency projects without considering the additional benefits from LEED certification. Finally,

should we be able to benchmark the energy efficiency of "mixed use" buildings and analyze it compared to LEED EBOM standards, this step would show us that the LEED EBOM framework is applicable.

To estimate the costs of LEED EBOM certification for a building, we performed a gap analysis (Appendix C). Using the LEED EBOM reference guide, we assessed the credits a building currently achieves, the number of credits each needs to reach certification, and the cost to achieve those credits. In terms of benefits, we analyzed the reduced operating costs from implementing efficiency projects and conducted interviews to identify the "soft benefits" of certification of value to the company. Should the benefits of LEED EBOM certification outweigh the costs, achieving LEED EBOM certification would be practical. Should the benefits from LEED EBOM certification surpass the returns solely from efficiency improvement projects, LEED EBOM certification would be the most advantageous. Finally, should a business case exist for the pursuing LEED EBOM certification, we planned to optimize and scale our methodology to be applicable to other sites and businesses.

Separate from analyzing the substantive benefits of greening existing buildings, we also explored the process dimension and organizational dynamics associated with sustainability projects. Should we find opportunities for significant improvements, we planned to investigate why these actions had not been undertaken sooner. Furthermore, we assessed the conditions needed to spur stakeholders to action.

3.1 Benchmarking Energy Efficiency

From utility usage data (both gas and electricity), gross square footage, space types, and other pertinent data, we calculated the energy efficiency of most buildings by utilizing the Department of Energy's Portfolio Manager, found at http://www.energystar.gov. For a complete discussion of Portfolio Manager and the methodology to determine a building's energy star score, please refer to Appendix A – Portfolio Manager: Methodology.

To be eligible to receive an energy performance rating from this tool, a score which determines whether a building is efficient enough to meet a key LEED EBOM energy and atmosphere prerequisite, a building's gross floor space must be made up of 50% or more of an eligible space type, such as an office,

school, or warehouse, and made up of 10% or less of a space type categorized as "other," such as a laboratory or manufacturing facility.

For those buildings with space types categorized as laboratories or manufacturing areas making up more than 10% of the building's gross square footage, we developed a method to calculate a comparable energy performance rating by using a combination of the Portfolio Manager tool, a laboratory benchmarking database called labs21 benchmarking tool, found at http://labs21benchmarking.lbl.gov/, and an excel spreadsheet called the labs21 tool, found in Appendix B. Even if a building was ineligible for an energy star score from Portfolio Manager, we were still able to use that tool to calculate the building's source energy-use intensity. With this measurement, the benchmarking database tool, and the labs21 excel workbook, we were able to compare the energy consumption of our "mixed use" buildings to similar facilities nationwide to determine the energy efficiency of our facilities. For a complete discussion of labs21 and the methodology to determine a laboratory's rating, please refer to Appendix B - labs21Methodology.

Determining the energy efficiency of each building allowed us to assign it to one of two categories, dictating the approach for its analysis. The categories consisted of those buildings that should focus exclusively on the returns from efficiency projects and those buildings appearing as relatively simple LEED EBOM certification candidates.

To accumulate LEED credits for certification, a building must meet all LEED prerequisites. One of the most difficult to achieve is a minimum energy star score of 69. If we found the energy star score of a building to be below 50, meaning the building is less efficient than a national average, it would make more sense for a company, from a net present value (NPV) perspective, to focus exclusively on energy efficiency projects before dedicating the effort to secure other LEED EBOM credits. If we determined the energy star score of a building to be at or above this standard, devoting the resources to secure LEED EBOM certification may make the most sense. Finally, for any building meeting this prerequisite and based on its overall energy performance, both tools used to determine energy efficiency would allow us to calculate the number of LEED optimized energy performance credits the building earns.

3.2 LEED EBOM Candidates: Gap Analysis and Cost Estimate

Credits under the LEED EBOM rating system address seven topics. These topics include sustainable sites, water efficiency, energy and atmosphere, materials and resources, indoor environmental quality, innovation in operations, and regional priority. 100 base credits are possible from the first five topics, while 10 extra credits are available from the last two. In order to achieve certification, a building must earn at least 40 credits. Higher levels of certification are possible with additional credits. The different levels of certification and the points required for each are shown in Figure 1.

Figure 1 – LEED Certification Levels

LEED Ratings	Points
Certified	40 to 49
Silver	50 to 59
Gold	60 to 79
Platinum	80 or above

Using the USGBC's Green Buildings Operation and Maintenance guide as a reference and a LEED EBOM scorecard (Appendix C), we conducted a gap analysis for each LEED EBOM candidate. Completing this scorecard allowed us to determine the number of credits each candidate already achieves and the number needed to accomplish higher levels of certification. To complete this analysis, we evaluated the results from benchmarking each candidate's energy efficiency, examined responses to a commuter survey, researched company policies, and interviewed company personnel responsible for all areas under each of the seven LEED EBOM topics. Once we knew the status of each candidate, we estimated the cost and effort required to earn additional credits by dividing the required credits into three cost buckets: zero to low, low to medium, and medium to high. Examples of zero to low cost credits were those that required internal staff time to create and implement LEED EBOM polices; examples of credits for low to medium cost were those that required more extensive energy audits, minor retrofits, or the purchase of new equipment; and examples of credits at medium to high cost were those that required

major capital investments. From this, we were able to get a general idea of the credits that were possible and those that were highly unlikely. This analysis not only provided us with a more refined estimate of the costs to achieve LEED EBOM credits, but it further pared down our list of LEED candidates, it gave us an idea of the level of certification possible, and it allowed us to approximate a range for outside consulting fees.

3.3 Energy and Water Audits

As part of an additional LEED EBOM energy and atmosphere prerequisite from the USGBC Green Buildings Operation and Maintenance Guide (2009), any building pursuing LEED EBOM certification must receive an American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) Level 1 audit. This audit is the basic starting point for building energy optimization and is geared toward the identification of no to low cost energy improvements as well as gaining an understanding of a building's general configuration and nature of energy systems. In addition, the audit verifies the energy-use benchmark, establishes a baseline for measuring improvements, and determines whether further evaluation is warranted.

Based on the results from our gap analysis and from benchmarking the energy efficiency of each building, we evaluated candidates for an ASHRAE Level 1 audit. While our gap analysis would reveal the best LEED certification candidates for an audit, because we also sought to analyze the benefits of efficiency projects independent of LEED certification, we assessed additional audit candidates based on building size and energy efficiency. The best possible candidates under this criterion would be the least energy efficient buildings, of similar size to our LEED certification candidates. Once we had specified audit candidates, we hired an outside contractor experienced in the requirements of ASHRAE to conduct our audits.

In addition to energy prerequisites, to be eligible for LEED certification, a building must also meet a minimum water efficiency of 20 percent below a baseline based on standard plumbing codes. To verify our buildings meet this prerequisite and to compile possible water use efficiency projects, we analyzed the

results of a water audit Raytheon SAS had completed in 2008. Had the company not performed this audit, we would have scheduled one for each of the buildings selected for energy audits.

3.4 Applicable Benefits

To compare the advantages of each approach, we calculated the financial and environmental benefits of the efficiency projects discovered through audits and identified and evaluated the "soft benefits" of value to the company that only LEED EBOM certification could provide.

To assess audit results, we analyzed the benefits of suggested projects in terms of total kilowatt-hour per year reduction, gallons of water saved, and net present value (NPV). To calculate NPV, we used the company's discount rate of 12%, at perpetuity, while assuming electricity rates would increase at 2% annually for the first ten years. As part of a sensitivity analysis to examine the effect of discount rate and energy price increases on NPV, we evaluated a situation with no annual energy rate increase, a situation using a 9% discount rate, and situations with annual energy price increases of 2% or 4%.

To identify and assess the soft benefits of LEED certification, we interviewed company personnel from business development, marketing, and human resources and evaluated the sustainability requirements of the company's biggest customers.

4 Results and Discussion

A key aspect of our analysis is the effect organizational dynamics play on motivating stakeholders to action. Having quality data demonstrating the possible positive NPV opportunities of LEED EBOM certification is not enough to overcome the barriers caused when a company focuses on the effort required, the upfront cost, or a project's payback period. In our analysis, we found the company would not likely pursue certification, despite its possible benefits, if doing so required too much upfront cost or effort. Consequently, to analyze the benefits of LEED EBOM certification and possibly motivate the company to agree to a LEED EBOM certification project, we sought relatively simple LEED EBOM certification candidates to provide the company with a "quick win." This impacted how we evaluated

buildings for certification, categorizing as suitable candidates only those already meeting strict LEED EBOM prerequisites.

4.1 Energy Benchmarking Results

Benchmarking energy efficiency proved to be this study's most important step. While the facilities management division at Raytheon SAS tracks and compiles utility bill data, it is not centrally managed to implement efficiency projects with the greatest potential for savings. Instead, upgrades are completed on an as needed basis. In other words, no tool was utilized to determine which buildings possess the greatest potential for savings, or if any could meet the efficiency standards for LEED certification. Benchmarking each building not only showed the company where to prioritize its efforts, it also provided objective data that served as an "eye opener" to motivate stakeholders to action. This first step demonstrated the possible benefits to the company and allowed us to convince stakeholders to fund low cost energy audits in support of our methodology.

Benchmarking energy efficiency was not without problems, however. When we attempted this, we discovered that not every building has a meter to measure electricity usage. Consequently, of the 16 buildings we had planned to evaluate, we immediately rejected six. Whether for LEED certification or to implement utility efficiency projects, a company must have a standardized, consistent way to measure each building's utility usage. Doing so allows an owner to establish a baseline from which to determine the impact of efficiency projects over time. Before we could proceed with an analysis of the six rejected buildings, the company would need to install utility meters.

For the 10 buildings we were able to analyze, four meet the building space type requirements of Portfolio Manager, enabling them to receive an energy star score (Figure 2). Of these four buildings, Raytheon SAS has plans to vacate building XX2 so, despite it receiving a score of 68, we dropped it from further analysis.

Figure 2 – Building Energy Star Scores and Source Energy Intensity from Portfolio Manager [1]

Building	Current Rating	Total Floor Space (Sq. Ft.)	Current Source Energy Intensity (kBtu/Sq. Ft.)
XX1	26	55,396	255.2
XX2	68	51,967	166.4
XX3	57	221, 395	220
XX4	3	63,068	203.2

A building must receive an energy performance rating of at least 69 in order to meet one of the more difficult LEED EBOM energy and atmosphere prerequisites. Analyzing these results showed that none of the three remaining buildings (XX1, XX3, or XX4) are close to this standard. However, these results did provide us with candidates to evaluate the returns possible only from implementing energy efficiency projects without considering the additional requirements to achieve LEED certification.

For the six remaining buildings, we benchmarked energy efficiency levels by first using the labs21 database to determine the average source energy intensity for comparable facilities and then by using the labs21 excel workbook to compare the company's "mixed use" buildings to these standards. Please refer to Appendix B – labs21: Methodology for the procedure and assumptions we used. We found that three of the six buildings meet the prerequisite and that two are energy efficient enough to achieve energy performance credits (Figure 3). With these results, we decided that buildings XX5, XX6, and XX7 were good candidates to undergo a LEED EBOM gap analysis while buildings XX8, XX9, and XX10 should be evaluated solely by the benefits possible from implementing energy efficiency improvements.

[1] I have changed the names of Raytheon's buildings for confidentiality reasons.

Figure 3 – labs21 Energy Benchmarking Results and Performance Credits

Building	Current Rating	Total Floor Space (Sq. Ft.)	Current Source Energy Intensity (kBtu/Sq. Ft.)	Peer Facility Average (kBtu/Sq. Ft.)	Meets Prerequisite	Optimized Energy Performance Credits
XX5	N/A	1,120,957	382	488	Y	0
XX6	N/A	45,137	383	596	Y	7
XX7	N/A	37,345	321	596	Y	12
XX8	N/A	783,652	546	562	N	0
XX9	N/A	161,495	460	518	N	0
XX10	N/A	85,116	733	768	N	0

4.2 Gap Analysis

Using the LEED EBOM reference guide, available from the USGBC, and with our LEED EBOM scorecard (Appendix C), we conducted a gap analysis of our three candidates to assess the current points each is already achieving and the costs to achieve different levels of certification (Figure 4).

Based on interviews with company personnel responsible for the seven areas under LEED EBOM certification, we determined that Raytheon SAS is currently following procedures or has systems in place so that every building on campus, if each could meet all prerequisites, could earn 21 LEED EBOM credits. Most of these credits are due to the company fulfilling all irrigation needs from a basin of reclaimed water (5 credits), an excellent campus-wide solid waste management plan (4 credits), and a campus-wide green cleaning program (5 credits). Nevertheless, the company does not currently have the information compiled into LEED-acceptable formats. To fully meet all requirements, the company would need to dedicate staff time to assemble the proper documentation.

In terms of each of our three LEED EBOM candidates, we looked at the systems in place in each building independently and discovered that building XX5 is currently meeting standards that would allow it to earn a total of 28 credits, building XX6 would earn 35 credits, and building XX7 would earn 44. The disparity is a result of varying energy efficiency levels and the uptake of alternate transportation programs (such as van pool and ride share) within each building. Since building XX7 is more energy efficient than XX5, it earns 12 more energy performance credits. Furthermore, based on a commuter survey, we

determined that 50% of building XX7's personnel use alternate transportation means. This allows building XX7 to earn 11 points in that category to building XX5's 7. A similar situation explains the difference between building XX6 and XX7. As with the previous 21 credits, however, actually realizing these points would require the company to dedicate staff time and possible consulting fees to properly document its results.

After determining how many credits each building currently achieves, we estimated the costs to achieve different levels of certification. Based on this analysis, we believe building XX5 can achieve Certification for low to medium cost while building XX6 can achieve Certification for zero to low cost. Furthermore, due mostly to its better energy efficiency, we trust that building XX7 can earn 6 more credits at zero to low cost to reach Silver Certification. This discovery caused building XX7 to stand out as our most promising LEED EBOM candidate. Please refer to Figure 4 for the rough costs of achieving different levels of certification. In this table, cumulative point totals in each column specify the level of certification for each cost bracket.

Figure 4 – Levels of LEED EBOM Certification by Cost (Estimated)

	Zero – Low	**Low - Med**	**Med – High**
XX5	34	49	60
XX6	41	56	60
XX7	50	65	76

Finally, our gap analysis revealed that many of the credits needed to achieve Silver Level Certification of building XX7 apply to every building on Raytheon SAS's El Segundo Campus. Therefore, if the company was able to achieve Silver Level Certification of XX7, it would possess a cache of 27 to 32 LEED EBOM approved credits applicable to any future project, provided each building could meet prerequisites. This is significant because the cost and effort to secure credits for building XX7 could be divided by all future LEED EBOM projects at the company, drastically reducing the appearance of the upfront investment for building XX7.

4.3 Audit Results

4.3.1 Energy Audits

After benchmarking each building's energy efficiency and conducting a gap analysis, we were able to select candidates for audits. Due to the great potential for savings from improvement projects and because we had found relatively simple LEED certification candidates, the company agreed to fund two ASHRAE Level 1 energy audits.

As the most promising LEED EBOM candidate, we selected building XX7 for one audit. Since we benchmarked building XX1 to be the least energy efficient building, of similar size to building XX7, we chose it for the second audit. This allowed us to compare the benefits of LEED certification (XX7) with the returns possible solely from implementing efficiency projects (XX1).

A local company specializing in LEED consulting and energy audits conducted our audits. Not only did the auditors' findings verify our energy benchmarking results, but they also provided the company with 11 "no to low cost" improvement projects (Figure 5).

Figure 5 – No to Low Cost Projects: Buildings XX1 and XX7

Building	Project
XX1	#1 Install Smart Plug Strips
XX1	#2 Replace Exit Signs with LED Signs
XX1	#3 Replace "Always On" Interior Lighting
XX1	#4 Install Lighting Occupancy Sensors
XX1	#5 Replace Exterior HID Lighting
XX1	#6 Replace Interior Lighting Bulbs and Ballasts
XX7	#1 Install Smart Plug Strips
XX7	#2 Install Lighting Occupancy Sensors
XX7	#3 Replace Exterior HID Lighting
XX7	#4 Replace Interior HID Lighting
XX7	#5 Replace Interior Lighting Bulbs and Ballasts

To analyze the most profitable projects, we calculated net present value using a discount rate of 12%, at perpetuity, while assuming a 2% annual increase in the cost of electricity for the first 10 years. The annual savings, NPV (12% @ 2% for 10 years), kWh/Yr. reduction, and upfront costs of these projects

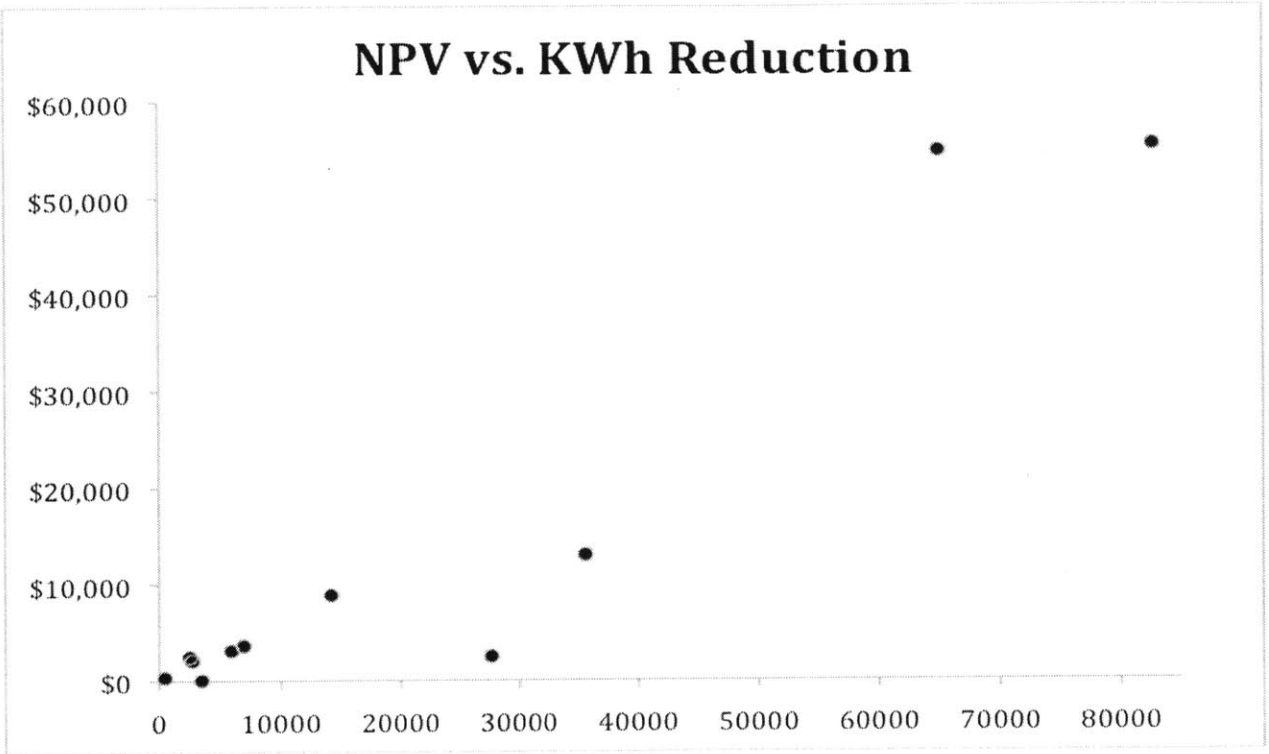
are summarized in Figure 6. As part of a sensitivity analysis, we also included the NPV for situations with no annual increase in the cost of electricity (NPV 12%); the NPV when using a discount rate of 9% (NPV 9%), since energy efficiency projects have a lower risk than new research and development projects; and the NPV for situations with perpetual annual energy price increases of 2% (NPV 12% @ 2%) or 4% (NPV 12% @ 4%). Based on this analysis, it is clear that even minor energy efficiency projects can lead to considerable financial benefits. Depending on the rate of increase of energy prices, this benefit is even more significant.

Figure 6 – Costs and Benefits of Energy Efficiency Projects

Building/ Projects	Upfront Cost	kWh/Yr. Savings	Annual Savings	NPV (12%/2% for 10 years)	NPV (12%/2%)	NPV (12%/4%)	NPV (9%)	NPV (12%)
XX1	$18,090	65003	$7,800	$54,810	$59,910	$79,410	$68,577	$46,910
XX1	$1,000	2759	$331	$2,093	$2,310	$3,138	$2,678	$1,758
XX1	$37,610	82695	$9,956	$55,437	$61,950	$86,840	$73,012	$45,357
XX1	$7,004	14161	$1,699	$8,875	$9,986	$14,234	$11,874	$7,154
XX1	$3,570	5979	$717	$3,131	$3,600	$5,393	$4,397	$2,405
XX1	$28,540	27663	$3,320	$2,488	$4,660	$12,960	$8,349	-$873
XX7	$360	2538	$305	$2,490	$2,690	$3,453	$3,029	$2,182
XX7	$206	497	$60	$355	$394	$544	$461	$294
XX7	$4,200	6990	$839	$3,641	$4,190	$6,288	$5,122	$2,792
XX7	$27,000	35668	$4,280	$13,000	$15,800	$26,500	$20,556	$8,667
XX7	$3,900	3531	$424	$63	$340	$1,400	$811	-$367

To depict the best projects, we plotted NPV, using a discount rate of 12% at perpetuity while assuming a 2% annual increase in the cost of electricity for the first 10 years, versus kWh per year reduction (Figure 7). In this figure, the best projects are shown in the upper right hand quadrant of the plot. The results show the projects with the biggest impact are from building XX1. This validates our energy benchmarking results as building XX7 should have relatively little room for improvement while building XX1 should have much to gain.

Figure 7 – NPV vs. kWh Reduction



In terms of the benefits of energy audits, it is clear that simple projects can produce great returns. From a financial perspective, these 11 projects, from only two of 16 buildings, have a NPV of $146,300, with the projects from building XX1 alone accounting for $126,800. Furthermore, these projects could reduce energy consumption by 247 MWh per year and associated green house gas emissions by 99 tons of CO2 per year. These results show that there are many low risk opportunities to realize immediate financial and environmental benefits from improvement projects.

4.3.2 Water Audit

When attempting to analyze the indoor water efficiency of Raytheon in El Segundo, we uncovered a water audit from 2008 performed by the local water basin. Initially, we thought there was great potential for water efficiency projects as the audit showed the company was using very outdated fixtures. According to the audit, the company's toilets and urinals operated at 3.5 and 1.5 gallons per flush (gpf), respectively, and its sinks operated at 2.2 gallons per minute (gpm). The water utility was willing to offer

a grant of $100K to install 1.28 gpf toilets and 0.125 gpf urinals. Furthermore, there were additional rebates of $200 per urinal to install improved fixtures. Quickly calculating the savings showed us that the return from these projects could be immense.

Upon further investigation, however, we learned that most of Raytheon SAS's fixtures had already been replaced. As fixtures had worn out, the company had converted toilets and urinals to 1.68 and 1.0 gpf models, respectively. Unfortunately, by changing the fixtures piecemeal, the company was not able to utilize the grant or the rebates, the water utility would now not offer another grant to improve fixtures further, and the urinal rebates would not apply as they were only applicable when changing 1.5 gpf urinals to 0.125 gpf models, not 1.0 gpf to 0.125 gpf ones.

Despite this disappointment, we did see an opportunity for improving the efficiency of the company's sinks. Our investigation showed that sinks are currently operating at 1.6 gpm. Retrofitting all 817 of Raytheon SAS's sinks to 1.0 gpm would save $7,500 annually. Using a 12 percent discount rate at perpetuity, we calculated the NPV of this project to be $53,790 (Figure 8), with building XX1's 9 sinks accounting for $590 of the value. While not of the magnitude we had initially thought available, this opportunity would still provide the company with significant savings. Finally, a lesson learned from this analysis is a company's facilities management team must stay abreast of the grants and rebates available from outside organizations when trying to maximize returns.

Figure 8 – Water Efficiency Project Calculations

Project	Upfront Cost	Annual Savings	NPV (12%)
1.0 gpm Sink Aerators	$8,710	$7,500	$53,790

4.4 LEED EBOM Benefits of Value to Raytheon

An important aspect in evaluating the business case for LEED EBOM certification was determining the soft benefits associated with it. Any company can realize the economic and environmental impacts from implementing efficiency projects. Furthermore, any company can enjoy the advantages of increased

worker productivity and associated benefits by ensuring a high standard of indoor environmental quality. For an organization to pursue LEED EBOM certification, however, there must be benefits that only third party verification can provide. By discussing aspects of LEED EBOM certification with personnel from business development, human resources, and marketing, we were able to gauge some of the benefits specific to Raytheon SAS.

The first benefit we discovered is the potential for LEED certification to be attractive to customers. We based this conclusion on the robust sustainability goals of Raytheon SAS's largest customer, The Department of Defense (DoD 2011). Recognizing that sustainability applies to all of its missions and programs, the DoD has sought to address its need for sustainability through investments that promote and improve green operations. These investments include the design of high performance buildings, projects that reduce the use of energy and water, the acquisition of energy from renewable sources, projects that optimally manage solid waste, and projects that reduce the use of toxic chemicals (DOD 2011). Despite the DoD's internal goals, however, it does not currently use green or sustainable operations as criteria when evaluating which companies to award its business. Nevertheless, this could change. When looking at where the DoD is headed, it could be advantageous for Raytheon SAS to be proactive about showcasing its sustainability operations. Were the DoD's criteria to change and a company's green accomplishments subject to consideration, having achieved LEED EBOM certification of a "mixed use" facility would allow a company to stand out from its competitors. Finally, a comprehensive LEED program would consolidate various sustainability and energy efficiency projects under one umbrella program that could be measured, validated, and promoted as a business discriminator to customers.

Another benefit of LEED EBOM certification could be its ability to attract talent. Many of Raytheon's employees are eligible for retirement or will be in a few years. Attracting top talent and grooming new leadership to backfill positions is crucial to future success. With the many opportunities available to top talent, a company with something that sets itself apart can be just the discriminator a person needs to join an organization. In a recent recruitment study done for Raytheon by *Universum*, the company found that an organization's reputation, to include its corporate social responsibility and environmental sustainability

practices, is one of the four drivers of employer attractiveness. Furthermore, in an "early careers recruitment study" conducted by Raytheon, 81% of respondents, who were recent college graduates, stated that the reputation of a company had a large impact or very large impact when making job decisions. Finally, being nimble enough to achieve LEED EBOM certification could be something for Raytheon to use to counter the views of those who may see the defense industry as bureaucratic and inflexible.

A final benefit we assessed is that of brand image. As stated previously, achieving LEED EBOM certification is relatively difficult. Being one of the first companies in the Aerospace and Defense industry to achieve LEED EBOM certification of a "mixed use" facility would be quite an accomplishment. Not only would certification show others that a company is committed to sustainability, but, in a broader sense, it would clearly demonstrate that an organization can set a goal, focus its efforts on a difficult objective, and accomplish it.

The soft benefits of LEED EBOM differ depending on the organization. Unfortunately, there is no way to determine the economic advantage of these benefits without the company first achieving certification. For a company with buildings close to meeting the requirements for LEED, it may make sense to implement a pilot program that achieves certification to gain a clearer understanding of these benefits. Should these types of benefits end up being worth the cost, the company could scale its pursuit of certification based on the lessons learned.

4.5 Scaling the LEED EBOM Process

Even if an organization decides LEED EBOM is an effective method for greening existing buildings, it may not make sense for a company to certify all of its buildings. Because a company can realize many of the benefits of LEED EBOM certification without actually achieving third party verification, after certifying a certain number of buildings, there may be diminishing returns to the soft benefits of certification. To address this issue, we created a decision tree to scale the process. Our intent was to provide a tool that would enable a company to determine the buildings for which it should pursue LEED

EBOM certification versus those in which it should only focus on improvement projects. Some of the key discriminators of the model are a building's starting energy efficiency, whether it is owned or leased, the percentage of the campus population in it, and whether customers with sustainability requirements have access.

As an example of our model, priority of resources would go to buildings owned by the company with energy efficiency levels below the national average based on the idea that the energy savings from these types of buildings offer the greatest benefit when compared to the benefits of other approaches. Should all owned buildings achieve energy efficiency levels above the national average, however, the model would direct a user to pursue certification for a building where customers with sustainability requirements have access. In this case, we believe certification would provide the greatest benefit versus any other approach. For a complete discussion of the methodology, refer to Appendix D.

The overall intent of this model is to optimize the benefits of LEED EBOM certification with the economic benefits from exclusively implementing efficiency projects. Since this model is partly based on soft benefits, should the metrics change, once a company is better able to quantify these values, the extent at which it should pursue certification may change.

5 Conclusions

The intent of this study was to determine if LEED EBOM certification is applicable, effective, and optimal for greening existing buildings. While we find that the LEED EBOM framework is applicable for standard and "mixed use" buildings, certification is not necessary to realize many of the financial and environmental benefits from improvement projects. Moreover, LEED EBOM certification does not guarantee a building will be "greener" than its non-certified industry peers. However, we believe the recognition LEED certification provides allows companies to realize many soft benefits. These benefits include certification's attractiveness to customers, its benefit to brand image, and its ability to attract and retain talent. Because the financial impact of these benefits may outweigh the costs to achieve certification, and perhaps be worth more to a company than stand alone efficiency projects, we cannot

reject our hypothesis. Furthermore, because we believe that building XX7 already meets many of the requirements for certification and that the additional effort required will be relatively minimal, we conclude there is a business case for the Raytheon SAS to pursue LEED EBOM Silver level certification of building XX7, enabling it to serve as a pilot project to validate these benefits.

As stated, achieving LEED EBOM Silver certification will require some upfront investment. Many of the policies and procedures the company currently follows have not been recorded in LEED acceptable formats. In order to earn LEED EBOM credits, the company will need to spend staff time documenting and compiling these policies. In addition, due to the company's inexperience with the LEED certification process, the company may require the assistance of outside consultants.

Despite the upfront investment, the company can realize immediate savings by implementing the water and energy projects we analyzed as part of this study. Furthermore, by achieving LEED EBOM Silver certification, the company will gain knowledge and experience that will be crucial for assessing and solidifying future certification plans. Finally, should the benefits from XX7's certification make it worthwhile to pursue LEED EBOM certification for other buildings, many of the credits the company earns from building XX7 will immediately apply to other projects. Accordingly, the marginal cost of LEED certification for each new building will be significantly lower.

Finally, until the results from building XX7 are known, Raytheon SAS should focus on implementing efficiency projects with a positive NPV across its campus to maximize the corresponding financial and environmental benefits.

5.1 Organizational Dynamics

While our results display great potential for improvements and for achieving LEED EBOM certification, it is important to note the organizational dynamics that not only prevented these findings from happening sooner, but also continue to create barriers to improvement. Sustainability projects are not usually a top priority for many organizations. Most companies would rather focus on areas that secure multi-million dollar contracts now, than areas leading to hundreds of thousands of dollars of savings over

time. As a lower priority, sustainability projects face challenges that other capital projects may not experience. These include acceptance issues, inadequate capital funding practices, and having the capacity to implement projects. Overcoming these barriers requires more than just good quality data, it also requires strong top-down leadership and a coalition of people willing to push change.

One barrier this study had some success overcoming is that of acceptance. Strong upper leadership not only provided the funding and resources needed to drive this project, but it also served as a liaison between divisions to remove many obstacles. At our level, an important aspect that allowed us to convince others to support our study was our immediate discovery of the tools necessary to analyze the company's energy efficiency data and demonstrate the great potential for savings. Doing this quickly allowed us to build credibility and capital, which enabled us to persuade others. Furthermore, constantly meeting with stakeholders allowed us to build rapport, which enabled us to demonstrate to them that our project was in the best interests of the company. Finally, by focusing on small wins verses effort intensive, ambitious projects, we were able to persuade stakeholders to be more willing to accept incremental change.

In order for this study to be successful going forward, top leadership and a strong cross-functional coalition will continue to be necessary to overcome the additional barriers mentioned. Current financing practices seek a two-year payback for sustainability projects. This is a poor method when determining which projects to fund as a two-year payback implies a project must experience an annual 50% return on investment. Sustainability projects should be evaluated at the same discount rate as other capital expenditure projects, if not a lower one due to their lesser risk. Organizations should then assess projects based on NPV and fund all those with a positive NPV. It will take strong leadership, however, to create the organizational change needed to treat sustainability projects on par with other endeavors and fund them as such. Finally, top-down leadership will be needed to accurately assess the capacity issues at the company. The facilities division at Raytheon SAS works on many projects to maintain and improve the efficiency of the campus. However, there may not be enough personnel to implement improvements driven by positive NPV or LEED EBOM requirements. While expanding capacity in order to be proactive

with projects may not be a welcomed solution, a team that is better able to manage projects and validate results may be worth the investment in the long run.

5.2 Recommendations and Implications for all Industries

The financial and environmental benefits of efficiency projects are significant. While the LEED EBOM framework is a valuable tool for implementing projects that result in considerable economic, environmental, and social benefits, regardless of LEED certification, companies should take steps to execute improvement projects immediately. As part of this process, organizations must install energy and water meters for all facilities in order to benchmark efficiency and determine where to prioritize efforts. Next, companies should perform water and ASHRAE Level 1 energy audits for all buildings to discover the improvement opportunities available. These projects should only be assessed in terms of NPV. As these projects are low-risk, companies should then finance all projects possessing a positive NPV. Finally, because it may not be a monetary issue, but a capacity one that prevents companies from realizing the savings from improvement projects, companies should evaluate whether they have the personnel necessary to carry out these projects as well as the consequences of failing to adjust their resources.

In terms of LEED EBOM certification, because we believe the benefits from actual certification are mostly due to "soft" factors, companies must first analyze the benefits of certification that are specific to their organizations. If companies find they could benefit from certification and they possess buildings that are already energy efficient, LEED certification may be an effective method to gain recognition for their efforts.

6 References

Capuzzi, Angelo. (2010). "Strategic Planning for LEED Certification." MBA Thesis, MIT, Massachusetts.

Carnegie Mellon University. (2004). "Replace outdated office lighting with quality lighting components featuring high-performance lamps, ballasts, fixture and advanced controls for 27 - 87% lighting energy savings, 0.7 - 26 % productivity gains, and 27% headache reduction, with ROIs over 236%." *Advanced Building Systems Integration Consortium*, <http://www.learningace.com/doc/2315941/d4f3f806bf4cbf0f37657c3a5a3f5996/lighting> (January 24, 2013).

Deloitte. (2008). "The Dollars and Sense of Green Retrofits." <http://www.deloitte.com/assets/Dcom-UnitedStates/Local%20Assets/Documents/us_re_Dollars_Sense_Retrofits_190608_.pdf> (January 25, 2013).

Department of Defense. (2011). "Department of Defense Strategic Sustainability Performance Plan FY 2011." <http://www.acq.osd.mil/ie/download/green_energy/dod_sustainability/DoD%20SSPP%20Public_2011.pd f> (February 17, 2013).

Energy Star. (2013). *Energy Star Portfolio Manager.* <http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager> (January 17, 2013).

Karolides, Alexis. (2002). "Green Building Approaches." *Green Building: Project Planning & Cost Estimating*, 3-22, RS Means, Massachusetts.

Kats, Greg, Alevantis, Leon, Berman, Adam, Mills, Evan, and Perlman, Jeff. (2003). "The Costs and Financial Benefits of Green Buildings." *A Report to California's Sustainable Building Task Force*, <http://www.usgbc.org/Docs/Archive/General/Docs1992.pdf> (January 25, 2013).

Leonardo Academy. (2008). "The Economics of LEED for Existing Buildings for Individual Buildings 2008 Edition." <http://www.leonardoacademy.org/download/Economics%20of%20LEED-EB%2020090222.pdf.> (January 31, 2013).

Lyneis, John. (2012). "Resistance from Top to Bottom: The Dynamics of Risk Management in Complex Organizations." PhD diss., MIT, Massachusetts.

Melaver, Martin, and Mueller, Phyllis. (2009). *The Green Building Bottom Line*, McGraw-Hill, New York.

Menassa, Carol, Mangasarian, Seth, El Asmar, Mounir, and Kirar, Carl. (2012). "Energy Consumption Evaluation of U.S. Navy LEED-Certified Buildings." *Journal of Performance of Constructed Facilities*, 26(1), 46-53.

Miller, Norm, Pogue, Dave, Gough, Quiana, and Davis, Susan. (2009). "Green Buildings and Productivity." *Journal of Sustainable Real Estate*, 1(1), 65-89.

Montoya, Michael. (2010). *Green Building Fundamentals*, Prentice Hall, Ohio.

Repenning, N. and Sterman J. (2001). "Nobody Ever Gets Credit for Fixing Problems that Never Happened: Creating and Sustaining Process Improvement." *California Management Review*, 43(4), 64-88.

Repenning, N. and Sterman J. (2002). "Capability Traps and Self-Confirming Attribution Errors in the Dynamics of Process Improvement." *Administrative Science Quarterly*, 47(2), 265-295.

Scheuer, Chris, and Keoleian, Gregory. (2002). "Evaluation of LEED Using Life Cycle Assessment Methods." *National Institute of Standards and Technology*, <http://www.fire.nist.gov/bfrlpubs/build02/PDF/b02170.pdf> (March 5, 2013).

Scofield, John. (2009). "Do LEED-certified buildings save energy? Not really...." *Energy and Buildings*, 41(12), 1386-1390.

U.S. Environmental Protection Agency. (2013). *EPA Green Buildings*. <http://www.epa.gov/oaintrnt/projects/index.htm> (March 5, 2013).

U.S. Green Building Council (USGBC) Inc. (2009). *Foundations of LEED*, USGBC, Washington, DC.

U.S. Green Building Council (USGBC) Inc. (2009). *Green Buildings Operation and Maintenance*, USGBC, Washington, DC.

Yudelson, Jerry. (2008). *The Green Building Revolution*, Island Press, Washington DC.

Yudelson, Jerry. (2010). *Greening Existing Buildings*, McGraw-Hill, New York.

Appendix A: Portfolio Manager: Methodology

A.1 Portfolio Manager[2]

Portfolio Manager, which can be found at http://www.energystar.gov, is an interactive energy management tool that allows building owners to track and assess energy and water consumption across an entire portfolio of buildings. In doing so, owners can identify under-performing buildings and verify efficiency improvements.

For many facilities, an owner can rate his buildings' energy performance on a scale of 1–100 relative to similar buildings nationwide. However, a building is not compared to the other buildings entered into Portfolio Manager to determine its energy star rating. Instead, statistically representative models are used to compare a building against similar buildings from a national survey conducted by the Department of Energy's Energy Information Administration. This national survey, known as the Commercial Building Energy Consumption Survey (CBECS), is conducted every four years, and gathers data on building characteristics and energy use from thousands of buildings across the United States. A building's peer group of comparison is those buildings in the CBECS survey that have similar building and operating characteristics. A rating of 50 indicates a building, from an energy consumption standpoint, performs better than 50% of all similar buildings nationwide, while a rating of 75 indicates that the building performs better than 75% of all similar buildings nationwide. A rating of 69 is required to meet a LEED EBOM prerequisite.

The energy performance rating system evaluates the performance of buildings that use all types of energy. To compare this diverse set of commercial buildings equitably, the ratings must express the consumption of each type of energy in a single common unit. The EPA has determined that source energy is the most equitable unit of evaluation. Source energy represents the total amount of raw fuel required to operate the building. It incorporates all transmission, delivery, and production losses, thereby enabling a

[2] The information in this section has been compiled from the Portfolio Manager Overview section of the Energy Star website available at http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager.

complete assessment of energy efficiency in a building. Furthermore, this type of energy correlates best with the resulting environmental impact and energy cost.

A rating is calculated based on the information an owner enters about his building, such as its size, location, space type, number of occupants, number of PCs, etc. The rating system then estimates how much energy the building would use if it were the best performing, the worst performing, and every level in between. The system then compares the actual energy data an owner enters to this estimate to determine where a building ranks relative to its peers.

The types of commercial buildings eligible to receive a rating are: Bank/Financial Institution, Courthouse, Data Center, Hospital, Hotel, House of Worship, K – 12 School, Medical Office, Wastewater Treatment Plant, Office, Residence Hall/Dormitory, Retail Store, Senior Care Facility, Supermarket, and Warehouse. In order to receive a rating, more than 50% of the building's gross floor area (excluding parking lots and garages) must be defined by one of these space types and no more than 10% of the building's gross floor area can be defined as other.

A.2 Methodology Applied to Raytheon SAS's Buildings

To analyze each building's energy efficiency, we collected the company's utility data from 2011, the gross square footage of each building, and the breakdown, by square footage, of each space type that makes up each building.

Some buildings at Raytheon SAS have their own individual electricity and gas meters. In this case, we were able to enter these buildings' energy use by utilizing the company's utility bills. Some buildings get their electricity through a substation and that electricity use is then measured for each building by sub meters. While this gave us electricity usage for these buildings, we could not measure these buildings' gas usage. However, we did have utility bills that showed us how much natural gas was used by the central plant. Because the products for which gas is used in this building are distributed to all other buildings, we made the assumption that each building's gas usage was proportional to its electricity usage and calculated the amount of natural gas used based on the total measured amount. For example, if building XX7 used 30

percent of the electricity from the substation, we assumed it would use 30 percent of the natural gas coming into the central plant. Furthermore, for any building without an energy meter, we did not enter any information into Portfolio Manger. Finally, we followed the steps outlined for the Portfolio Manger Tool at http://www.energystar.gov/index.cfm?c=evaluate_performance.bus_portfoliomanager_benchmarking to name our meters and properly input our data.

To categorize each of Raytheon SAS's buildings, we calculated the percentage of floor space based on the breakdown the company provided us. For this breakdown, we used total gross square footage by building as well as the square footage by building space type. When totaling up square footage by space type for each building, however, the sum did not match the building's total gross square footage. We attributed this difference to common areas, such as hallways and restrooms, which were not categorized. In this case, we distributed the difference by proportioning by the space types we could identify. As with energy use, we followed the steps outlined in the Portfolio Manager Tool to input the data.

Because some of the company's buildings consist of space types in proportions that make them ineligible for Portfolio Manager, these buildings did not receive an energy star rating. However, the tool did calculate the source energy for these buildings. With this value, we could use the tools described in Appendix B to calculate the energy efficiency of these "mixed use" buildings.

Appendix B: labs21Methodology

Because some buildings from this study consist of laboratories that make up more than 10 percent of the building's gross floor space, these types of buildings are ineligible for an energy star score. Consequently, we cannot use only Portfolio Manager to determine energy efficiency; we must use a combination of tools. In this case, our first step is to find the source energy intensity of our building using Portfolio Manager and the procedure outlined in Appendix A. Once we have this value, we can use the labs21benchmarking tool, found at http://labs21benchmarking.lbl.gov/, and such metrics as lab area ratio, lab type, occupancy hours, and climate zone to determine the peer facility average for these types of buildings. The technical bulletin outlining the procedure on how to use this tool in the context of LEED EBOM can be found at http://labs21benchmarking.lbl.gov/docs/Applying+Labs21+Benchmarking+for+LEED-EB+12-13-10.pdf. Once we have our source energy intensity and the average source energy intensity, we can use the labs21 tool shown below to compare values. Inputting total floor space, space types, and the two source energy intensity values into this tool allows us to calculate whether our building meets a key LEED EBOM energy and atmosphere prerequisite as well as how many energy performance credits it earns.

I. Use this Option 1-Labs calculator if laboratories occupy at least 10% of total floor area

Related instructions and tools

Labs21 Guidance on how to use the tool for LEED EB: O&M — Labs21 Benchmarking Tool

II. Basic Information

Project Building Name	
LEED Registration Number	
Project Administrator	
Responsible Party (if different)	
Measured energy end date (enter the final date of the year of metered energy used in this calculation)	12/31/2012
Gross floor area (sq ft)	37,345

III. Determine Labs option eligibility

Complete yellow cells showing the floor space for each major space type in the building

Do not enter parking/garage space

	INPUT AREA			
	Space Name	Space Type (choose from drop-down list)	Gross floor area (sq ft)	% of Total floor area
1	Laboratory	Laboratory	32,261	86%
2	Office	Office	4,189	11%
3	Warehouse	Warehouse- Self-storage	895	2%
4				
5				
6				
	Whole Building	Combined	37,345	100%

Enter your building energy use on the Labs 21 website (see link under I. above), and follow the guidance document there for determining your baseline National Average. Transfer the result to section IV below

IV. Determine EAc1 Points for Option 1-Labs

This Project Building's annual weather-normalized Source Energy Use Intensity (from Portfolio Manager)	321	kBtu/sf
Peer Facility Average (from your Labs 21 Benchmark Statistics. See example in V. below)	596	kBtu/sf

Approximate percentile points above National Average	**33**
EAc1 points for Option 1 Adjusted Benchmark Score	12

Enter Percentile Points Above Average in LEED Online for Case 2, Option 1. Upload to the online Template the pdf of the Peer Facility results page from Labs21

Appendix C: LEED EBOM Example Scorecard

LEED-Existing Buildings: O&M v2009

Registered Project Checklist

Project Name

Date

Sustainable Sites — Possible Points: 26

Y	N	?			
			Credit 1	LEED Certified Design and Construction	4
			Credit 2	Building Exterior and Hardscape Management Plan	1
			Credit 3	Integrated Pest Mgmt, Erosion Control, and Landscape Mgmt Plan	1
			Credit 4	Alternative Commuting Transportation	3 to 15
			Credit 5	Site Development–Protect or Restore Open Habitat	1
			Credit 6	Stormwater Quantity Control	1
			Credit 7.1	Heat Island Reduction–Non-Roof	1
			Credit 7.2	Heat Island Reduction–Roof	1
			Credit 8	Light Pollution Reduction	1

Water Efficiency — Possible Points: 14

Y	N	?			
Y			Prereq 1	Minimum Indoor Plumbing Fixture and Fitting Efficiency	
			Credit 1	Water Performance Measurement	1 to 2
			Credit 1	Additional Indoor Plumbing Fixture and Fitting Efficiency	1 to 5
			Credit 1	Water Efficient Landscaping	1 to 5
			Credit 1	Cooling Tower Water Management–Chemical Management	1
			Credit 1	Cooling Tower Water Management–Non-Potable Water Source Use	1

Energy and Atmosphere — Possible Points: 35

Y	N	?			
Y			Prereq 1	Energy Efficiency Best Management Practices	
Y			Prereq 2	Minimum Energy Efficiency Performance	
Y			Prereq 3	Fundamental Refrigerant Management	
			Credit 1	Optimize Energy Efficiency Performance	1 to 18
			Credit 2.1	Existing Building Commissioning–Investigation and Analysis	2
			Credit 2.2	Existing Building Commissioning–Implementation	2
			Credit 2.3	Existing Building Commissioning–Ongoing Commissioning	2
			Credit 3.1	Performance Measurement–Building Automation System	1
			Credit 3.2	Performance Measurement–System-Level Metering	1 to 2
			Credit 4	On-site and Off-site Renewable Energy	1 to 6
			Credit 5	Enhanced Refrigerant Management	1
			Credit 6	Emissions Reduction Reporting	1

Materials and Resources — Possible Points: 10

Y	N	?			
Y			Prereq 1	Sustainable Purchasing Policy	
Y			Prereq 2	Solid Waste Management Policy	
			Credit 1	Sustainable Purchasing–Ongoing Consumables	1
			Credit 2.1	Sustainable Purchasing–Electric	1
			Credit 2.2	Sustainable Purchasing–Furniture	1
			Credit 3	Sustainable Purchasing–Facility Alterations and Additions	1
			Credit 4	Sustainable Purchasing–Reduced Mercury in Lamps	1
			Credit 5	Sustainable Purchasing–Food	1

Materials and Resources, Continued

Y	N	?			
			Credit 6	Solid Waste Management–Waste Stream Audit	1
			Credit 7	Solid Waste Management–Ongoing Consumables	1
			Credit 8	Solid Waste Management–Durable Goods	1
			Credit 9	Solid Waste Management–Facility Alterations and Additions	1

Indoor Environmental Quality — Possible Points: 15

Y	N	?			
Y			Prereq 1	Minimum IAQ Performance	
Y			Prereq 2	Environmental Tobacco Smoke (ETS) Control	
Y			Prereq 3	Green Cleaning Policy	
			Credit 1.1	IAQ Best Mgmt Practices–IAQ Management Program	1
			Credit 1.2	IAQ Best Mgmt Practices–Outdoor Air	1
			Credit 1.3	IAQ Best Mgmt Practices–Increased Ventilation	1
			Credit 1.4	IAQ Best Mgmt Practices–Reduce Particulates in Air Distribution	1
			Credit 1.5	IAQ Mgmt Plan–IAQ Mgmt for Facility Alterations and Additions	1
			Credit 2.1	Occupant Comfort–Occupant Survey	1
			Credit 2.2	Controllability of Systems–Lighting	1
			Credit 2.3	Occupant Comfort–Thermal Comfort Monitoring	1
			Credit 2.4	Daylight and Views	1
			Credit 3.1	Green Cleaning–High Performance Cleaning Program	1
			Credit 3.2	Green Cleaning–Custodial Effectiveness Assessment	1
			Credit 3.3	Green Cleaning–Sustainable Cleaning Products, Materials Purchases	1
			Credit 3.4	Green Cleaning–Sustainable Cleaning Equipment	1
			Credit 3.5	Green Cleaning–Indoor Chemical and Pollutant Source Control	1
			Credit 3.6	Green Cleaning–Indoor Integrated Pest Management	1

Innovation in Operations — Possible Points: 6

			Credit 1.1	Innovation in Operations: Specific Title	1
			Credit 1.2	Innovation in Operations: Specific Title	1
			Credit 1.3	Innovation in Operations: Specific Title	1
			Credit 1.4	Innovation in Operations: Specific Title	1
			Credit 2	LEED Accredited Professional	1
			Credit 3	Documenting Sustainable Building Cost Impacts	1

Regional Priority Credits — Possible Points: 4

			Credit 1.1	Regional Priority: Specific Credit	1
			Credit 1.2	Regional Priority: Specific Credit	1
			Credit 1.3	Regional Priority: Specific Credit	1
			Credit 1.4	Regional Priority: Specific Credit	1

Total — Possible Points: 110

Certified 40 to 49 points Silver 50 to 59 points Gold 60 to 79 points Platinum 80 to 110

Appendix D: LEED Decision Tree

In order to maximize returns, we created a decision tree to scale our process and enable Raytheon to determine the buildings for which it should pursue LEED EBOM certification versus those in which it should only focus on improvement projects. Because many of the benefits of LEED EBOM certification depend on difficult to quantify factors, specific to an industry, these aspects are a large part of this tool. Furthermore, we believe this tool will be most useful once a company has a better understanding of these types of benefits and can adjust the metrics accordingly.

The first discriminator of this tool is whether a company owns a targeted building or has at least a 5-year lease for it. If not, we did not think it would make sense to pursue LEED certification or implement efficiency projects. In this case, the company should select another building.

Our next gate is whether a building has meters to measure its use of utilities. If not, because we cannot measure efficiency without individual meters, the decision tool directs the company to install meters before proceeding. If so, the tool instructs the company to benchmark the building's energy efficiency using the procedures outlined in Appendices A or B.

Should the building's energy efficiency allow it to meet a key LEED energy and atmosphere prerequisite, the company is directed to conduct a LEED EBOM credit gap analysis on the building. If the building's energy efficiency does not meet the prerequisite, whether customers with sustainability requirements have access to the building or whether the building employs > 2.5 percent of the campus population is considered. The reasoning for this first caveat is, a company is better able to display its certification efforts to customers with sustainability requirements when these customers are in a certified building. The reasoning for the second caveat is, because a benefit of LEED EBOM certification is the potential to attract and retain talent, it is better to certify buildings where the highest probability exists for this talent to work. If these two caveats do not apply, but the building's energy performance score is below 50, the company is directed to implement energy efficiency projects on the building and grant it first priority for resources since the potential for financial and environmental benefits are greatest. If these two caveats do not apply and the building's energy efficiency is above the national average, this building

has last priority for efficiency projects. Finally, if the two caveats do apply, the building has second priority for efficiency projects in order to allow it to meet the LEED prerequisite and push for certification.

For those buildings the tool directs to conduct a gap analysis, should a building possess enough credits to achieve certification, the tool directs the company to register the building for certification. Should the building not have enough credits to achieve certification, once again the two caveats are considered. Should these stipulations not apply, the tool rejects the building from consideration for LEED certification. Should these caveats apply, the tool directs the company to implement improvements or policies to achieve enough credits so the building can register for certification.

While not perfect or final, this tool is a first attempt at assisting companies to maximize the benefits from greening their existing buildings. A key step in refining this model will be implementing a pilot project that achieves LEED EBOM certification in order to better understand the benefits associated with it. Once these benefits are knows, a company will have a better idea how to optimally green their buildings for the greatest return.