FEASIBILITY OF GREEN BUILDING AT WPI

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By

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ABSTRACT

College campuses, with significant numbers of older facilities, have the opportunity to lead the green building movement while reaping economic, health, environmental, educational, and marketing benefits. This project assessed the current status of green building programs at Worcester Polytechnic Institute (WPI), the costs and benefits of building green, and the costs and benefits of LEED certification to make the business case for LEED-certified buildings. This project also proposed a strategic plan for green building programs at WPI to promote and measure green building improvements to new and existing facilities. Lastly, this project assessed the feasibility of certifying existing facilities with the LEED Existing Building rating system. By evaluating all of the costs and the major benefits, the results of this project demonstrate that the benefits of building green and LEED certification outweigh the costs and that through strategic planning WPI can become a leader among colleges implementing green building programs.

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1.0 INTRODUCTION

As the effects of global warming become more visible and the issue of global warming continues to gain attention, society is looking for ways to reduce its impact on what has been called the climate crisis. Looking beyond household or office recycling and carpooling, the nation needs to address one of the largest contributors to energy usage and carbon dioxide emissions: buildings. According to the United States Green Building Council (USGBC), the operation of buildings consumes 40 percent of energy and 71 percent of electricity used in the United States and is responsible for 38 percent of the United State's carbon dioxide emissions (2007e). One proven way to reduce the negative environmental impact of a building is to implement green or sustainable building design and construction practices.

Green, or sustainable, building is defined by the United States Environmental Protection Agency (EPA) as "the practice of creating healthier and more resource-efficient models of construction, renovation, operation, maintenance, and demolition" (2007). A wide range of benefits can be found through building green, including environmental, economic, and health. To promote green building, the USGBC developed a green building rating system called Leadership in Energy and Environmental Design (LEED) (USGBC 2007c).

LEED evaluates a building in six different categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design Process (USGBC 2007c). To receive LEED certification, a building must be registered to show the owner's intent to pursue LEED, meet all prerequisites, and obtain a certain number of points throughout the categories. While all building sectors are eligible to register and certify a building, college and university campuses are an important target for LEED certification and building green in general. This is due to their current growth, energy usage, outdated facilities, and educational missions.

The United States Department of Energy (DOE) states that "universities consume energy like mini-cities" (2006). University facilities operate as houses, retail shops, restaurants, offices, sports centers, and schools. Energy costs are rising along with the students' demands for energy-intensive amenities such as air conditioning and high-speed internet (USDOE 2006). In recognition of the financial and assorted other benefits that can be found through green building, as well as the marketability of LEED-certified buildings, many college campuses have registered and certified their recent building projects.

As of 2005, higher education facilities were the third most common LEED-registered project type, accounting for 7.1 percent of all LEED-registered projects (Yudelson 2006). As of March 2008, two of three LEED-certified buildings and five of seven LEED-registered projects in Worcester, Massachusetts were on college campuses (USGBC 2008d). Worcester Polytechnic Institute (WPI), the university on which this thesis focuses, accounts for one of the LEED-certified buildings and one of the LEED-registered buildings in Worcester.

While many colleges are jumping on the "green" bandwagon, few have strategically planned their approach to green building. Green building policies exist on many college campuses, including WPI, but a commitment to sustainability in future building projects is only part of the picture. A strategic plan must be developed to promote and measure the status and benefits of building green and green building programs. One way to do this is to develop a Balanced Scorecard (BSC).

The BSC approach to strategic planning was developed by Robert Kaplan and David Norton (WPI '62) as a tool to provide managers with a fast, comprehensive view of business (Kaplan & Norton 1992). Found to be most successful when used to drive change, BSCs have been implemented at top companies, government agencies, and non-profit organizations. Defying the short-lived popularity of most strategic management tools, the BSC was included in the *Harvard Business Review*'s list of the 75 most influential ideas of the twentieth century (Niven 2006). The BSC is unique because it includes both financial and operational measures to create a balance between leading and lagging indicators, short- and long-term objectives, and internal and external performance (NetMBA 2007).

The goal of this thesis was to promote green building at WPI through the development of a strategic planning tool and the assessment of green building costs and benefits. Using the BSC approach, this academic project proposes a strategic plan to promote and measure the benefits of green building at WPI. To further promote green building, this project evaluated the costs and benefits of building new facilities to green building standards and the LEED premium, or the costs associated with LEED certification. Lastly, this thesis investigated the LEED Existing Buildings rating system for use on existing buildings at WPI. The results of this thesis demonstrate that the benefits of green building and LEED certification outweigh the costs and that through strategic planning WPI can become a leader and strong competitor among colleges implementing green building programs.

2.0 BACKGROUND

To evaluate the costs and benefits of building green at WPI, having a general understanding of green building was important. This section explores the history of the green building movement, the current green building standards of choice, and the general benefits green buildings provide. To relate this information to building green on college campuses, this section also includes information regarding construction on college campuses, green building design on college campuses, and the status of green building on WPI's campus. In order to understand the methods used to complete this project, the engineering economic techniques used are explained and the BSC and its uses are explored.

2.1 The Green Building Movement

The green building movement dates back to the energy crisis of the 1970s. With the increase in fuel prices, Americans began to question their reliance on fuel for transportation and building operation (Building Design & Construction 2003). Within four years of the OPEC oil embargo, the American Institute of Architects (AIA) formed the AIA Committee on Energy, the United States Government formed the Department of Energy (DOE), and the DOE established the National Renewable Energy Laboratory. During this time, some of the first green building techniques were used.

The term sustainable development was defined for the first time in 1987 by the United Nations World Commission on Environment and Development as that which "meets the needs of the present without compromising the ability of future generations to meet their own needs" (United Nations 2005). Sustainable development continued to be a popular topic among architects and engineers at conferences and meetings over the next six years. The topic spread to the public with the election of President Bill Clinton.

On Earth Day 1993, President Clinton announced the "Greening of the White House" (Building Design & Construction 2003). The goal was to make the presidential mansion "a model for efficiency and waste reduction" (p. 5). An energy audit performed by the DOE, an environmental audit completed by the EPA, and a number of design charettes led to numerous improvements to the two-hundred-year-old building. The improvements resulted in $300,000 in annual water and energy savings, as well as landscaping and solid waste expenses, and reduced the White House's atmospheric emissions by 845 tons of carbon per year.

The success of the Greening of the White House sparked two important steps in the history of the green building movement. The first was the green renovation of other federal buildings and national parks such as the Pentagon and the Grand Canyon (Building Design & Construction 2003). The second was the establishment of the President's Council on Sustainable Development. The council developed a list of 140 recommendations to improve the environment. Following that lead, many other federal agencies and departments made their own renovations.

Alongside the government's push for green building was the incorporation of the United States Green Building Council (USGBC). In 1993, the same year as the Greening of the White House, the USGBC, a non-profit organization, was founded to promote green building (USGBC 2007d). Since that time, the USGBC has created and continues to develop standards to evaluate sustainable buildings. These standards, called Leadership in Energy and Environmental Design (LEED), serve as a rating system for the design, construction, and operation of green buildings.

2.2 LEED

Between the development of LEED in 1998 and 2007, over 1,000 projects were certified, over 8,000 projects were registered for LEED certification, and over 40,000 building and design professionals became LEED Accredited (Hicks 2007). The original rating system has been further developed, and nine different systems have been created. These rating systems include standards for New Commercial Construction and Major Renovations, Existing Building Operations and Maintenance, Commercial Interiors, Core and Shell Development Projects, Homes, Neighborhood Developments, Schools, Retail, and Healthcare (USGBC 2007c). It should be noted that LEED for Schools is primarily used for K-12 schools, and although it can be used for higher education facilities, it is not required (USGBC 2008b). Based on the certification of most higher education facilities, this thesis focuses on LEED for New Commercial Construction and Major Renovations (LEED-NC) and LEED for Existing Building Operations and Maintenance (LEED-EB).

In each standard, LEED evaluates a building's sustainability in six categories: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, Indoor Environmental Quality, and Innovation and Design Process (USGBC 2007b). USGBC affirms that approaching the whole building reduces operating costs, results in healthier and more productive occupants, and conserves our natural resources (USGBC 2007c). Each category identifies and a number of items eligible for points and some categories identify specific requirements, or prerequisites, that must be satisfied to receive certification. The percentage of total points in each category in LEED-NC guidelines is shown in Figure 1. The percentage of total points for LEED-EB is shown in Figure 2.

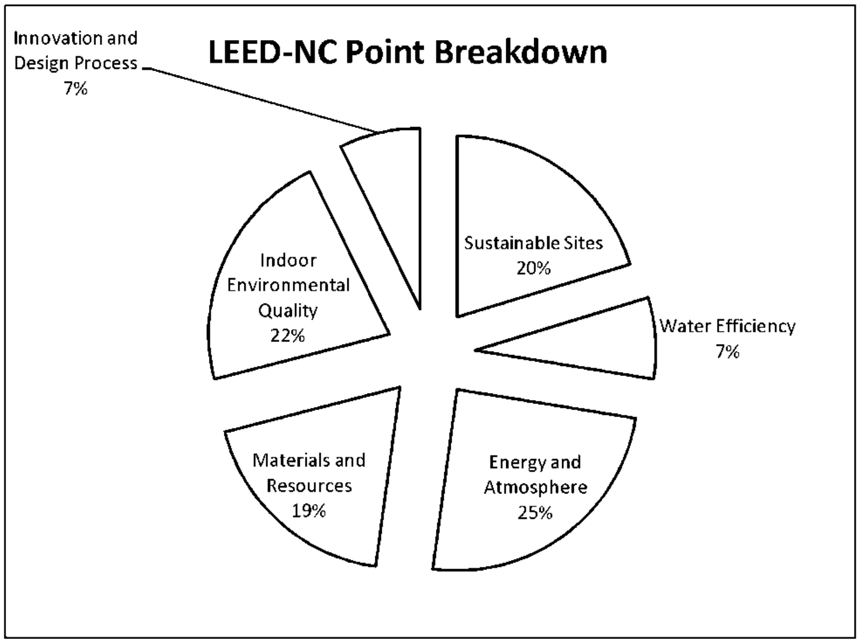

Figure 1: LEED-NC Point Breakdown (USGBC 2007b)

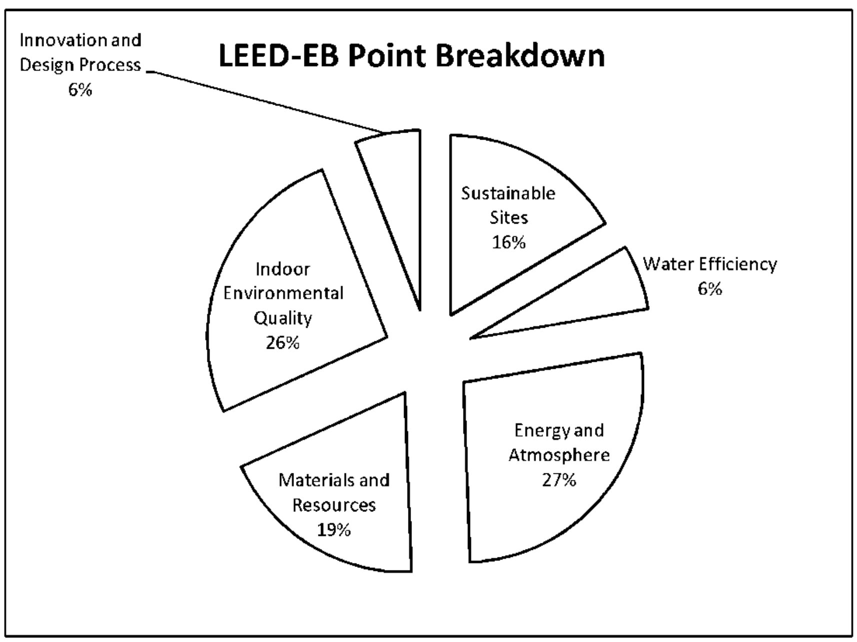

Figure 2: LEED-EB Point Breakdown (USGBC 2007a)

The total points a project receives determines the level of certification the project receives. Table 1 shows the points required for the LEED-NC and LEED-EB levels.

Table 1: LEED Points Required (USGBC 2007a, 2007b)

Rating Level	NC Points Required	EB Points Required
Certified	26-32	32-39
Silver	33-38	40-47
Gold	39-51	48-63
Platinum	52-69	64-85

As shown, LEED for Existing Buildings contains more possible points, yet the percentage of points required to obtain each level of certification is the same.

A study completed in 2003 for the California Sustainable Building Task Force assessed the cost of building to each LEED certification level (Kats 2003a). The study analyzed cost data for 33 buildings – 25 office buildings and 8 schools – completed between 1995 and 2004 to determine the premium cost, or green premium. Table 2 summarizes the data compiled in this study.

Table 2: Average Green Cost Premium by LEED Certification Level (Kats 2003a)

LEED Certification Level	Average Green Cost Premium
Certified	0.66%
Silver	2.11%
Gold	1.82%
Platinum	6.50%

The average price increase for the 33 buildings studied was 1.84 percent. As shown, the green premium for gold was less than silver. Kats, the author of the study, attributes this anomaly to the number of buildings studied for each certification level. Only six gold buildings were studied, whereas 18 silver buildings were studied. Another factor would be the date the facilities were constructed. For example, the date of completion for the silver buildings ranged from 1994 to 2004, while the date of completion for gold buildings ranged from 2000 to 2003.

The green premium is generally attributed to higher priced materials, increased design time, modeling costs, and LEED certification costs (Kats 2003b). At WPI, the estimated green premium for East Hall, a new residence building, was 2.6 percent at the beginning of the project (Cannon 2007). It should be noted that the architect of this facility found the green premium to be so high because of the green roof. Using a different roof, the green premium would be 1.1 percent.

This project also considers the LEED premium, or costs associated with LEED certification. The LEED premium is comprised of soft costs and the costs to register and certify a project. LEED soft costs include extra design time, LEED documentation time, and modeling costs (RSMeans 2006). Not included in soft costs are the cost of materials, technology, or construction labor. A study for the General Services Administration found the following soft costs for court houses and office buildings based on certification level and the process used.

Table 3: LEED Soft Costs Per Square Foot (RSMeans 2006)

<table>
<tr><th colspan="2">Building Type</th><th colspan="2">Court House</th><th colspan="2">Office Building</th></tr>
<tr><th colspan="2">Process</th><th>Owner Hires LEED Expert Outside Project Team</th><th>Owner Hires Design Team to Perform LEED Duties</th><th>Owner Hires LEED Expert Outside Project Team</th><th>Owner Hires Design Team to Perform LEED Duties</th></tr>
<tr><td rowspan="3">LEED Rating</td><td>Certified</td><td>$0.41 to $0.46</td><td>$0.43 to $0.45</td><td>$0.41</td><td>$0.35</td></tr>
<tr><td>Silver</td><td>$0.41 to $0.55</td><td>$0.44 to $0.54</td><td>$0.44 to $0.49</td><td>$0.36 to $0.44</td></tr>
<tr><td>Gold</td><td>$0.61 to $0.81</td><td>$0.56 to $0.73</td><td>$0.69 to $0.70</td><td>$0.58 to $0.59</td></tr>
</table>

The other major factor in the cost of building green with the USGBC are the costs and fees associated with LEED certification. The table below shows cost of USGBC membership and the rates for LEED certification. As shown, USGBC members receive a discounted rate when registering and certifying a project. Currently, WPI is not a USGBC member, but would be eligible for the discounted rates if the party responsible for registration and LEED documentation was a USGBC member. The responsible party could be the architect, LEED consultant, or construction manager. The USGBC membership shown in the second column is an annual dues. The cost of project registration is a set fee, while the cost of certification is dependant on the square footage of the building (USGBC 2008c). If the project receives a LEED-platinum rating, the certification fees are reimbursed.

Table 4: Cost of LEED Registration and Certification (USGBC 2008c)

	USGBC Membership (1-2 Univ. Campuses)	LEED Registration	LEED Certification		
			Less than 50,000 SF	50,000-500,000 SF	More than 500,000 SF
USGBC Member	-	$450.00	$1,750.00	$0.035/SF	$17,500.00
USGBC Non-Member	$750.00	$600.00	$2,250.00	$0.045/SF	$22,500.00

Other factors that can increase or decrease the green and LEED premiums are the level of LEED certification, stage when the decision to seek LEED certification is made, project type, green technology used, level of direction given by the owner, geographic location, and design team's experience with green buildings and the LEED process (Yudelson 2008). As shown in Table 2, the level of LEED certification affects the green premium. If the decision to go green and/or seek LEED certification is made after 50 percent of the construction documents are complete, changes required for LEED certification become more involved and costly. Certain types of projects require more costly changes, such as laboratories. Also, certain types of green technology, like photovoltaics and green roofs, cost more regardless of any other factors. However, LEED certification can be achieved without these. The more direction the owner gives, the more organized the team's strategy can be. The geographic location can affect the cost of the project because the climate and local codes can make LEED certification more or less difficult. It has also been found that the green premium is reduced when team members have increased experience with LEED-certified projects and green buildings.

2.3 Benefits of Green Building

Any time a cost is added to a project, the owner needs to find a rational justification for the increase. For this reason, many studies have assessed the general benefits of green buildings. It has been found that green buildings can reduce energy usage and operating costs, and improve the asset value of a building (RSMeans 2006). Green buildings can also improve occupant productivity, reduce worker absenteeism, and contribute to higher employee retention rates.

Further economic benefits include reduced operating costs, reduced maintenance costs, increased building value, and tax benefits. Green buildings incorporate many energy efficient technologies that can reduce usage by 25 to 40 percent (Yudelson 2008). Energy-saving buildings can also be easier to operate and maintain because the owner conducts functional testing of energy-using systems before the building is commissioned. The building's efficiency increases the asset value of the building. "For a small up-front investment, an owner can reap benefits that typically offer a payback of three years or less and a rate of return exceeding 20 percent" (Yudelson 2008, p. 32). Finally, many states, as well as the federal government, offer tax benefits for green buildings.

Productivity benefits are primarily found through the service industry (Yudelson 2008). Healthier indoor spaces, created by improved air quality, increased daylighting, and temperature control, have been found to be worth one to five percent of employee costs.

Certifying a project can also provide the owner with risk-management benefits. The certification serves as verification of measures to improve the indoor air quality (Yudelson 2008). This becomes increasingly important as the issue of mold and its effects on building occupants gains attention. Aside from serving as a level of protection against litigation, green buildings can also reduce risk by reducing delays due to preferred status in permitting in many cities, and the resulting ease of renting, selling, and insuring the facility.

Green buildings have also been found to provide health benefits. Improving the indoor air quality of a building through measures such as increased ventilation and low-toxicity finishes has been shown to reduce occupants' symptoms by 21 to 46 percent (Yudelson 2008). Reducing symptoms can directly benefit companies' health insurance rates.

Important benefits relating to public relations and marketing can also be attained through building green. Owning or occupying a green building shows concern for the well-being of tenants and employees, and concern for the environment (Yudelson 2008). In addition, occupying or owning green buildings can reinforce or improve the company's or organization's brand image.

The final general benefits discussed in this report are recruitment and retention of employees. A green work environment can have an impact on recruiting and retaining employees (Yudelson 2008). The average turnover rates in the US are estimated to be between 10 and 20 percent, and at a cost of $50,000 to $150,000 to lose an employee. While employees leave for many reasons, one contributor is a poor physical environment. Improving the environment through building green can reduce the rate of turnover and save the organization money.

While many studies have discussed and computed the benefits of green buildings in general, a small number of studies have been completed on the benefits of building green K-12 schools. One study shows that students progress 20 percent faster on math tests and 26 percent faster on reading tests in buildings with improved indoor air quality and more natural light (RSMeans 2006). Also, on average, green schools use 33 percent less energy than conventionally designed and built schools (Kats 2006). Two of the questions this project attempts to answer are how these general and education-specific benefits apply to a college campus and how they can be quantified.

2.4 Construction Trends on College Campuses

The amount of construction on college and university campuses is booming. According to the 2007 College Construction Report published by *College Planning and Management Magazine*, a 260-percent increase in college and university construction spending occurred from 1997 to 2006, shown in Figure 3 (Abramson 2007). In 2006, new buildings accounted for 68.6 percent of the total cost of construction on campuses, additions accounted for 14 percent, and retrofits accounted for 17.4 percent.

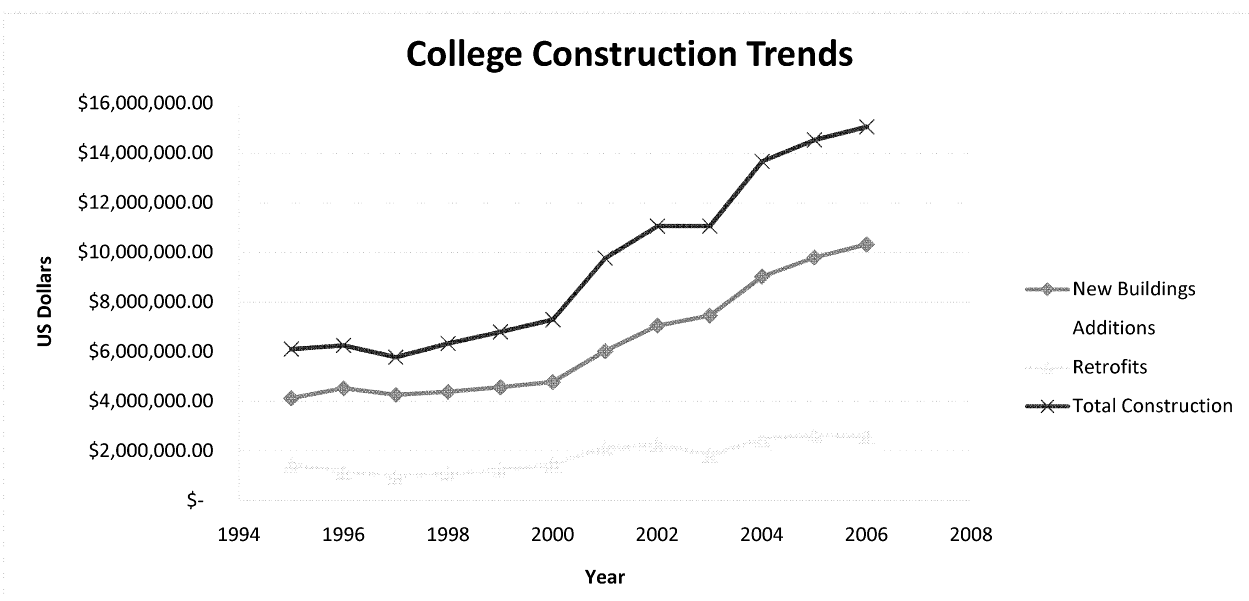

Figure 3: College Construction Completed from 1995-2006 (Adapted from Abramson 2007)

2.5 Green Building on College Campuses

With the large amount of construction, college campuses have become an important target for green building initiatives. Green buildings on college campuses can not only provide environmental and economic benefits, they can serve as a hands-on learning experience for students. For these reasons and more, college campuses are incorporating green building into their policies and onto their campus.

With only a 6-percent increase in construction on college campuses from 2004 to 2005 (Abramson 2007), a 34-percent increase was seen in LEED-registered projects in the higher education sector (Yudelson 2006). As of 2005, higher education facilities were the third most common LEED-registered project type, accounting for 7.1 percent of all LEED-registered projects (Yudelson 2006). With this growth, green building and general sustainability measures are quickly gaining attention on college campuses.

A report published in October 2007 by the Sustainable Endowments Institute, a nonprofit organization founded to "advance sustainability in campus operations and endowment practices," studied the sustainability of the top 200 schools, based on endowment size (Sustainable Endowments Institute 2007). The Institute compiled the following results:

- 59 percent of schools have green-building policies that specify minimum performance levels, such as LEED-silver
- 61 percent of the schools reported having or currently constructing at least one LEED-certified building

These results are positive for the green building movement since they both represent more than half of the schools surveyed, but they do leave much room for improvement.

2.6 Green Building at WPI

WPI has experienced recent growth with the completion of two major construction projects and the beginning of another within two years (WPI 2006). One of the completed projects, the Bartlett Center, is LEED-certified and a new residence hall under construction, East Hall, is seeking LEED-silver certification (USGBC 2008d). According to the WPI Master Plan, many new projects are planned including a new athletics and recreation center and construction of new housing at Salisbury Estates (WPI 2003). With this planned growth, WPI has the opportunity to continue building green.

Judith Nitsch '75, PE, LEED AP, Chair of the Physical Facilities Committee on the WPI Board of Trustees, confirmed that the WPI Board of Trustees recently passed a resolution to be sustainable in all future construction and to aim for the highest feasible level of LEED certification wherever possible (Nitsch 2007a). This change will hopefully help WPI's sustainability report card.

WPI received a "D-" on the 2008 College Sustainability Report Card (Sustainable Endowments Institute 2007). The Report Card grades the sustainability of the top 200 schools, based on endowment size, in the following categories: Administration, Climate Change & Energy, Food & Recycling, Green Building, Transportation, Endowment Transparency, Investment Priorities and Shareholder Engagement. Each category receives an individual grade that is then averaged for the final grade. The average school grade was a "C+." Table 5 shows a breakdown of WPI's scorecard and Appendix A includes a copy of the scorecard.

Table 5: WPI's Sustainability Scorecard (Sustainable Endowments Institute 2007)

Category	Grade
Administration	F
Climate Change & Energy	F
Food & Recycling	C
Green Building	D
Transportation	F
Endowment Transparency	F
Investment Priorities	C
Shareholder Engagement	F

Table 6 shows the scores of some of WPI's competitors in regards to admissions as well as schools in Worcester (Epstein 2007). Of this group, WPI has tied for the lowest score with Rochester Institute of Technology and, most important for this thesis, has the lowest Green Building Score.

Table 6: Competitor Scorecards (Sustainable Endowments Institute 2007)

School	Overall Score	Green Building Score
California Institute of Technology	C	A
Carnegie Mellon University	B-	A
Clark University	B	C
College of the Holy Cross	C	B
Drexel University	C-	C
Massachusetts Institute of Technology	B+	A
Northeastern University	B	A
Rensselaer Polytechnic Institute	C-	C
Rochester Institute of Technology	D-	B
University of Connecticut	C	A
University of Massachusetts	C+	B
Worcester Polytechnic Institute	**D-**	**D**

In order to make improvements to WPI's green building score, a green building policy must be in place, LEED certification must be sought for new buildings, green building standards must be incorporated into new building projects, renovations to existing buildings must be in accordance with green standards, and retrofits must be completed to conserve resources (Sustainable Endowments Institute 2007). To encourage changes that could raise WPI's Green Building score, this thesis evaluates the potential costs and benefits of new green buildings and develops a strategic plan for green building programs at WPI. To quantitatively analyze the costs and benefits, a general understanding of engineering economics must be developed.

2.7 Engineering Economics

Engineering economics is the search for, recognition of, comparison of, and evaluation of alternatives (Kasner 1979). Engineering economics is important because economic criteria must be evaluated when profit is the final objective. Although WPI is classified as a non-profit organization and educating students is its ultimate objective, the Institute can find financial benefits through engineering economics. The economic analysis used in this project evaluates the costs and benefits of building green using standard economic analyses to determine the cost-benefit ratio.

A cost-benefit analysis determines the relationship between the benefits of a project and the cost (Kasner 1979). In this analysis, the net benefits are then divided by the costs. Any result greater than 1.0 demonstrates that the benefits outweigh the costs. A cost-benefit analysis can also incorporate the time value of money to find the present or future worth. Some of the benefits evaluated in this project are reduced energy costs, water savings, and increased productivity.

Financial measures are important to make a decision but cannot be the only factor involved. Other factors such as the impact on the customer or stakeholder must be considered. One way to insure that all perspectives related to the operation of an organization are considered is to implement a BSC.

2.8 Balanced Scorecard (BSC)

The Balanced Scorecard is a measurement system developed to provide managers with a fast, comprehensive view of business (Kaplan & Norton 1992). Traditional measurement systems, based heavily on financial performance, have become out-of-date in today's business world. Paul Niven, the author of <u>Balanced Scorecard Step-by-Step: Maximizing Performance and Maintaining Results</u>, relates relying solely on financial performance measures to driving by the rearview mirror (2006).

The Balanced Scorecard, introduced by Robert Kaplan and David Norton, WPI class of 1962, in a 1992 issue of the *Harvard Business Review*, includes financial measures, but complements them with operational measures.

> Think of the balanced scorecard as the dials and indicators in an airplane cockpit. For the complex task of navigating and flying an airplane, pilots need detailed information about many aspects of the flight. They need information on fuel, air speed, altitude, bearing, destination and other indicators that summarize the current and predicted environment. Reliance on one instrument can be fatal. Similarly, the complexity of managing an organization today requires that managers be able to view performance in several areas simultaneously. (Kaplan & Norton 1992)

The Balanced Scorecard serves three main purposes: a measurement system, a communication tool, and a strategic management system (Niven 2006). The Scorecard has received so much attention, it was included in the *Harvard Business Review*'s list of the 75 most influential ideas of the twentieth century.

The measures used in the original Balanced Scorecard are broken into four perspectives: customer, internal business, innovation and learning, and financial (Kaplan & Norton 1992). The customer perspective usually involves customer satisfaction, customer acquisition, and customer loyalty (Niven 2006). Included in the internal process perspective are processes the organization must excel at to keep adding value to customers. The employee skills, information systems, and environment needed to close the gap between the objectives of the customer perspective and internal processes perspective are part of the innovation and learning perspective. The financial perspective consists of financial measures to determine if strategy execution is producing improved bottom-line results.

Working together, the four perspectives create a balance between short- and long-term objectives, financial and non-financial measures, leading and lagging indicators, and internal and external performance (NetMBA 2007). The perspectives create cause-and-effect relationships that show the trade-offs that have been made between measures and demonstrate the goals of the company's strategic plan (Kaplan & Norton 1993).

Strategy is broadly discussed and debated in the business world, but four barriers keep it from being executed: vision, people, management, and resources (Niven 2006). The vision barrier occurs when employees cannot see, or are unaware of, the company's strategy. The people barrier concerns employee motivation. Companies should provide incentives for managers working towards long-term goals rather than only short-term goals. When companies do not link budgets to strategy, resources become a barrier. Finally, the management barrier is created if management spends its time in monthly meetings analyzing finances, and little or no time discussing "value-creating or destroying mechanisms in the firm" (Niven 2006, p. 12).

2.8.1 Balanced Scorecard Applications

Kaplan and Norton have found the BSC to be most successful when used to drive change (1993). BSCs effectively keep companies looking and moving forward "by linking today's actions with tomorrow's goals" (Kaplan & Norton 1992; Kaplan & Norton 1996). BSCs also translate strategic objectives into coherent performance measures (Kaplan & Norton 1993). BSCs address the issues of increased intangible assets, the difficulty of implementing strategy, and effectively measuring performance (Niven 2006).

As the concept of the BSC has developed, the operational measures (customer perspective, internal business perspective, and innovation and learning perspective) and the scorecard itself have been adapted to more appropriately fit businesses and situations. One adaptation that is becoming increasingly popular is in the area of sustainability and environmental management. As companies are implementing environmental management and sustainability systems, a method to properly integrate them is necessary.

Sustainability Balanced Scorecards (SBSC) help highlight important strategic environmental objectives and intangible assets that are vital to stay competitive (Bieker). According to Thomas Bieker of the Institute for Economy and the Environment at the University of St. Gallen, "the use of a SBSC as a planning instrument could enhance transparency of potentials for (economic, environmental or social) value-added emerging from social and/or ecological aspects and prepare the implementation process of the strategy" (p. 3). Bieker outlines the strategies used most frequently in a SBSC: reducing and managing risk, enhancing and fostering reputation and credibility, enhancing efficiency and productivity, differentiating in the market, and developing markets and society.

In an article published in the May/June 2006 edition of the APPA's *Facilities Manger*, Maureen Roskoski identifies using a balanced scorecard to effectively measure sustainable facility management policies. Roskoski says that "it is a lot easier to create green buildings from the start, than it is to modify existing systems and recreate them into energy-efficient, eco-friendly workplaces" (p. 34). She suggests using tools such as the LEED-EB rating system, life-cycling cost assessments, and total cost of ownership approaches to advocate sustainable facility management and using a SBSC to monitor the effectiveness of the sustainability policy.

While SBSCs are very relevant to this project, BSCs implemented at WPI are as well. The WPI Information Technology Division (IT), including the Academic Technology Center, the Computing and Communications Center, and Gordon Library, uses the BSC approach in their strategic planning. Implemented in 2004 by WPI's CIO and VP of Information Technology, Thomas Lynch III, PhD, the balanced scorecard is still used today and has helped IT implement many positive changes (Lynn 2008). According to senior project manager Vicki Lynn, IT has made improvements in the learning and growth perspective based on the initiatives implemented. She also said the BSC has made decision making easier. The BSC has become such an important part of IT's daily workings that all staff members are provided one of Niven's books and new staff members attend a BSC training session.

2.8.2 Process to Develop a Balanced Scorecard

Not only is it important to recognize the many uses of BSCs, but also how they are developed and implemented. The first step to developing a BSC is to define the core purpose or mission of the organization (Niven 2006). A mission serves as a beacon or a compass to guide an organization, but differs from a goal or strategy by never being completely fulfilled. An effective mission statement should inspire change, be easily understood, and be long-term in nature. According to Paul Niven, mission statements should be designed to last for 100 years or more (2006).

After developing a mission statement, values must be identified. Values are the beliefs or principles of an organization that are exemplified through the everyday behavior of employees (Niven 2006). Similar to the mission statement, values should not regularly change, but rather act as guiding principles while the organization and society changes. There may come a point when an organization's values become a hindrance or prove unethical. At that time, redefining the values is appropriate.

From the mission statement and values, the organization must develop a vision statement. The vision statement defines what the organization wants to become. It typically includes the desired scope of business activities, strong held values, areas of leadership, and how they will be viewed by stakeholders. The vision statement must follow the mission statement and values because “a vision without a mission is simply wishful thinking, not linked to anything enduring” (Niven 2006, p. 83). Effective vision statements are concise, inspirational, feasible, verifiable, inline with the mission and values, and appeal to stakeholders.

The next step before developing a BSC is to develop a strategy. Strategy is a difficult word to define because it means different things to different organizations. For most organizations, strategy is selecting different activities or methods from their competitors to find a unique place in the market.

After defining the organization’s mission, values, vision, and strategy, a Strategy Map must be developed. A Strategy Map is “a one-page graphical representation of what you must do well in each of the four perspectives in order to execute your strategy successfully” (Niven 2006, p. 18). Essentially, the Strategy Map displays strategic objectives in each of the perspectives and graphically represents how they are linked to each other.

To begin a Strategy Map, the organization must first decide if the four perspectives are appropriate (Niven 2006). The four original perspectives developed by Kaplan and Norton, financial, customer, internal process, and learning and growth, should be considered a template. Other perspectives can be added or substituted, such as innovation or environment. Niven recommends that organizations “choose the perspectives that allow you to capture the key stakeholders of the organization and describe how you will ultimately serve each and thereby successfully implement your strategy” (2006, p. 103). To determine the applicability and usefulness of the chosen perspectives, test how easily they can intertwine to tell a coherent story.

The next step to develop a Strategy Map is to gather and review background information (Niven 2006). Information can be retrieved from annual reports, the mission statement, the organization’s values, its vision statement, its strategic plan, project plans, consulting studies, competitor data, benchmarking reports, and performance results. This information will help develop a broad understanding of the organization’s competitive position, appropriate strategy, objectives, measures, and the overall nature of the business. After gathering and reviewing information, conducting interviews to confirm the findings may also be necessary (Niven 2006).

With the perspectives selected and information gathered, strategic objectives must be developed for each perspective. Strategic objectives are succinct statements, typically starting with a verb, that describe what must be done to implement the organizations strategy (Niven 2006). Examples of strategic objectives are “Reduce carbon dioxide emissions” and “Lower tuition costs.” The number of objectives should be limited to three to four for each perspective. This will help focus the Strategy Map on vital objectives. The objectives are then displayed with the corresponding perspective in a way that shows how the perspectives intertwine. Figure 4 is the WPI IT's Strategy Map. The four perspectives are listed down the left and the strategic objectives are shown in circles. Arrows show the relationship between the strategic objectives.

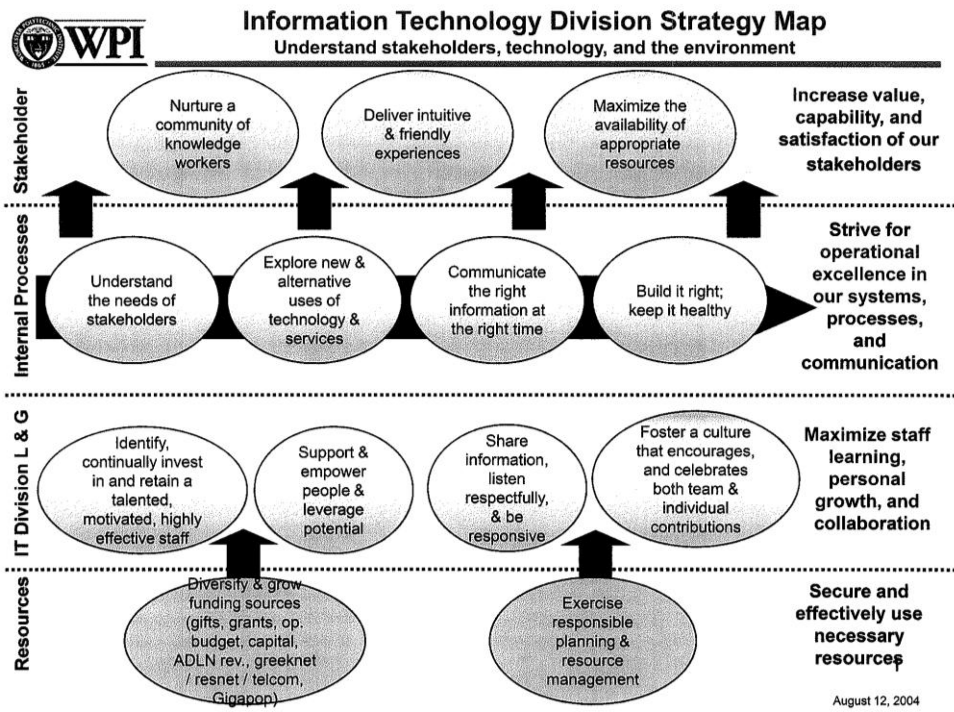

Figure 4: WPI IT's Strategy Map (Lynn 2008)

Once a Strategy Map has been developed and strategic objectives defined, one must define measures to determine if objectives are being achieved. Performance measures are important not only to determine if the Balanced Scorecard is effective but also to show employees how their actions can help improve the organization and help reach goals (Niven 2006). Two types of measures are used in the Balanced Scorecard: leading and lagging. "Lag indicators represent the consequence of actions previously taken, while lead indicators are the measures that lead to – to drive – the results achieved in the lagging indicators" (Niven 2006 p. 144). For example, sales, a lagging indicator, may be caused by time spent with customers, a leading indicator. A Balanced Scorecard must incorporate both types of measures, for one is ineffective without the other. Good measures should be quantitative, linked to strategy, relevant, and easy to understand. There should be 15-25 measures on the Balanced Scorecard.

The final steps to developing a Balanced Scorecard are setting targets and prioritizing initiatives. A target is a "quantitative representation of the performance measure at some point in the future" (Niven 2006, p. 181). Targets can be long-term, midrange, or short-term. Short-term goals, typically taking a year or less to accomplish, provide timely feedback and can serve as an early warning system. Long-term targets, typically taking 10 to 30 years to accomplish, require tremendous effort from the entire organization. Midrange targets fall in the middle for time range and effort required to complete.

The information compiled in this chapter provides a foundation for the cost and benefit analysis of new green buildings at WPI and the development of a BSC for green building and green building programs at WPI. The methods and means to complete this thesis are discussed in the following chapter.

3.0 METHODOLOGY

Focusing on evaluating the costs and benefits of building green and developing a strategic plan for implementing green design features at WPI, this thesis was broken down into four distinct, related objectives:

- Evaluation of the costs and benefits of green building for new buildings at WPI
- Assessment of the costs and benefits of certifying a facility with the USGBC's LEED program
- Development of a Balanced Scorecard to evaluate the impact and status of green building at WPI
- Investigation of the feasibility and uses of the LEED-EB rating system

The process to achieve each objective is outlined in the following sections.

3.1 Evaluation of the Costs and Benefits of Green Building for New Buildings at WPI

The first objective of this study was to determine the costs and benefits of green engineering on WPI's campus, including direct and indirect benefits. Determining and evaluating the benefits of green engineering on this campus are important in order to justify the potential added expense and the change to previous practices.

This portion of the project focused only on the main facilities on campus bounded by Salisbury Street, Park Avenue, Institute Road, and Boynton Street. These buildings were selected because of their similarity to the facilities from which national statistics are derived and the availability of usage rates for a complete calendar year. The national and local statistics on costs and benefits of green engineering used in this study are primarily from K-12 schools and office buildings rather than houses as many of the WPI owned properties outside the given boundaries are. Within these boundaries, it should be mentioned that the Higgins House and Garage are not used in the calculations for oil and natural gas because they do not receive heat from the power plant (Grudzinski 2008). For a complete list of buildings included and a map of their locations, please refer to Appendices B, C, D, and E.

The financial costs and benefits of green building were determined through archival research on the costs and benefits of building green, research into WPI's facility's energy usage, and an analysis using engineering economics. Electricity, natural gas, and oil usage were collected from files kept by the Facilities department to determine the average utility cost per square foot. The usage was then multiplied by the average rate for each energy type per month of the year in Massachusetts. For example, in January 2007, the main buildings at WPI consumed 1,356,600 kilowatt hours of electricity, and the average commercial rate of electricity in Massachusetts for the same month and year was 15.79

cents per kilowatt hour (Energy Information Administration 2008a). Therefore, the estimated cost for January 2007 was $215,628.24.

Local averages were used because many of the bills had additional late fees or outstanding amounts. To reduce the risk of error, only usage rates were used. In most cases this will result in higher costs due to arrangements WPI has with utility companies. While this would then increase or inflate the savings, it is believed that using the lowest percentages for savings when calculating benefits will compensate for the increase.

The financial costs and benefits that were evaluated were the premium to build green, the energy savings, the water savings, the increased future earnings, the increased productivity, and the employment impacts. The economic analysis was performed from the owner's viewpoint and included standard equations for analysis including benefit/cost ratio and net present value. The values used came from research on green building, as well as information specific to WPI. For example, to quantify energy savings, the average percent savings found through green buildings was used along with the energy usage of the main buildings at WPI. Whenever information on WPI was available, those values were used to make sure the analysis related as closely as possible to WPI.

The values selected maximize the cost and minimize the benefit to produce a conservative result. The results were broken down into direct benefits such as energy savings, and indirect benefits, such as jobs created by recycling.

3.2 Assessment of the costs and benefits of certifying a facility with the USGBC's LEED program

As mentioned in the background chapter, one part of the cost of going green is the actual cost of certifying a project with LEED, or the LEED premium. Discussion and concern over the associated fees and costs with registering and certifying a project with LEED has surface at WPI. Some project owners feel that LEED certification provides little benefit, while others believe that LEED certification is essential to the project. To address the controversial issue of the cost of LEED certification, this portion of the thesis determined the premium to certify a project with LEED.

To achieve the objective of assessing the costs and benefits of certifying a facility with the USGBC's LEED program, this portion of the thesis looked into the costs of USGBC membership, LEED project registration, LEED project certification, and other costs related to certification, such as modeling costs and time spent documenting information. It also considered the benefits of LEED certification including marketability and increased building value to determine the necessity of certifying a project.

Cost information was found through research into the USGBC's LEED program and case studies. Benefit information was found through similar research. Using the cost information found, the LEED premium per square foot was determined. A discussion of the benefits and necessity of LEED certification followed. After determining the financial feasibility of building green at WPI, the development of a strategic plan for future construction and renovations was necessary.

3.3 Development of a Balanced Scorecard to Evaluate the Impact and Status of Green Building at WPI

The process to develop a Balanced Scorecard for green building at WPI included collecting background information, developing a mission statement, values, vision, and strategic objectives, and defining initiatives, measures, and targets for each objective. Background information was collected to determine WPI's status on green building and green building policies. A mission statement, values, and vision were developed as the foundation of the Balanced Scorecard and strategic objectives, initiatives, measures, and targets were defined as the working aspects of the Scorecard.

3.3.1 WPI's Current Status and Policies on Green Building

Determining WPI's status on green building was completed through archival research, as well as communication with Alfredo DiMauro, Assistant VP for Facilities; Christopher Salter, Director of Project Management and Engineering; Judith Nitsch, Chair of the Physical Facilities Committee of the Board of Trustees; and Janet Richardson, VP for Student Affairs and Campus Life. Research focused on LEED-certified and -registered buildings on campus as well as water and energy saving upgrades on campus. This research was important to determine the starting point of the Balanced Scorecard so reasonable goals for the future could be set.

Determining WPI's policies on green design for campus buildings was important in assessing WPI's goals and perceived benefits in environmental sustainability. WPI's policies on green building show the strength of and reasons behind the University's commitment to environmentally sustainable practices. Determining WPI's motivation to incorporate green design into their policies and practices was important. Predicted motivations were to save money, reduce the University's impact on the environment, impress potential students, use this practice as an educational tool, promote research and innovation, increase marketing opportunities, or any combination thereof. Determining the benefits WPI is seeking through green engineering helped direct recommendations at the completion of this project.

Determining WPI's policies on green design was achieved through interviews and communication with WPI officials and related personnel such as Fred DiMauro, Assistant VP for Facilities, and Judith Nitsch of the Board of Trustees. Communication with these personnel was deemed important as shown by a 2005 survey completed by Turner Construction. This survey of building owners, developers, consultants, engineers, architects, corporate owner-occupants, and educational institutions on green building found that on college and university campuses, the administration and board of trustees were perceived to have the most important influence on deciding to build green (Turner Construction 2005).

After determining WPI's current policies, it was important to have comparative information; having information on WPI's sustainability policies is only helpful if it can be compared with other colleges and universities. This information was obtained from research into sustainability policies of WPI's competitors and other universities in Worcester, MA.

The first step of this research was to identify a group of colleges and universities to which WPI was comparable. This group was selected with help from Adam Epstein of the WPI Admissions Office (2007). Included in the group, were nine college and universities that WPI is competitive with in admissions and three universities in Worcester.

The research into these schools' sustainability policies was completed based on information published on their official webpages. The comparative study included a search of three key phrases: "sustainability," "green building," and "LEED." Following the links found through the search engine, the schools were then assessed on the categories listed and explained below.

- Date of Search: This identifies the day that the information was retrieved from the internet.
- Website: This identifies the school's official main website, where all searches began.
- Sustainability Website: If the school has a website discussing environmental sustainability or environmentally conscious practices, this is considered "yes."
- Comprehensive: This item refers to the sustainability website. If the website has a link to additional pages of information regarding the school's sustainability, the website is considered comprehensive.
- Director of Sustainability: If answered "yes," this school has a Director of Sustainability or an official holding a similar title. If this official is in charge of other duties or there is no Director of Sustainability, the answer is "no." Examples of similar titles were Environmental Coordinator and Sustainability Coordinator.
- Green Building Policy: If the college or university's website outlined standards for new and/or existing buildings in regards to sustainability, this was answered "yes."
- LEED Certified Buildings: This category lists the number of LEED-certified buildings, according to the research on the official website of the school.
- LEED Registered Buildings: This category lists the number of LEED-registered buildings, according to the research on the official website of the school. This also included mention of buildings aiming for LEED certification or in the application process for LEED certification as these projects should be registered.

The USGBC website was also reviewed to verify the number of LEED-certified and registered projects. Project owners must give permission for project information to be available online, so a school may have more LEED-registered or -certified projects than the USGBC website portrays.

The final step in determining WPI's status on green building was to determine what green building technologies WPI has integrated into existing facilities, what system WPI uses to track the initiatives, and how new projects are selected. This was completed with an interview with Christopher Salter, Director Project Management and Engineering.

3.3.2 Developing a Mission Statement, Values and Vision

After determining WPI's current status and policies on green building, the next step was to develop the foundation of the balanced scorecard. This was done through the development of a mission statement, values, and vision. These three foundations of the Balanced Scorecard are developed in a top-down approach, as shown in the figure below.

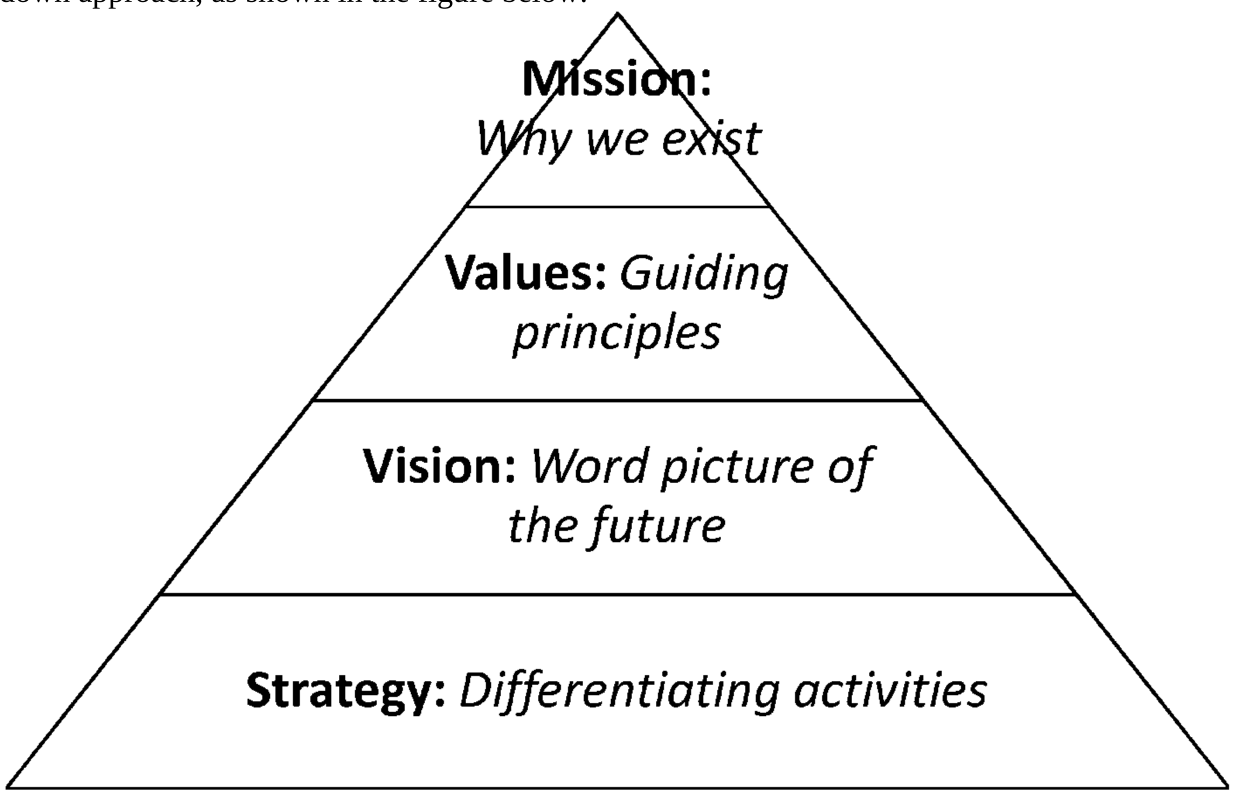

Figure 5: Balanced Scorecard Development (Adapted From Niven 2006)

The mission statement – the core purpose of the organization – was developed by reviewing the mission statements of WPI, the WPI Facilities Department, and the USGBC (Appendix F). These statements were selected to be models for format and content based on their relevance to this project. Values – principles of an organization exemplified by day-to day behavior – were developed based on the benefits of green building and the stated values of WPI and the USGBC (Appendix G). Finally, the vision – what the organization wants to become – was developed with comparison to WPI's vision statement (Appendix H). After preliminary statements were developed, feedback from the Thesis Committee of this author was sought and used to develop them further.

3.3.3 Developing Strategic Objectives, Initiatives, Measures and Targets

After defining a mission statement, values, and vision of a GBBSC, strategic objectives emerged. Following the development of objectives, initiatives to reach them, measures to quantify them, and targets by which they must be achieved were set. Preliminary strategic objectives were brainstormed and presented to the Thesis Committee for suggestions. The strategic objectives were developed further and initiatives, measures, and targets were defined for each strategic objective. Once again, the Thesis Committee was consulted. The suggestions and opinions of the thesis committee were weighted heavily in the development of the GBBSC as it was important for the objectives to be in line with the ideals and capabilities of the University.

Once all components of the GBBSC were developed, each strategic objective was defined. Brevity in articulating strategic objectives, typically around five words, leaves room for misinterpretation. Defining strategic objectives insures that all members of the organization understand their purpose. The final step to the development of the Balanced Scorecard was to develop a plan for implementation.

3.4 Investigation of the feasibility and uses of the LEED-EB rating system

The final objective of this project was to investigate the feasibility and uses of the LEED-EB rating system for WPI. LEED-EB is the rating system for existing building operation and maintenance. Determining the feasibility of using this rating system in future campus renovations was important because of the large number of facilities over 50 years old and the significance LEED-EB certified buildings play in the Sustainable Endowments Institute Assessment and the AASHE STARS program, which WPI is currently piloting.

To determine the feasibility of LEED-EB certification for WPI facilities, this thesis investigated the age of WPI's facilities, the LEED-EB rating system, example projects, and implementation strategies and issues. Because older facilities are typically less energy and water efficient, determining the age of WPI's facilities and the date of recent major renovations was important to determine the need for green renovations. Examining the LEED-EB rating system and example projects was also important to determine the feasibility of using the rating system on WPI's facilities. Lastly, it was important to review strategies to committing to the LEED-EB rating system and the issues that other facility managers have found.

This objective was completed with communication with Alfredo DiMauro and research into LEED-EB case studies. Information similar to the costs and benefits found through LEED-NC was sought but could not be found. Compared to LEED-NC, LEED-EB is newer and less popular, which resulted in a lack of extensive published research.

Through archival research, a literature review, interviews, an economic analysis, and the development of a strategic plan, this thesis determined the costs and benefits of building green at WPI and developed a GBBSC to measure and promote green building. The results of the objectives, following the methods outlines, are presented in the next chapter.

4.0 RESULTS

By setting clear objectives and identifying the necessary steps to achieve them, this project was able to analyze the costs and benefits of new green buildings at WPI, assess the costs and benefits of LEED certification, develop a GBBSC, and assess the use of the LEED Existing Buildings guidelines for renovations to existing buildings. This chapter describes the results achieved in each of the objectives.

4.1 Costs and Benefits of Green Building in New Buildings at WPI

The cost and benefits of building green at WPI were evaluated based on local and national averages, as well as information and data specific to WPI. For each cost and benefit, all information found through research was considered to determine the most appropriate values. The complete list of green building statistics and information collected from national and local sources is shown in Appendix I. An interest rate of 5 percent, inflation rate of 2 percent, and term of 20 years were used for all calculations. The following sections outline the selection of appropriate data and the calculation of the costs and benefits of new green buildings.

4.1.1 Costs of Green Building

The cost increase of green buildings, or green premium, was calculated with consideration to current building prices per square foot and statistics on the green premium. The first step in determining the cost of green building was to determine the cost of conventional buildings. Table 7 shows the cost per square foot of many of the facilities one would find on a college campus. The costs displayed show the cost of construction as well as design and construction fees.

Table 7: Cost per Square Foot of University Facilities (RSMeans 2007)

Building Type	Cost/SF
Auditorium	$ 149.65
College Classroom (2-3 Story)	$ 156.65
College Dormitory (2-3 Story)	$ 164.95
College Dormitory (4-8 Story)	$ 161.10
College Laboratory	$ 160.75
College Student Union	$ 142.75
Computer Data Center	$ 254.65
Gymnasium	$ 135.60

To determine the green premium, studies on the costs and benefits of green buildings were referenced. One of the most prominent researchers on the costs and benefits of green buildings is Gregory Kats. A study he performed on offices and school buildings constructed between 1994 and 2004 for the California Sustainable Building Task Force (CA) found that the green cost premium ranged from 0.66 to 6.50 percent of the total cost of the facility (Kats 2003a). The average green premium of the facilities in Kats's CA study was 1.84 percent. A more recent Kats study, completed with data on K-12 schools constructed from 2001 to 2006, found that the average green premium was 1.64 percent (Kats 2006). Another consideration in the costs and benefits of building green at WPI was the estimated premium of the new residence hall, East Hall. In a presentation to the trustees in early 2007, the green premium of East Hall was estimated to be 2.6 percent. Cannon Design, the architect for East Hall, noted that a significant contributor to the green premium was the live green roof. Had a different roof been substituted, the green premium would have been approximately 1.1 percent.

Other green premium cost data found was in the form of cost per square foot. Another study Kats performed for the Massachusetts Technology Collaborate (MA) in 2003 found the average green premium to be \$3 to \$5 per square foot, while the Kats's K-12 study found it to be \$3 per square foot (2003b, 2006). Using the cost per square foot information found using RSMeans, the green premium per square foot was used to find the equivalent green premium percentage. This is shown in Table 8.

Table 8: Comparision of Green Premium Cost/SF and Percentages (RSMeans 2007)

Building Type	Cost/SF	Cost of Going Green (Per SF)			Total Cost of Facility			Green Premium (%)		
Auditorium	$ 149.65	$3	-	$5	$ 152.65	-	$ 154.65	2.0%	-	3.2%
College Classroom (2-3 Story)	$ 156.65	$3	-	$5	$ 159.65	-	$ 161.65	1.9%	-	3.1%
College Dormitory (2-3 Story)	$ 164.95	$3	-	$5	$ 167.95	-	$ 169.95	1.8%	-	2.9%
College Dormitory (4-8 Story)	$ 161.10	$3	-	$5	$ 164.10	-	$ 166.10	1.8%	-	3.0%
College Laboratory	$ 160.75	$3	-	$5	$ 163.75	-	$ 165.75	1.8%	-	3.0%
College Student Union	$ 142.75	$3	-	$5	$ 145.75	-	$ 147.75	2.1%	-	3.4%
Computer Data Center	$ 254.65	$3	-	$5	$ 257.65	-	$ 259.65	1.2%	-	1.9%
Gymnasium	$ 135.60	$3	-	$5	$ 138.60	-	$ 140.60	2.2%	-	3.6%

The green premium has been decreasing over time with increased experience on the part of owners, designers and contractors, and more products on the market (Yudelson 2008). For this reason, more recent studies were considered to be more accurate. Considering the percentages in this section, the current green premium was estimated to be 2.6 percent. This value is higher than many of the more recent estimates, but using a higher percentage of cost will result in a more conservative result. Applying this percentage to the cost per square foot, the green premium for various types of facilities was determined.

Table 9: Green Premium by Building Type

Building Type	Cost/SF	Green Premium/SF
Auditorium	$ 149.65	$ 3.89
College Classroom (2-3 Story)	$ 156.65	$ 4.07
College Dormitory (2-3 Story)	$ 164.95	$ 4.29
College Dormitory (4-8 Story)	$ 161.10	$ 4.19
College Laboratory	$ 160.75	$ 4.18
College Student Union	$ 142.75	$ 3.71
Computer Data Center	$ 254.65	$ 6.62

4.1.2 Benefits of Green Building

After assessing the costs of green buildings, it was necessary to evaluate the benefits. Many different types of benefits can be found through building green, including economic, environmental, and health. In all research studied, the benefits have been found to outweigh the costs. This thesis focused on only a few to highlight the benefits that WPI could experience. The benefits that were quantified were categorized as direct, immediate impacts to WPI, or indirect, residual impacts to WPI and/or the greater community.

4.1.2.1 Direct Benefits of Green Building

The direct benefits that were quantified include energy savings, water and wastewater savings, and employment impacts of increased productivity. Energy savings were calculated using usage rates from WPI, local cost averages, and green building energy savings averages. According to Kats's K-12 study, green K-12 schools use 33 percent less energy on average (2006). According to Kats's MA report, green buildings are 25 to 30 percent more energy efficient than conventional buildings (2003b). According to a USGBC publication from 2002, energy savings of 20 to 50 percent can be found in LEED-certified buildings. The value chosen for this cost-benefit analysis was 30 percent, based on the assumed increased accuracy of more recent studies and a desire to be conservative. Applying these savings to the projected energy costs of WPI results in $1.03 annual savings per square foot and $15.43 savings per square foot over twenty years. Refer to Appendix J to find more information regarding these calculations.

The second direct benefit of green building evaluated was water and wastewater savings. Water and wastewater costs were estimated to be 5 percent of the cost of energy (Kats 2006). Water and wastewater savings were assumed to be 32 percent as found in Kats's K-12 study. This resulted in annual savings of $0.05 per square foot and savings of $0.82 over twenty years. The annual savings was comparable to Kats's estimate of $0.06 per square foot (2006). The results of the water and wastewater analysis are reasonable for academic buildings but would be low for residential buildings which use more water. Nevertheless, annual savings of $0.05 per square was used in the analysis. For more information on the calculation of water and wastewater savings, see Appendix K.

The last direct impact calculated in this project was employment impact of increased productivity. According to Kats's K-12 study, research done at Carnegie Mellon shows that improved temperature control increases worker productivity by 0.2 to 15 percent, with an average of 3.6 percent (2006). High performance lighting, another contributor to productivity, results in increases of 0.7 to 26.1 percent, with an average of 3.2 percent. Using the lowest productivity increases, the average annual salary for Massachusetts, the number of WPI employees, and the square footage of the main buildings on campus, the annual savings were found to be $0.32 per square foot. This value projects to be $4.75 per square foot over twenty years. Although all WPI employees do not work in the buildings studied in this project, using the lowest increases in productivity still produces a conservative value. For a table of showing the analysis of productivity, see Appendix L.

The following table shows the cost-benefit analysis with only total impact of direct benefits. Considering only direct benefits, the benefit/cost ratio is over 5 and the payback period is under 40 months.

Table 10: Direct Cost-Benefit Analysis of 2-3 Story College Classroom Facility

	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Water & Wastewater Savings	$ 0.05	$ 0.82
Employment Impact - Increased Productivity	$ 0.32	$ 4.75
Cost of Green (College Classroom)	$ (4.07)	$ (4.07)
Net Benefits	**$ (2.67)**	**$ 16.93**

4.1.2.2 Indirect Benefits

Many benefits of green buildings apply to building occupants and the community, but will not provide direct financial benefit to the building owner. These benefits include indirect energy savings, the employment impact of recycling, and future earnings of students.

Indirect energy savings result from decreased energy prices from a reduced market demand. Kats's K-12 study cites three reports concerning reductions in the long-term wellhead price, or the rate producers charge for natural gas and oil. A study from the Lawrence Berkeley National Laboratory found 0.8 to 2 percent reductions in long-term average wellhead prices from a 1 percent reduction in natural gas demand (Kats 2006). Another study, from Platts Research & Consulting, found that a 0.75 to 2.5 percent reduction in prices can be found from the same reduction in demand, 1 percent. The final study, from a 2004 Massachusetts state report, found that indirect savings from a reduced market demand due to the use of renewable energy and energy efficient systems is equivalent to 90 percent of the direct savings.

Essentially, these studies show that the indirect savings from a reduction in energy usage can be equal to 75 to 250 percent of the direct savings (Kats 2006). To be conservative, this project assumes that the indirect energy savings are equivalent to 75 percent of the direct savings. This assumption results in annual savings of $0.77 per square foot and savings of $11.57 per square foot over 20 years. Refer to Appendix M for the calculation of these values.

The second indirect benefit that this study examines is that of increased future earnings. Students in green K-12 schools perform 3 to 5 percent better on tests (Kats 2006). According to Kats's K-12 report, an International Monetary Fund study found that an increase in test scores from 50 percent to 84 percent can be linked to a 12-percent increase in annual earnings. Based on this finding, an annual earnings increase of 1.06 to 1.76 percent can be attributed to a 3- to 5-percent increase in test scores.

While these values are based on K-12 schools, these values should translate to a college or university setting. The average annual salary of the WPI graduates of 2006 was $52,615 (Appendix N). WPI graduates could experience a $558 to $926 increase in annual earnings if educated in green buildings. Considering only the bachelors degrees awarded in 2006 and assuming earnings rise at the rate of inflation, indirect savings were found to be $4.99 per square foot over twenty years (Appendix O). This value is very conservative since it encompasses only undergraduate students and includes the square footage of all of the main facilities on campus, including three residence halls. Determining a way to calculate the square footage used per student is recommended for further research.

An increase in annual earnings has a direct impact on WPI graduates but could have an indirect impact on annual giving to WPI and WPI's attractiveness to potential students. The average salary of WPI graduates is printed in admissions material and provides potential students insight into what is to come for them (Epstein 2008). Also, alumni comprise approximately 74 to 77 percent of all donations, depending on the year (Kurland 2008). A link could be found between the amount of money alumni make and the amount of money they donate to WPI. Further research would be necessary to confirm this.

The last indirect impact studied in this project was the employment impact of increased recycling. According a UC Berkeley study, for every 1000 tons of waste disposed, 2.5 jobs are created, whereas recycling the same amount creates 4.7 jobs (Kats 2006). Currently, WPI recycles 17 percent of its waste, but the University recently launched a new plastics, glass and aluminum recycling program (Pellerin 2008). Assuming a gradual increase to 50 percent of waste diverted in 10 years, determined feasible by an analysis of other colleges and universities, approximately one half of a job could be created in Year Ten alone. Using the average salary in Massachusetts, this amounts to $0.26 per square foot over twenty years. Since this calculation is based on a gradual increase in percentage, the annual savings were not included on the summary tables. To review the study of the percentage of waste recycled at other colleges and universities, refer to Appendix P. To find out more about how this benefit was quantified, refer to Appendix Q.

The following table shows the cost-benefit analysis considering only indirect benefits. Considering only indirect benefits, the benefit/cost ratio is over 4 and the payback period is approximately 4 years.

Table 11: Indirect Cost-Benefit Analysis of 2-3 Story College Classroom Facility

	Annual ($/SF)	20-year ($/SF)
Indirect Energy Savings	$ 0.77	$ 11.57
Future Earnings	$ 0.33	$ 4.99
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (College Classroom)	$ (4.07)	$ (4.07)
Net Benefits	**$ (2.97)**	**$ 12.75**

Finally, the complete results of the quantified costs and benefits of new green buildings at WPI are shown below. As shown, the benefits outweigh the costs resulting in a net benefit of $33.76 per square foot. The benefit/cost ratio is over 9 and the payback period is under 20 months.

Table 12: Complete Cost-Benefit Analysis

	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 11.57
Water & Wastewater Savings	$ 0.05	$ 0.82
Future Earnings	$ 0.33	$ 4.99
Employment Impact - Increased Productivity	$ 0.32	$ 4.75
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (College Classroom)	$ (4.07)	$ (4.07)
Net Benefits	**$ (1.56)**	**$ 33.76**

This analysis was duplicated for various types of facilities found on college campuses. These results can be found in Appendix S. Appendix R contains the calculations for the payback period.

4.1.2.3 Benefits Not Quantified

This study did not quantify many direct and indirect benefits. Some worthy of highlighting include health, employee retention, tax credits, emissions reductions, and indirect benefits of energy efficiency.

The first direct benefit not quantified is that of health. Green buildings have proven to reduce the symptoms and occurrence of many illnesses including sick building syndrome, flu, and asthma. For example, green buildings with improved indoor air quality have been found to reduce colds and flu by over 50 percent (Kats 2006). Reducing sickness in building occupants contributes to decreased employee sick days, increased student attendance, and decreased insurance rates.

Employee recruitment and retention was also left out of the cost-benefit analysis. Research shows employee retention is higher for those working in green buildings. A study of green K-12 schools in Washington State estimated a 5-percent decrease in teacher turn-over (Kats 2006). Employee retention can be a significant benefit when evaluating the magnitude and cost of turnover. According to Jerry Yudelson, another green building expert, most organizations lose 10 to 20 percent of their employees per year. The cost of turnover is estimated by Kats to be 25 to 200 percent of annual salary and benefits, and $50,000 to $150,000 by Yudelson (Kats 2006, Yudelson 2008). Reducing employee turnover could be a significant benefit to WPI.

When considering retention at a college or university, one must also consider student retention. If students perform better on tests, they are less likely to leave an institution. Also, living and studying in green buildings may make them more comfortable and satisfied with the facilities and campus environment. Increasing student retention is a major benefit to the university from both marketing and financial standpoints. The cost to recruit, admit, and orient students through the first semester is essentially lost if a student leaves before graduating. This benefit could not be quantified due to the lack of and unavailability of information.

The last direct benefit not quantified in this study was tax credits. Different states offer a variety of tax benefits and preferred status during permitting. The federal government offers a tax credit of 30 percent and a tax reduction up to $1.80 per square foot for solar thermal and electric systems, and for 50 percent reductions in energy used for HVAC, lighting, and water heating systems (Yudelson 2008).

The first indirect impact not quantified results from implementing energy efficient systems. The 2004 MA state report, cited by Kats, found that 160 short-term jobs and 30 long-term jobs are created for every $10 million in investments in energy efficiency (Kats 2006). This benefit was not quantified due to the complexity of estimating the amount of energy efficiency investments.

Another indirect benefit of building green worthy of mention is emissions reductions. Green buildings can reduce emissions of nitrogen oxides, sulfur dioxide, carbon dioxide, and coarse particulate matter (Kats 2006). These emissions are principle components and causes of smog, acid rain, green house gas, and respiratory problems respectively.

Through quantifying select direct and indirect benefits and examining a broader range of benefits, one can see the value of building green. The amount of money saved on energy costs alone outweighs the green premium. An overlapping part of the green premium that must be examined is the LEED premium, the costs associated with LEED certification.

4.2 Costs and Benefits of Certifying a Facility with the USGBC's LEED Program

The LEED premium includes soft costs and fees collected by the USGBC. From research, it was unclear if the LEED premium was part of the green premium. In many cases soft costs are included in the green premium. Without certainty on the presence or extent of the overlap between the green premium and the LEED premium, this project assessed the LEED premium as a separate entity. Using LEED registration and certification fees, and the soft costs of LEED certification, the LEED premium was determined per square foot. This value was then used to determine the percentage of the total building cost for which the LEED premium counted. The table below shows the final results, per certification level, for a two- to three-story college classroom facility. For more information on the calculations, please refer to Appendix S.

Table 13: LEED Premium

Certification Level	Green Soft Costs	Certification Costs	LEED Premium	Percentage of Project Cost
Source	(RSMeans 2006)	(USGBC 2008c, RSMeans 2007)	-	-
Certified	$ 0.46	$ 0.06	$ 0.52	0.3%
Silver	$ 0.55	$ 0.06	$ 0.61	0.4%
Gold	$ 0.81	$ 0.06	$ 0.87	0.6%

As shown, the LEED premium adds less than 0.6 percent to the total building cost.

Upon determining the LEED premium, the benefits and importance of certifying a building was researched. Third-party validation is necessary to call a building "green." Yudelson stresses the importance of LEED certification for commercial and institutional buildings:

> In the commercial and institutional arena, if a building is not rated and certified by an independent third party with an open process for creating and maintaining a rating system, it can't really be called a green building. If building owners and designers say they are following LEED but not bothering to apply for certification of the final building, you should rightly wonder if they will really achieve the results they claim. (2008, p. 13)

Yudelson further explains that project owners who claim to be building a green facility without certifying the project through LEED or another independent organization are deceiving themselves and others. When certification is not a goal, many aspects required for certification get cut from the project, primarily due to budget reasons.

4.3 A Balanced Scorecard to Evaluate the Impact and Status of Green Building at WPI

A BSC to measure the current status and strategically plan the future of green buildings at WPI was developed with information on the current status of green building at WPI, a comparison of green buildings at competitor schools, and information and suggestions for WPI officials on objectives for building green. Determining WPI's status on green buildings included research into WPI's green building policy and green building improvements. To judge where WPI stands in regards to green building relative to its competitors and neighbor institutions, research was completed on green building activity on other campuses. Finally, information from WPI faculty and officials was used to develop the GBBSC.

4.3.1 WPI's Current Status and Policies on Green Building

WPI's current status on green building was achieved through interviews with WPI officials. Currently, WPI has one LEED-certified building, the Bartlett Center, and one LEED-registered building, East Hall. These buildings are two of the three major new construction projects on WPI's campus within the last two years. The third project, Gateway Park, was built using many energy and water saving systems and environmentally sustainable building practices, but LEED certification was not originally sought.

WPI's policy on green building was obtained with the help of Judith Nitsch, member of the Board of Trustees and chair of the Physical Facilities Committee. WPI's current policy on green building, as stated in the March 2007 Board of Trustee Meeting Minutes, consists of a short statement:

> The committee also discussed whether WPI should have an official statement or policy on LEED certification. Trustee Nitsch proposed a policy that all new construction projects be undertaken with the intent of being LEED certified. This demonstrates a commitment to sustainable building and development. The Board approved this principle (Nitsch 2007b).

After determining the existence of this policy and obtaining a written copy of the statement above, determining what types of environmentally sustainable building improvements were being made to existing facilities and in what magnitude was also necessary. Speaking with Chris Salter, WPI's Director of Project Management and Engineering determined that WPI is installing low-flush toilets, occupant sensor lighting and more, but no formal way of determining which facilities had these installations and any savings that come from them exists (Salter 2008).

The next step in determining WPI's current status was to compare WPI to other colleges. After reviewing competitor and neighborhood institution websites, the following information was tabulated and shown in Table 14.

Table 14: Review of Competitor Websites

	College/University Website Review								Review of LEED Website	
School	Date of Search	Website	Sustainability Website	Comprehensive	Director of Sustainability	Green Building Policy	LEED Certified Buildings	LEED Registered Projects	LEED Certified Projects	LEED Registered Projects
Assumption College	25-Nov-07	www.assumption.edu	No	N/A	NM	NM	NM	NM	0	0
Carnegie Mellon University	25-Nov-07	www.cmu.edu	Yes	Yes	Yes	Yes	6	3	6	3
California Institute of Technology	12-Dec-07	www.caltech.edu	No	N/A	NM	NM	2	1	0	1
Clark University	12-Dec-07	www.clarku.edu	Yes	Yes	Yes	NM	1	1	1	1
College of the Holy Cross	25-Nov-07	www.holycross.edu	No	N/A	NM	NM	NM	1	0	1
Drexel University	25-Nov-07	www.drexel.edu	No	N/A	NM	NM	NM	1	0	0
Massachusetts Institute of Technology	12-Dec-07	www.mit.edu	Yes	Yes	Yes	Yes	NM	1	0	0
Northeastern University	12-Dec-07	www.northeastern.edu	No	N/A	NM	NM	NM	NM	0	2
Rensselaer Polytechnic Institute	12-Dec-07	www.rpi.edu	No	N/A	NM	NM	NM	1	0	1
Rochester Institute of Technology	12-Dec-07	www.rit.edu	No	N/A	NM	NM	NM	NM	0	0
University of Connecticut	12-Dec-07	www.uconn.edu	Yes	Yes	Yes	Yes	1	1	1	1
University of Massachusetts - Amherst	19-Feb-07	www.umass.edu	Yes	Yes	NM	NM	0	0	0	0
Worcester Polytechnic Institute	9-Apr-08	www.wpi.edu	Yes	Yes	NM	Yes	1	1	1	1
Worcester State College	25-Nov-07	www.worcester.edu	Yes	No	NM	NM	NM	NM	0	1

The letters "NM" mean no mention, or no information could be found. "N/A" means not applicable.

Of note, Clark University had two sustainability webpages. One page was brief and focused on the recycling program. The second webpage was a report on Clark's sustainability (Clark University 2007). It discussed such topics as recycling, carbon footprint, classes that deal with sustainability, and energy usage. This report was a concise example of what should be included on a college sustainability website.

The Massachusetts Institute of Technology (MIT) also had a sustainability webpage focusing on facilities. Topics covered on the website included cogeneration plant conservation, landscaping initiatives, recycling, solar power, and sustainable design (MIT 2007). The sustainable design website outlined the following green building policy: "MIT established the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Silver Certification as a minimum standard for all new Capital Projects in design from 2001 forward" (MIT 2007). Interestingly, as of December 12, 2007, and according to the USGBC website, MIT had not certified or registered a building. The MIT website also states that the Brain and Cognitive Science Complex is in the application process for LEED Certification, but this cannot be confirmed on the USGBC website. As straightforward as these results seem, they can be misleading as owners can decide whether or not to allow the USGBC to post project information.

Rochester Institute of Technology (RIT) did not have a website explaining environmental sustainability initiatives on their campus, although the campus does have a sustainability academic program (RIT 2007). The Golisano Institute of Sustainability has the following vision and mission statement:

> The Golisano Institute for Sustainability (GIS) at Rochester Institute of Technology is an exciting and wholly unique initiative. GIS will play a major role in enabling the transformation of global industrial enterprises into sustainable systems by undertaking comprehensive interdisciplinary initiatives in education, research, and technology transfer.

> Programs within GIS will take a holistic approach toward optimizing production and consumption systems by simultaneously addressing material flow, energy utilization, societal needs, ecological impacts, technology and policy factors, and the economics of sustainable business enterprises. Graduates of GIS will be prepared to effect meaningful change on a global scale. (RIT 2007)

RIT's enthusiasm in teaching sustainability is encouraging, but information regarding their environmentally sustainable practices on campus is difficult to find.

Lastly, the University of Connecticut has an extensive green building policy. The policy, incorporated into the University's master plan, was implemented in 2004 (UConn 2004). Including efforts to plan sustainable sites, safeguard water, conserve materials and resources, improve energy efficiency, and enhance the indoor environmental quality, the policy uses LEED as a sustainability benchmark. These comprehensive green design guidelines serve as a good example to WPI. The information found through this part of the project was used to strategize ways for WPI to advance in green building and environmentally sustainable building practices.

4.3.2 Mission Statement, Values, and Vision

Once background information had been collected and WPI's status on green building established, the next step to develop a Green Building Balanced Scorecard (GBBSC) was to create a mission statement, values, and vision. The mission statements of WPI, the WPI Facilities Department, and the USGBC were referenced for their relevance when developing the mission statement for the GBBSC (Appendix F). Input from WPI faculty and officials led to the final mission statement: to build and maintain facilities to high levels of occupant safety and comfort, environmental sustainability, and performance for the betterment of society.

When developing values, the core values of WPI and USGBC were used as examples (Appendix G). The values developed for the GBBSC are safety, comfort, environmentally sustainable, betterment of campus, efficient, collaborative learning, and integrated design.

The last step to the development of the foundation of the GBBSC was creating the vision. With research into the WPI vision (Appendix H), the GBBSC vision developed is as follows: Building and renovating WPI's facilities, WPI seeks to become a model for efficiency and environmental sustainability and a leader in green building in Worcester and competitive college circles, while maintaining the values of the University and promoting the use of buildings as educational laboratories.

4.3.3 Strategic Objectives, Initiatives, Measures and Targets

To finish developing the GBBSC, strategic objectives, initiatives, measures, and targets needed to be defined. Before this could happen, the original four perspectives had to be assessed for their suitability. Three of the original perspectives (financial, internal operations, and learning and growth) were kept, while customer was changed. For the GBBSC at WPI, "customers" of the building include students, faculty, staff, prospective students, alumni, and investors. As pointed out by Vicki Lynn of the

IT Division, these parties are not customers in the typical sense; they are not always right (Lynn 2008). This perspective was instead changed to community to encompass all involved.

Strategic objectives were then developed for each of the perspectives. To verify the presence of leading and lagging indicators, a Strategy Map was developed. Shown below, the arrows start at leading indicators (the drivers of change) and point to lagging indicators (consequences of actions already taken) (Niven 2003).

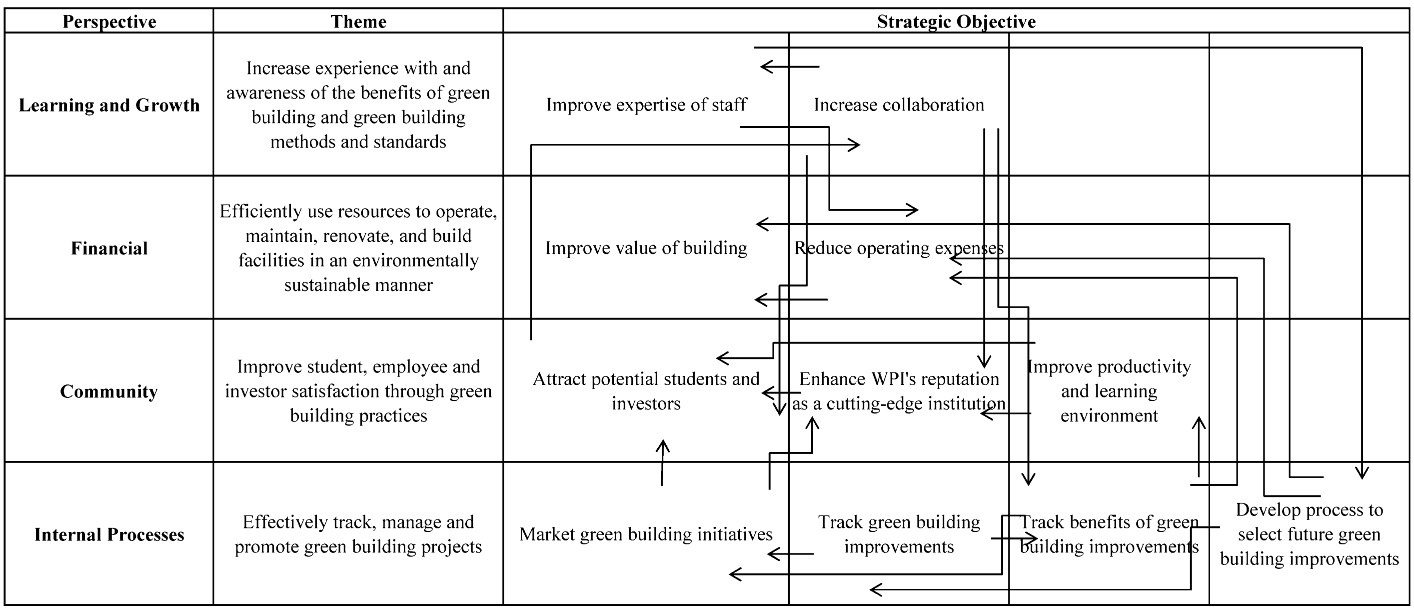

Figure 6: Strategy Map

The Strategy Map can also identify key perspectives and objectives. Perspectives and objectives that are important to obtaining the vision have more arrows leading to and from them. To facilitate analyzing the Strategy Map, the results were tabulated. Shown in Tables 15 and 16, the number of lagging indicators is the number of objectives for which the objective in question is a lagging indicator, or the number of arrows pointing to the objective. The number of leading indicators represents the number of objectives for which the objective in question is considered a leading indicator, or the number of arrows pointing away from the objective.

Table 15: Strategy Map Indicator Count by Perspective

Perspective	Total Lagging Indicators	Total Leading Indicators	Total Indicators
Learning and Growth	2	6	8
Financial	5	1	6
Community	8	3	11
Internal Processes	7	8	15

As shown in Table 15, the Internal Processes perspective has the most leading indicators and Community has the most lagging indicators.   This means many of the objectives rely on achieving the objectives of the Internal Processes perspective; Internal Processes will drive change. The high number of lagging indicators in the Community perspective means that these objectives are highly dependant on the success of other objectives.

Table 16: Strategy Map Indicator Count by Objective

Perspective	Objective	Lagging Indicator	Leading Indicator	Total Indicators
Learning and Growth	Improve expertise of staff	1	2	3
	Increase collaboration	1	4	5
Financial	Improve value of building	2	0	2
	Reduce operating expenses	3	1	4
Community	Attract potential students and investors	4	1	5
	Enhance WPI's reputation as a cutting edge-institution	3	1	4
	Improve productivity and learning environment	1	1	2
Internal Processes	Market green building initiatives	3	1	4
	Track green building improvements	1	2	3
	Track benefits of green buildings improvements	2	2	4
	Develop process to select future green building improvements	1	3	4

Increasing Collaboration and Attracting Potential Students and Investors tied for the highest number of total indicators. This does not necessarily mean that these objectives are most important to the organization, but that they are most important for achieving success. For example, Increased Collaboration has the highest number of leading indicators, which means that this objective should be achieved first and will drive change. Attract Potential Students and Investors has the highest number of lagging indicators. This means that this could be one of the last objectives to be met. Theoretically, this makes sense. Collaboration will help achieve goals faster and start momentum surrounding green building at WPI. Once goals are achieved, potential students and investors will take notice and having green buildings at WPI may affect their decisions.

After analyzing the Strategy Map, initiatives, measures, and targets were set for each objective. The complete GBBSC with definitions is shown on the next page.

GREEN BUILDING BALANCED SCORECARD

Mission: *To build and maintain facilities to high levels of occupant safety and comfort, environmental sustainability and performance for the betterment of society*

Values: *Safety, Comfort, Environmentally Sustainable, Betterment of Campus, Efficient, Collaborative Learning, Integrated Design*

Vision: *Building and renovating WPI's facilities, WPI seeks to become a model for efficiency and environmental sustainability and a leader in green building in Worcester and competitive college circles, while maintaining the values of the University and promoting the use of buildings as educational laboratories*

Perspective	Theme	Strategic Objective	Initiative	Measure	Target
Learning and Growth	**Increase experience with and awareness of the benefits of green building and green building methods and standards**	**Improve expertise of staff:** Improving the knowledge base of the staff of the Facilities Department will help promote green building on WPI's campus	**Pursue LEED Accredited Professionals:** Members of the Facilities Department should seek to become LEED APs	**No. of LEED APs on staff**	**1 LEED AP by 06/2009**
		Increase collaboration: Increasing collaboration between faculty, students and the Facilities department on green building projects will help advance green building on WPI's campus	**Use facilities as laboratories:** Using the components of green buildings, such as rain water collection systems, for experiments in projects or classes will help educate students and provide useful information to the facilities department	**No. of student projects relating to the green building operations**	**x% Increase or # increase over y years**
Financial	**Efficiently use resources to operate, maintain, renovate, and build facilities in an environmentally sustainable manner**	**Improve value of building:** WPI can track the over value of facilities	**Implement value engineering model:** WPI should adopt a value engineering approach to evaluating facilities. Determining the value of facilities by dividing the worth of the facility by the cost. In this system, buildings with lower operating costs will be worth more.	**Engineering value of all main facilities based on cost per square foot:** Finding the value of facilities on campus can help highlight facilities that need green building improvements	**50% of Facilities under $x/SF in x years:** Set a minimum value for facilities and short and long term targets to get facilities above this value
		Reduce operating expenses: Use green buildings to WPI's financial advantage	**Implement green building improvements and encourage energy reduction measures:** Implementing water and energy saving techniques as well as encouraging good practices (shutting off heat before opening windows, turning off lights when leaving a room, etc.)	**Usage rates per SF or per user:** Track current rates by rate/square foot or rate/user.	**% decrease over x years:** Set a realistic goal for a decrease in usage rates. Setting goals that the entire campus can contribute to increase buy-in to the Balanced Scorecard and sustainability program

Perspective	Theme	Strategic Objective	Initiative	Measure	Target
Community	**Improve student, employee and investor satisfaction through green building practices**	**Attract potential students and investors:** WPI can use green buildings to attract potential students, solicit donations from alumni, and more	**Publicize green building in WPI magazines, admissions brochures and alumni mailings:** Green buildings cannot work to our advantage unless they are publicized. This Initiative focuses on publications to potential students, alumni and friends of WPI	**Attractiveness or competitiveness of WPI in regards to green buildings: Survey** incoming students on the influence green buildings had on their decision to attend WPI and how they felt WPI compared in regards to green buildings to the other schools they considered	**x% Increase over y years:** Track the percentage of students who felt WPI was competitive in the area of sustainability and green building
			Provide unique opportunities for students and investors: To set WPI apart, unique opportunities for research must be provided	**No. of grants received by faculty related to environmental sustainability and the study of green buildings:** Encourage faculty to apply for grants related to green building and environmental sustainability	**$x of grants within y years:** Track the amount of grants faculty are receiving
		Enhance WPI's reputation as a cutting-edge institution: WPI can use green buildings and the use of them as laboratories to enhance the University's reputation	**Provide access to green building policies and green building improvements:** Besides writing articles, and publishing magazines including green building initiatives, current policies should be available online as a resource to those collecting information	**Improvement of green building score on College Sustainability Report Card:** WPI currently has a D- as an overall grade and a D for green buildings. The Report Card sites that WPI has "no known green building policy." Improving WPI's green building score will also improve the overall score and improve WPI's reputation for sustainability	**Improve green building score by one letter grade by 2010 report:** Achieve a C in Green Building
		Improve productivity and learning environment: These improvements will help current students and employees excel	**Improve day lighting and temperature control:** These improvements have been found to increase productivity, test scores and more	**Occupant comfort in faculties and control over temperature and lighting:** Survey faculty, staff and students in green facilities on their satisfaction with the facility, any noticeable changes in productivity, ability to control temperature, etc.	**x% Increase over y years:** Track the occupant satisfaction, break results into categories relating to daylighting, temperature control and productivity
				Green building performance: Monitor and measure comfort factors such as relative humidity, temperature and natural light levels.	**Target levels for each season over two trial years:** Track the levels and corresponding survey results to determine target levels
				Adjustment of HVAC systems according to results of building performance: Use the results of the previous measure to determine the fine tune the system	**Adjust system 2 times per year:** Adjust settings in facilities at a minimum of two times per year

Perspective	Theme	Strategic Objective	Initiative	Measure	Target
Internal Processes	**Effectively track, manage and promote green building projects**	**Market green building initiatives:** WPI can enhance their reputation by making the general public aware of green building improvements	**Press releases for major improvements:** Release press releases for major green building improvements, LEED certified buildings and plans for new LEED buildings	**No. of press releases on green buildings improvements:** Track the number of press releases and articles in outside publications on green buildings	**Minimum of 2 per year**
		Track green building improvements: It is important that WPI keep track of green building improvements in a systematic way. This can help provide statistics and numbers for press releases and evaluations such as the College Sustainability Report Card	**Campus-wide potential LEED Points Tracking:** One way to track improvements would be to track potential LEED points on campus. Another would be to identify green building initiatives and create a database on campus, by improvement and by building	**No. of potential LEED points on campus:** Determine the number of LEED points the facilities on campus qualify for.	**x% Increase or # increase over y years:** This may need to be set once a the number of points on campus is determined
		Track benefits of green buildings improvements: WPI also needs to track the benefits we are experiencing through green building. This can help direct funds to energy and water reducing features and highlight the success of projects	**Develop tables of water and energy usages:** WPI should develop a spreadsheet of electricity, heat and water usage by building	**No. of years tabulated:** Currently, WPI should tabulate the current year, and a few years back. Once this information is collected and it is standard procedure to update the spreadsheet every month, this measure would be unnecessary	**Current year and 3 previous years by 01/2009**
			Collect information on health, test performance, and class attendance of classes in green buildings and classrooms, or students living in green buildings: WPI could potentially not only become a leader in green building, but also in green building research. Little research has been done on the benefits of green buildings on college campuses	**No. of items on which complete data is collected:** Engage biology or pre-health faculty in studies of green buildings and rooms on campus. Studies could be completed on the health of students in the New Residence Hall vs. an existing residence hall. Assuming the new Rec Center will be LEED, start collecting data on the attendance in gym classes for comparison to attendance in gym classes in the new facility	**2 items by 2012:** Track two different non-financial benefits by 2012
		Develop process to select future green building improvements: Determining when and where improvements will be made is crucial to the status of green building on our campus	**Form committee to develop process to selection future green building improvements:** Select a committee to determine how to select future green building projects	**Development of comprehensive system to select future improvements**: Develop system to select future green improvements based on the value engineering model, LEED-EB points, etc.	**System implemented by certain date**

After the development of a proposed GBBSC, the next step was to develop an implementation plan.

4.3.4 Implementation of a Green Building Balanced Scorecard

When building and implementing a BSC, most companies and organizations choose one of two routes: hire a consultant or develop one in-house. Advantages and disadvantages to both exist. When hiring a consultant, company-wide acceptance of the process is easier to obtain. Hiring a consultant shows the organization's commitment to the project (Niven 2006). It is also easier for the staff to dedicate time to development meetings with a consultant than internal meetings, and the consultant can serve as an unbiased mediator (Lynn 2008, Niven 2006). Overall, the process with the assistance of a consultant runs smoother and requires less time. The disadvantage of hiring an outside professional is the added expense of the consultant's fees.

The advantage of developing a BSC in-house is saving money. However, without hiring a consultant, obtaining employee buy-in and convincing staff to commit time to the project become more difficult. Also, disagreements may be harder to resolve without a third party. A BSC can be successfully developed internally, but requires more work, patience, and time.

Regardless of which process is chosen for the BSC development and implementation, the most important part is getting division- or company-wide buy-in (Niven 2006). From the beginning, everyone must feel that they are part of the process to develop the scorecard and that their opinions are taken into consideration. By contributing to the development of the BSC, users feel important, better understand the concept, and are less likely to fear the changes that may ensue.

This project developed a GBBSC with the assistance and input of only a small group of individuals. If the proposed GBBSC is to be implemented, a diverse team should be selected to work on the further development and implementation of the GBBSC.

A BSC team should include a sponsor, a champion, and members of all departments involved (Niven 2006). A team sponsor takes responsibility of the GBBSC, must be able to communicate the strategic importance of the GBBSC, and be in complete support of its implementation. The team sponsor is in charge of providing financial and human resources to the team and communicating with senior management. The champion is in charge of the coordination of meetings and reports, and provides details of the methodology and strategy of the BSC development. The champion also selects and trains the remaining members of the team. Niven recommends that the GBBSC team be comprised of the most senior level staff possible from all areas or departments that the GBBSC encompasses. These team members can then serve as ambassadors to their departments.

During the BSC development, the team is responsible for developing the BSC and getting employee buy-in and input. The team should also develop a plan for training employees on the BSC and measuring the objectives at regular intervals. Periodic status reports should be provided to upper management and annual reports to the entire organization. As the organization changes and time passes, the BSC team may redefine the vision and identify new strategic measures. The continuous development of the BSC strengthens its value to the organization.

4.4 Feasibility of LEED-EB Certification for WPI Facilities

After developing a strategy for new green buildings and green building renovations, emphasizing the need for green renovations to existing buildings and determine the feasibility of using the LEED-EB rating system was important. The LEED-EB rating system focuses on the operations and maintenance of existing buildings. Rating buildings in the same categories as LEED-NC, LEED-EB offers points for having green cleaning policies, using efficient water and energy systems, using renewable energy, employing sustainable purchasing, and more (USGBC 2007a). As of January 2008, more than 60 buildings were LEED-EB certified and more than 840 were LEED-EB registered (Cortese 2008).

Universities and companies across the nation, recognizing the potential for cost savings and increased productivity, have sought LEED-EB certification as a solution. One of the most widely discussed examples of LEED-EB projects is the Adobe Towers in San Jose. Adobe Systems renovated three towers consisting of 989,358 square feet of office space and 838,473 square feet of semi-enclosed garage (Denise 2007). The first tower to be completed, the West Tower, received LEED-EB platinum in June 2006. In December 2006, the two other towers received LEED-EB platinum certification as well, making Adobe the first company to have three platinum-rated facilities.

Adobe systems invested $1.4 million on the renovations, received $389,000 in rebates, and now saves $1.2 million each year in operating costs (Denise 2007). The three towers achieved these results by reducing electricity usage by 35 percent, natural gas by 41 percent, domestic water by 22 percent, and landscape water by 76 percent. The facilities also divert up to 85 percent of solid waste, reduce CO_2 emissions by 17 percent, and reduce total pollution by 26 percent. Adobe has had a commitment to energy efficiency for a long time, which meant that it was well-prepared for LEED-EB certification (Zimmerman 2006). Yet, even doubling the upfront costs, Adobe would have earned their investment back in just over two years.

Seeing the benefits companies have experienced, colleges are beginning to think about certifying facilities with LEED-EB. A college campus is the perfect setting for LEED-EB. Campuses typically have a large number of outdated facilities that could experience significant reductions in energy and water usage. Further, the length of ownership, or length of time the benefits can be reaped, far exceeds that of commercial space, and is often more than 100 years. Financially, colleges, especially private institutions, have an advantage in green building and green building renovations because they have the ability to combine capital and operating budgets to make decisions based on life-cycle costs (Yudelson 2008).

As of February 2008, only 6 college buildings had been LEED-EB certified, but many are making commitments to certifying facilities (Daniels 2008). For example, the University of California at Santa Barbara plans to certify 25 of its buildings with the LEED-EB program within five years (Bocchicchio 2008). The small number of certified buildings on other college campuses makes LEED-EB an area where WPI can excel and become a leader.

Founded in 1865, WPI's original buildings are still being used (WPI 2007a). This thesis found that the average age of the main WPI buildings is 65 years, and the average age since major renovations is 32 years (Appendix U). Based on this, WPI can make significant improvements to efficiency and reduce the environmental impact of its buildings, while simultaneously improving the indoor environment and occupant productivity.

The steps to implement the LEED-EB rating system on a college campus, aside from the certification process, are to prepare an executive summary to communicate the vision and goals for the LEED-EB program on campus and to get campus buy-in (Zimmerman 2006). The mission, values, and vision developed for the GBBSC could provide a foundation for the executive summary.

A formal assessment of the facilities should occur to determine the current status of each facility and what green solutions would be cost-effective and cost-prohibitive (Zimmerman 2006). This assessment would be based not only on the energy usage, but also the air quality, commissioning, chemicals in the building, and more. Once this is completed, determining where the facility stands against the LEED-EB rating system is easy.

To achieve LEED-EB certification, a facility must meet all prerequisites, achieve a certain number of points, and operate as a green facility for three months (Daniels 2008). The facility is restricted to relocating 50 percent or less of the occupants during any necessary renovations; otherwise the facility should seek LEED-NC certification (USGBC 2007a). According to Jubilee Daniels, a Sustainability Planner and LEED-EB Consultant, one-third of the credits are operation or policy changes such as recycling or landscaping practices (2008). Another third of the credits are physical changes to the facility, such as remodeling and energy upgrades. Many of the later credits are from the LEED-NC rating system, which makes achieving LEED-EB gold or platinum very costly unless the facility is LEED-NC certified.

To select a facility to begin with, Daniels suggests choosing a facility that has projects that are already necessary, needs to be commissioned, and has occupants who are easy to work with and enthusiastic about environmental sustainability (2008). Daniels also finds that once a single facility is LEED-EB certified, certifying others on the same campus takes about one-tenth of the time because many of the credits carry over for the entire campus. One difficulty that has been found with LEED-EB certification is collecting data in the USGBC required format (Zimmerman 2008).

Overall, establishing a LEED-EB program at WPI would allow the facilities department to improve existing buildings, add value to the department and WPI, become better caretakers of the environment, and increase visibility on campus (Zimmerman 2006). Often, the facility manager and department go unrecognized for the work they perform. Certifying buildings by the LEED-EB program does increase the work load of the facility manager, but it provides benefits to the building owner and occupants and gives well-deserved recognition and credit to the facility manager. Certifying buildings with the LEED-EB program can also help WPI's score on the College Sustainability Report Card and provide points for the AASHE STARS program, in which WPI is currently enrolled as a pilot school (Sustainable Endowments Institute 2007, AASHE 2008).

Through cost and feasibility analyses, and the development of a strategic plan, it is apparent that green building and environmentally sustainable building improvements are worth WPI's time and money. Building new facilities to LEED-NC standards can directly save WPI over $16 per square foot over 20 years and WPI can earn back the initial investment in green technology within 40 months. Certifying new facilities with LEED-NC and existing facilities with LEED-EB can enhance WPI's reputation and competitiveness among competitive college circles, and the Worcester community, provide health and productivity benefits of occupants, and garner financial benefits to WPI. Lastly, implementing a green building balanced scorecard will further develop WPI's commitment to green building and track the progress of this fast-spreading movement.

5.0 CONCLUSIONS

This thesis explored the status and future of green buildings at WPI. To promote building green, it assessed the costs and benefits of green building and LEED certification, developed a GBBSC to measure green building, and evaluated the use of the LEED-EB rating system for campus use. The results of these analyses show the feasibility of green building at WPI in regard to finances and the processes to plan for, construct, and renovate green facilities.

Currently WPI has one LEED-certified building, the Bartlett Center, and one LEED-registered building. WPI has also established a green building policy and enrolled in the pilot program of AASHE STARS.

Many misconceptions about the costs of green building exist; some believe the costs to build green and to certify with LEED are extraordinary and prohibitive. The results of this project prove that this is not necessarily the case. As illustrated by the examples in the background chapter of this report, a building can be green and LEED-certified without adding more than one percent to the total project cost. Conservatively estimating the premium to be 2.6 percent, this project found the additional cost of building a new two- to three-story, classroom facility to be $4.07 per square foot, with the net benefits over twenty years amounting to $33.76 per square foot. While many building owners are opposed to the upfront cost of green building, the initial investment is usually paid back within three years. The analysis performed for this project found the payback time to be less than 20 months.

With respect to building certification, the costs associated with LEED certification, or the LEED premium, were found to be 0.3 to 0.6 percent of the total facility cost. For a typical two- to three-story college classroom facility, this amounts to $0.52 to $0.87 per square foot. This cost, evaluated separately from the green premium, is needed to ensure that the facility operates at the proper efficiency and fully reaps the rewards associated with building green. When a building owner decides against applying for LEED certification, they often sacrifice other important green features with it. LEED serves as a goal and validator to make sure green design decisions are completely implemented.

Beyond new buildings, existing buildings are an important target for green building at WPI. The average age of WPI's main buildings is 65 years, and the average age since major renovations is 32 years. Significant energy and water savings can be found through implementing the LEED Existing Buildings rating system. Providing not only financial benefits, LEED-EB can also contribute to scores on the College Sustainability Report Card and AASHE STARS program. Research shows that once one facility achieves LEED-EB certification, the time to certify other buildings on the same campus decreases considerably.

Using cost information to make the business case for building green, this thesis also proposed a strategic plan to measure current and future green building projects and renovations. The strategic plan, using the Balanced Scorecard approach, identified four perspectives where green building should be measured: community, internal processes, financial, and learning and growth. Objectives were developed for each perspective with measures to determine if an objective is reached and targets to capture an appropriate time frame. The Green Building Balanced Scorecard serves as a way to measure short- and long-term objectives in regards to building operations, building improvements, marketing of green building, and more. Using this approach would help the WPI Facilities Department set and achieve goals, serve as a framework for decision-making, and improve department-wide communication and understanding of the goals of the WPI's green building strategy.

6.0 FUTURE WORK

Green building is a quickly moving trend with a need for continued research. Future research on green building at WPI is needed to focus on the development of strategic plans and policies, and the costs and benefits of LEED-EB. The proposed GBBSC is only a beginning to strategic planning. Future work investigating the further development and implementation of a GBBSC, or other strategic management tool, is needed to create additional content and determine the time and resources necessary for implementation. Also, the current green building policy should be developed further to select a minimum level of LEED certification or to develop tailored guidelines and commitments regarding topics such as waste reduction, use of sustainable materials, recycling, and energy and water conservation.

LEED-EB is relatively new and less popular in comparison with LEED-NC. For this reason, more research is needed into the costs and benefits of LEED-EB certified buildings. This research could be the focus of a student project.

Ultimately, WPI should seek to use existing and new facilities for research on green building. Relatively little information is available on the costs and benefits of green building in higher education. Using the resources of a university of science and technology, WPI is well equipped to fill the gap in existing research.

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APPENDIX A: WPI's Sustainability Report Card

Category	Grade	Remarks
Administration	F	Worcester Polytechnic Institute has no known policy relating to campus-wide sustainability initiatives
Climate Change & Energy	F	A class installed a small solar array on campus in order to raise awareness of green energy options. The institute has not made public any steps taken to address energy efficiency or converstaion possibilities, and has not made progess toward the use of renewable energy.
Food & Recycling	C	The institute contracts with two local producers, including a local dairy. Dining services provides reusable dishawre to strudents and has eliminated the use of Styrofoam products. Cooking oil is recyced through the institute's "Fry-o-Later" program.
Green Building	D	The institute declared its first LEED-certified building in 2006, but has no known green building policy
Transportation	F	The institute has not made public any programs or practices that encourage or facilitat the use of alternative forms of transportation.
Endowment Transparency	F	The institute has no known policy of disclosure of endowment holdings or its shareholder voting record. Therefore, there is no known ability to access this information.
Investment Priorities	C	The institute aims to optimize investment return and has not made any public statements about investigating or investing in renewable energy funds or community development loan funds.
Shareholder Engagement	F	The institute has not made any public statements about active ownership or a proxy voting policy.

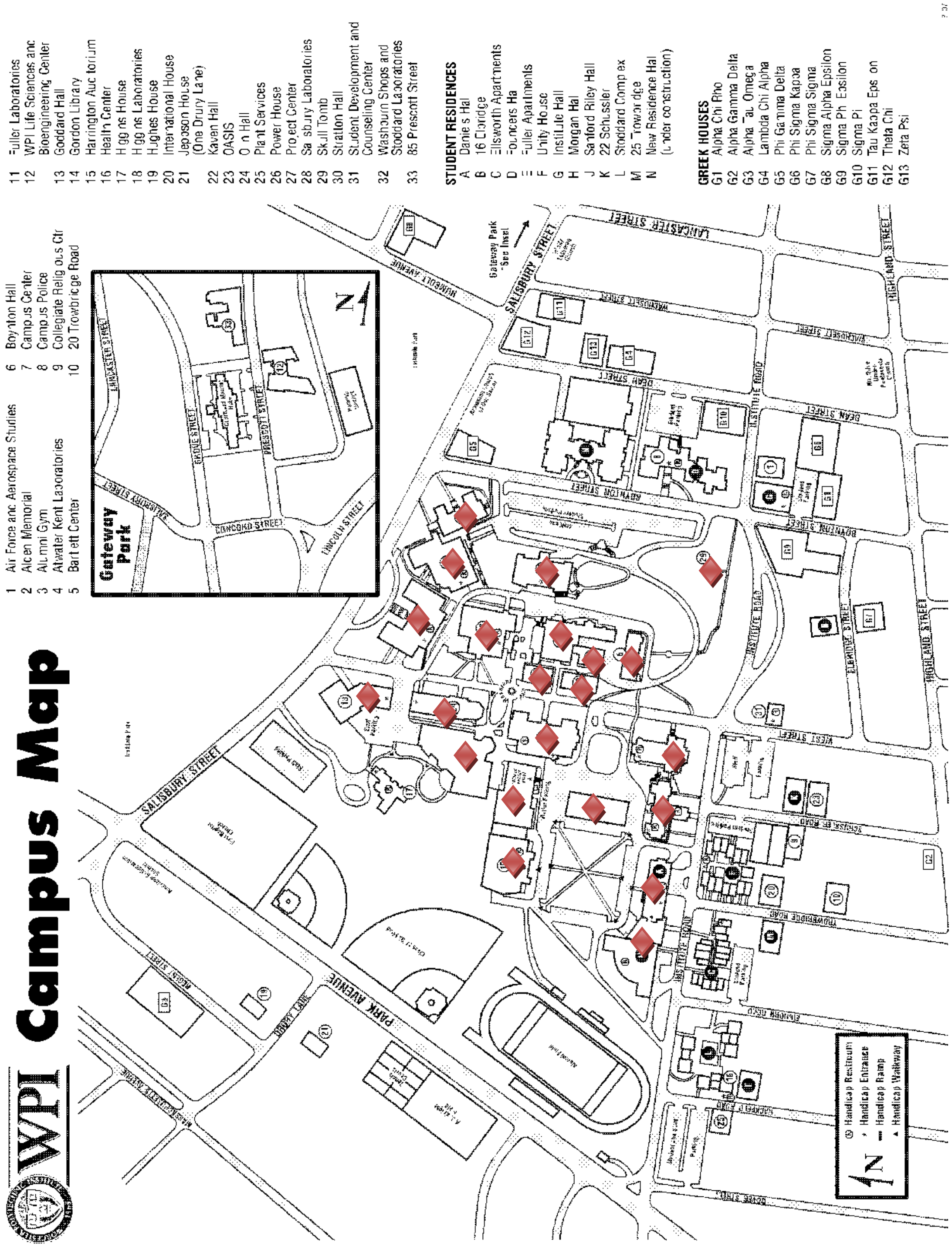
(Adapted from Sustainable Endowments Institute 2007)

APPENDIX B: WPI Buildings Heated by Power Plant

Building Name	Gross S.F.	Occupancy
Alden Hall	34,794	Auditorium/Classrooms
Alumni Gym	34,056	Gym, Offices, Pool
Alumni Gym Extension	15,416	Lockers, Offices
Atwater Kent	74,517	Classrooms, Labs
Bartlett Center	16,200	Admissions, Financial Aid
Boynton Hall	33,204	Offices, Administration
Campus Center	70,300	Offices, Meeting Rooms, Dining
Daniels Hall	57,760	Residence Hall, Offices
Fuller Labs	73,250	Classrooms, Auditorium
Goddard Hall	61,301	Classroom/Lab/Offices
Gordon Library	69,516	Library, Meeting Rooms
Harrington	89,675	Gymnasium, Classrooms
Higgins Labs	76,422	Classrooms/Labs
Kaven Hall	39,055	Classrooms/Labs
Morgan Daniels Wedge	6,123	Meeting Rooms
Morgan Hall	62,200	Res. Hall, Offices, Food Services
Olin Hall	36,534	Classrooms
Powerhouse	8,810	Boiler Room
Project Center	9,660	Offices, Classrooms
Salisbury Labs	69,830	Classrooms/Labs
Sanford Riley	46,646	Residence Hall, Administrative
Skull Tomb	750	Meeting Place
Stratton Hall	24,380	Classrooms, Offices, Phys. Plant Workshops & Storerooms
Washburn	42,606	Classrooms/Labs
Total Gross SF:	**1,053,005**	

Building Square Footage and Occupancy: DiMauro 2008a
List of Buildings Heated by Power Plant: Grudzinski 2008

APPENDIX C: Map of WPI Buildings Heated by Power Plant



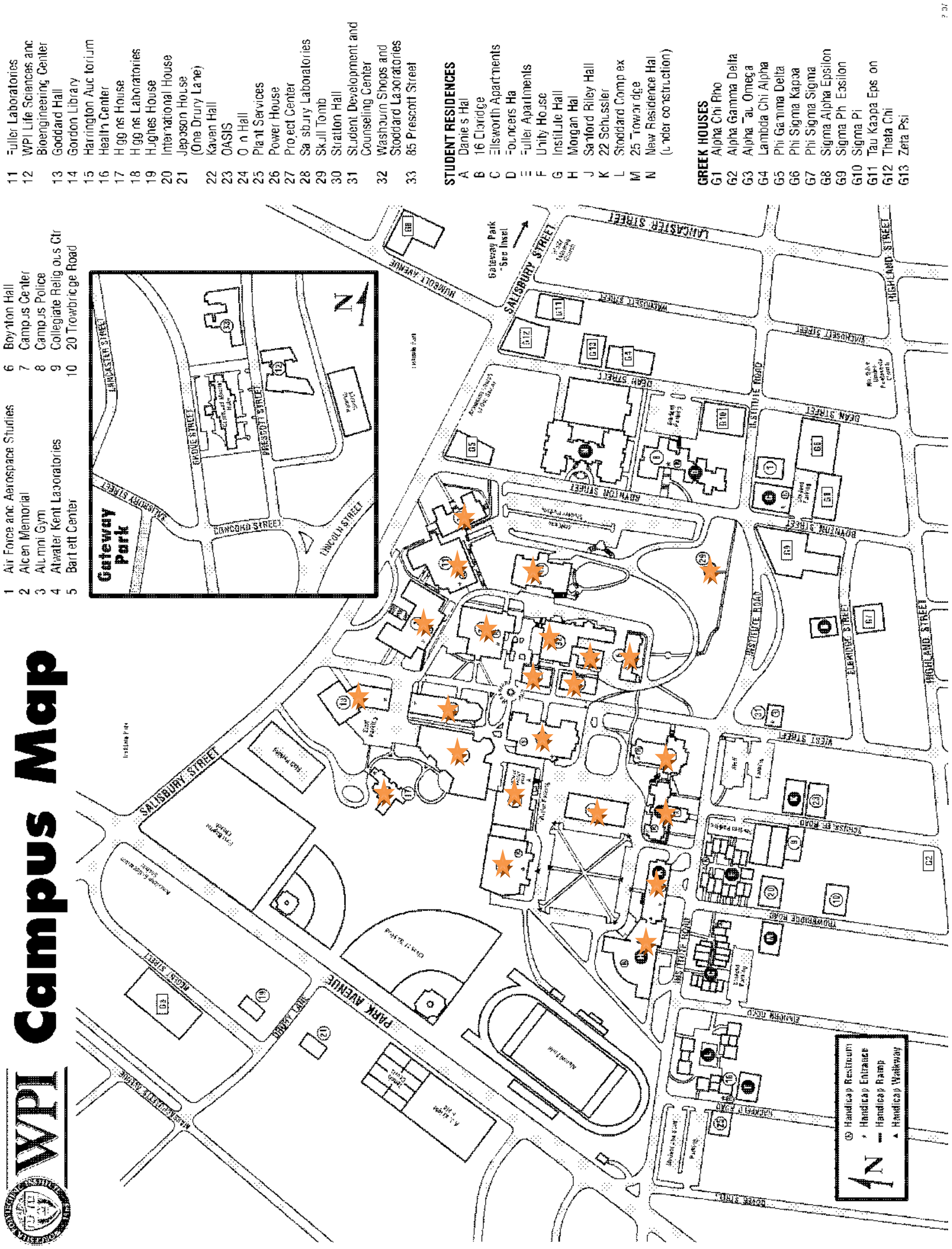
(WPI 2008a)

APPENDIX D: WPI Buildings Powered by Main Electricity Meter

Building Name	Gross S.F.	Occupancy
Alden Hall	34,794	Auditorium/Classrooms
Alumni Gym	34,056	Gym, Offices, Pool
Alumni Gym Extension	15,416	Lockers, Offices
Atwater Kent	74,517	Classrooms, Labs
Bartlett Center	16,200	Admissions, Financial Aid
Boynton Hall	33,204	Offices, Administration
Campus Center	70,300	Offices, Meeting Rooms, Dining
Daniels Hall	57,760	Residence Hall, Offices
Fuller Labs	73,250	Classrooms, Auditorium
Goddard Hall	61,301	Classroom/Lab/Offices
Gordon Library	69,516	Library, Meeting Rooms
Harrington	89,675	Gymnasium, Classrooms
Higgins House	15,883	Offices/Food Services/Mtg. Rooms
Higgins House Garage	3,500	Storage/Offices
Higgins Labs	76,422	Classrooms/Labs
Kaven Hall	39,055	Classrooms/Labs
Morgan Daniels Wedge	6,123	Meeting Rooms
Morgan Hall	62,200	Res. Hall, Offices, Food Services
Olin Hall	36,534	Classrooms
Powerhouse	8,810	Boiler Room
Project Center	9,660	Offices, Classrooms
Salisbury Labs	69,830	Classrooms/Labs
Sanford Riley	46,646	Residence Hall, Administrative
Skull Tomb	750	Meeting Place
Stratton Hall	24,380	Classrooms, Offices, Phys. Plant Workshops & Storerooms
Washburn	42,606	Classrooms/Labs
Total Gross SF:	**1,072,388**	

Building Square Footage and Occupancy: DiMauro 2008a
List of Buildings on Main Electricity Meter: Grudzinski 2008

APPENDIX E: Map of WPI Buildings Powered by Main Electricity Meter



(WPI 2008a)

APPENDIX F: Relevant Mission Statements

WPI:

WPI educates talented men and women in engineering, science, management, and humanities in preparation for careers of professional practice, civic contribution, and leadership, facilitated by active lifelong learning. This educational process is true to the founders' directive to create, to discover, and to convey knowledge at the frontiers of academic inquiry for the betterment of society. Knowledge is created and discovered in the scholarly activities of faculty and students ranging across educational methodology, professional practice, and basic research. Knowledge is conveyed through scholarly publication and instruction. (WPI 2008c)

WPI Department of Facilities:

The mission of the Facilities Department is to provide a safe, clean, properly maintained environment for the WPI community, in support of academic and social activities. Facilities staff will furnish the highest quality service, with the highest level of professionalism. (WPI 2008b)

USGBC:

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. (USGBC 2007d)

APPENDIX G: Relevant Values

WPI:

Lehr und Kunst
Excellence
Close faculty/student interaction
Collaborative learning and research
Respect for all members of our community (WPI 2007d)

USGBC:

Promote the triple bottom line
Establish leadership
Reconcile humanity with nature
Maintain integrity
Ensure inclusiveness
Exhibit transparency (USGBC 2006)

APPENDIX H: Relevant Vision Statements

WPI:

> Offering integrated theory and practice through a project-based curriculum and global opportunities in all levels of study, WPI will continue to build an environment that promotes innovative thinking, values mutual respect and diversity, highly regards scholarship, and engenders life-long learning for the campus community. (WPI 1998)

APPENDIX I: Cost and Benefit Data Collected

	Cost/Benefit	Direct/Indirect	Information Found	Source
Green Premium	*Cost*	Direct	2% of cost	Kats 2006
	Cost	Direct	0.66-6.50% of cost	Kats 2003a
	Cost	Direct	2% decrease in green premium with experience	Kats 2006
	Cost	Direct	$3-5/sq ft	Kats 2003b
Energy Savings	*Benefit*	Direct	33% less energy	Kats 2006
	Benefit	Direct	20-50% energy savings	USGBC 2002
	Benefit	Direct	30% less energy	Kats 2003a
	Benefit	Direct	25-30% more energy efficient	Kats 2003b
	Benefit	Indirect	1% decrease in gas usages to a 0.8-2% reduction in average wellhead prices	Kats 2006
	Cost	Direct	$2/sq ft/year	Kats 2003b
	Benefit	Direct	$0.40-1.00/sq ft decrease in energy costs	Yudelson 2006
University Energy Usage	*Cost*	Direct	32% for space heating	USDOE 2006
	Cost	Direct	24% for water heating	USDOE 2006
	Cost	Direct	22% for lighting	USDOE 2006
	Cost	Direct	5% space cooling	USDOE 2006
	Cost	Direct	17% for other	USDOE 2006
	Cost	Direct	Average school energy use in 05/06 was $1.15/sq ft (e&g)	Kats 2006
Water and Wastewater	*Cost*	Direct	5% of the cost of energy	Kats 2006
	Benefit	Direct	Water use reduction of 40%	USGBC 2008a
	Benefit	Direct	Water use reduction of 32%	Kats 2006
Health	*Benefit*	Direct	13.5-72.5% reduction in asthma	Kats 2006
	Benefit	Direct	15-85% reduction in colds	Kats 2006
	Benefit	Direct	87.3% reduction in flu	Kats 2006
	Benefit	Direct	20-45% reduction in respiratory problems	Kats 2006
	Benefit	Direct	20-23.5% reduction in headaches	Kats 2006
	Benefit	Direct	33-67% reduction in sick building syndrome	Kats 2006
	Cost	Direct	health care costs of $1650 per child w/ asthma	Kats 2006
	Benefit	Direct	Health care savings of $45 per person w/ flu per year	Kats 2006
	Benefit	Direct	1.41 fewer sick days/teacher	Kats 2006
Productivity	*Benefit*	Direct	0.2-15% increase from temp control	Kats 2006
	Benefit	Direct	0.7-26.1% increase from high performance lighting	Kats 2006
	Benefit	Direct	0.5-34% increase	Kats 2003b
	Benefit	Direct	1-5% of employee costs	Yudelson 2006
Absenteeism	*Benefit*	Direct	5-15% reduction	Kats 2006
Test Scores	*Benefit*	Indirect	3-19% increase	Kats 2006
Future Earnings	*Benefit*	Indirect	Increase in test scores from 50-84% is associated with a 12% increase in annual earnings	Kats 2006
Employee Retention	*Benefit*	Direct	5% reduction in teacher turn over	Kats 2006
	Benefit	Direct	Cost of turnover equal to 25-200% of annual salary	Kats 2006
	Benefit	Direct	Cost of turnover equal to $30000 to $150000	Yudelson 2006
Jobs Created	*Benefit*	Indirect	For every 1k tons waste disposed, 2.5 jobs are created - for ever 1k waste recycled, 4.7 jobs created	Kats 2006
	Benefit	Indirect	$10 million in energy efficiency investments creates 160 short term jobs and 30 long term jobs	Kats 2006
Tax Credits	*Benefit*	Direct	Photovoltaics- 30%	Yudelson 2006
	Benefit	Direct	Solar Thermal Systems - 30%	Yudelson 2006
	Benefit	Direct	Microturbines - 10%	Yudelson 2006
	Benefit	Direct	Energy conservation investments, including HVAC, envelope, lighting and water heating systems - $1.80/sq ft	Yudelson 2006

APPENDIX K: Water and Wastewater Calculations

Energy Cost	$ 3,668,018.69
Percentage of Energy Cost	5%
Water/Wastewater costs	$ 183,400.93
Percent Saved	32%
Total Savings	$ 58,688.30
Savings/SF	$ 0.05

EQUATIONS:

$$\text{Water/Wastewater costs} = \text{Energy Costs} * 0.05$$

$$\text{Total Savings} = \text{Water/Wastewater costs} * 0.32$$

$$\text{Savings/SF} = \frac{\text{Total Savings}}{\text{Square Footage}}$$

APPENDIX J: Energy Usage & Savings Calculations

Main Campus Energy Usage for 2007

Month	January	February	March	April	May	June	July	August	September	October	November	December	Year Total
Electricity Used (KWH)	1365600	1431288	929432	1391712	1322400	1372800	1576800	1567200	1684800	1648800	1504800	1514400	17310032
Cost of Electricity (cents/KWH) [MA]	15.79	16	14.95	12.42	13.81	15.24	15.26	15.65	15.89	14.62	14.38	15.12	-
Estimated Cost of Electricity	$ 215,628.24	$ 229,006.08	$ 138,950.08	$ 172,850.63	$ 182,623.44	$ 209,214.72	$ 240,619.68	$ 245,266.80	$ 267,714.72	$ 241,054.56	$ 216,390.24	$ 228,977.28	$ 2,588,296.47
											Total Electricity Used		$ 2,588,296.47
											Assumed Savings	30%	$ 776,488.94
											SF	1,072,388	
											Electricity Savings/SF		$ 0.72
Natural Gas Used (therms)	115528	9188	64156	36948	113986	25247	1895	1443	1991	3899	47282	123893	545456
Cost of Natural Gas (cents/MCF) [US]	597.3	595.6	626.1	$ 642.00	$ 702.70	777.4	799.3	800.4	764.5	682.1	610	579.40	-
Estimated Cost of Natural Gas Acct 1	$ 66,995.02	$ 5,312.98	$ 38,998.13	$ 23,029.72	$ 77,765.01	$ 19,055.36	$ 1,470.56	$ 1,121.34	$ 1,477.79	$ 2,582.05	$ 28,001.96	$ 69,692.82	$ 335,502.74
Natural Gas Used (MMBTU)	-	-	-	-	-	-	-	3.16	111.44	4613.48	12688.59	15784	$ 33,200.67
Cost of Natural Gas ($/MMBTU)	-	-	-	-	-	-	-	5.31	5.25	5.17	5.06	4.91	-
Estimated Cost of Natural Gas Acct 2	-	-	-	-	-	-	-	$ 16.78	$ 585.06	$ 23,851.69	$ 64,204.27	$ 77,499.44	$ 166,157.24
Oil Used (Gallons)	99665	75537	70017	10001	-	-	-	-	-	-	-	-	255220
Cost of Oil (Cents/Gallon)	218.5	228.5	234.1	237.8	-	-	-	-	-	-	-	-	-
Estimated Cost of Oil	$ 217,768.03	$ 172,602.05	$ 163,909.80	$ 23,782.38	-	-	-	-	-	-	-	-	$ 578,062.25
											Total Heating Fuel Used		$ 1,079,722.22
											Assumed Savings	30%	$ 323,916.66
											SF	1,053,005	
											Heat Savings/SF		$ 0.31
											Total Energy Savings/SF		$ 1.03

EQUATIONS:

$$\text{Estimated Cost of Electricity} = \frac{\text{Electricity Used} * \text{Cost of Electricity}}{100}$$

$$\text{Total Electricity Used} = \sum \text{Estimated Cost of Electricity}$$

$$\text{Electricity Savings Per Square Foot} = \frac{\text{Total Electricity Used} * \text{Assumed Savings}}{\text{Square Footage}}$$

$$\text{Estimated Cost of Heat} = \frac{\text{Oil or Natural Gas Used} * \text{Cost of Oil or Natural Gas}}{100}$$

$$\text{Total Fuel Used} = \sum \text{Estimated Cost of Heat}$$

$$\text{Heat Savings Per Square Foot} = \frac{\text{Total Fuel Used} * \text{Assumed Savings}}{\text{Square Footage}}$$

$$\text{Total Energy Savings Per Square Foot} = \text{Electricity Savings Per Square Foot} + \text{Heat Savings Per Square Foot}$$

APPENDIX L: Productivity Calculations

Affected by	Range	Percentage Increase	Average Salary in MA	Annual Savings Per Faculty &/or Staff	No. of Faculty/Staff	Square Footage	Annual Savings of all Faculty & Staff /SF
Source		(Kats 2006)	(U.S. Department of Labor 2007)		(Hassett 2008)	(DiMauro 2008)	
Temperature Control	Low	0.2	$ 47,340.00	$ 94.68	800	1,072,388	$ **0.07**
	Average	3.6	$ 47,340.00	$ 1,704.24	800	1,072,388	$ 1.27
	High	15	$ 47,340.00	$ 7,101.00	800	1,072,388	$ 5.30
High Performance Lighting	Low	0.7	$ 47,340.00	$ 331.38	800	1,072,388	$ **0.25**
	Average	3.2	$ 47,340.00	$ 1,514.88	800	1,072,388	$ 1.13
	High	26.1	$ 47,340.00	$ 12,355.74	800	1,072,388	$ 9.22

EQUATIONS:

$$\text{Annual Savings Per Faculty \& Staff} = \frac{\text{Percentage Increase} * \text{Average Salary in MA}}{100}$$

$$\text{Annual Savings Of All Faculty \& Staff Per Square Foot} = \frac{\text{Annuals Savings Per Faculty \& Staff}}{\text{Square Footage of Buildings Studied}} * \text{No. of Faculty \& Staff}$$

APPENDIX M: Indirect Energy Saving Calculations

Indirect energy savings = Direct Energy Savings * 0.75

APPENDIX N: Average Salary of WPI Graduates

Major	Average Salary	Number Reported
Aerospace Eng.	$ 53,500	1
Bio/Biotech	$ 37,800	5
Biochem & Chem	$ 52,400	3
Biomed	$ 49,429	7
Civil	$ 50,592	13
Chemical Eng	$ 53,829	17
Computer Sci	$ 57,805	13
Electrical & Comp. Eng	$ 55,818	32
Humanities	$ 38,000	3
Industrial Eng	$ 50,567	3
Management	$ 45,000	1
Math Actuarial	$ 45,000	1
Manufacturing Eng	$ 53,083	6
Mechanical Eng	$ 53,410	31
Management Information Systems	$ 48,167	6
Management Eng	$ 52,000	5
Technical Communication	$ 52,000	1
	Total No. Reported	148
	Total Average	$ 52,615

(WPI 2008e)

APPENDIX O: Increased Future Earning Calculations

Potential Earnings Increase	Average Salary of WPI Grads	Average Annual Earnings Increase
1.06%	$ 52,615	$ 557.72
1.76%	$ 52,615	$ 926.03

Average Annual Earnings Increase	Bachelors Degrees Awarded in 2006	Total Annual Earnings Increase	Square Footage	Annual Earnings/SF
$558	641	$357,499	1,072,388	$0.33
$926	641	$593,566	1,072,388	$0.55

EQUATIONS:

$$\text{Average Annual Earnings Increase} = \text{Potential Earnings Incease} * \text{Average Salary of WPI Grads}$$

$$\text{Annual Earnings per Square Foot} = \frac{\text{Average Annual Earnigs Increase} * \text{Bachelors Degrees Awarded in 2006}}{\text{Square Footage}}$$

APPENDIX P: Recycling at Other Colleges & Universities

University	Percentage of Waste Recycled
Boston College	52
Brown	35
Clark	15
College of the Ozarks	35
Duke	33
Harvard	45
Marquette University	20
Miami University	60
Middlebury	60
North Carolina U	39
RIT	27.5
Southern Methodist University	67
St. Lawrence	25
Stanford	61
University at Buffalo & SUNY	30
University of Arkansas	28
University of Brittish Columbia	46
University of Iowa	22
University of Michigan	30
University of Vermont	35
Univserity of Washington	44
Virginia Commonwealth University	25
Virginia Tech	22
Washington & Lee	45
Washington State University	57
Wheaton College (IL)	15
Average	**37.4**

(Sustainable Endowments Institute 2007)

This list was compiled by searching the College Sustainability Report Card for college and university recycling rates. All schools with listed rates were included.

APPENDIX Q: Employment Impacts of Recycling

	FY2006-2007	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Years 11-20
Waste	629.2	604.3	579.5	554.6	529.8	505.0	480.1	455.3	430.5	405.6	380.8	380.8
Recycled Material	132.5	157.3	182.1	207.0	231.8	256.6	281.5	306.3	331.1	356.0	380.8	380.8
Percentage Diverted	17%	21%	24%	27%	30%	34%	37%	40%	43%	47%	50%	50%
Jobs - Waste	1.57	1.51	1.45	1.39	1.32	1.26	1.20	1.14	1.08	1.01	0.95	0.95
Jobs - Recycling	0.62	0.74	0.86	0.97	1.09	1.21	1.32	1.44	1.56	1.67	1.79	1.79
Total Jobs	2.20	2.25	2.30	2.36	2.41	2.47	2.52	2.58	2.63	2.69	2.74	2.74
Job Increase	-	0.05	0.11	0.16	0.22	0.27	0.33	0.38	0.44	0.49	0.55	0.55

Jobs Created		0.05	0.11	0.16	0.22	0.27	0.33	0.38	0.44	0.49	0.55	0.55
Average Salary (MA)		$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340	$ 47,340
Income Increase	$ -	$ 2,586	$ 5,173	$ 7,759	$ 10,346	$ 12,932	$ 15,519	$ 18,105	$ 20,692	$ 23,278	$ 25,865	$ 25,865
Income/SF	$ -	$ 0.002	$ 0.005	$ 0.007	$ 0.01	$ 0.012	$ 0.014	$ 0.017	$ 0.019	$ 0.022	$ 0.024	$ 0.024

<u>EQUATIONS</u>:

$$\text{Percentage Diverted} = \frac{\text{Goal} - \text{Original}}{\text{10 years}} * \text{Years from start} + \text{Original}$$

$$\text{Recycled Material} = (\text{FY2006-2007 Waste} + \text{FY2006-2007 Recycled Material}) * \text{Percentage Diverted}$$

$$\text{Waste} = (\text{FY2006-2007 Waste} + \text{FY2006-2007 Recycled Material}) - \text{Recycled Material}$$

$$\text{Jobs created by waste} = \frac{2.5 * \text{waste}}{1000}$$

$$\text{Jobs created by recycling} = \frac{4.7 * \text{Recycled Material}}{1000}$$

$$\text{Income Increase} = \text{Jobs Created} * \text{Average Salary}$$

$$\text{Income/SF} = \frac{\text{Income Increase}}{\text{Square Footage}}$$

APPENDIX R: Net Present Value and Payback Period Calculations

Costs/Benefits of Green Facilities																								
	Annual ($/SF)	Inflation Rate	Interest Rate	Year																				20-year ($/SF)
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	
Direct Energy Savings	$ 1.03	2%	5%	$ 1.00	$ 0.97	$ 0.95	$ 0.92	$ 0.89	$ 0.87	$ 0.84	$ 0.82	$ 0.79	$ 0.77	$ 0.75	$ 0.73	$ 0.71	$ 0.69	$ 0.67	$ 0.65	$ 0.63	$ 0.61	$ 0.59	$ 0.58	$ 15.43
Indirect Energy Savings	$ 0.77	2%	5%	$ 0.75	$ 0.75	$ 0.75	$ 0.75	$ 0.75	$ 0.75	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 0.76	$ 15.13
Water & Wastewater	$ 0.05	2%	5%	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 0.05	$ 1.07
Future Earnings	$ 0.33	2%	5%	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 0.33	$ 6.66
Employment Impact - Increase Productivity	$ 0.32	2%	5%	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 0.31	$ 6.30
Employment Impact - Recycling	$ -	2%	5%	$ 0.00	$ 0.00	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.02	$ 0.01	$ 0.01	$ 0.01	$ 0.01	$ 0.26
Cost of Green (College Classroom)	$ (4.07)			$ (4.07)																				$ (4.07)
Net Financial Benefits	**$ (1.56)**			$ (1.62)	$ 2.43	$ 2.41	$ 2.38	$ 2.36	$ 2.34	$ 2.31	$ 2.29	$ 2.27	$ 2.25	$ 2.23	$ 2.20	$ 2.18	$ 2.16	$ 2.14	$ 2.12	$ 2.11	$ 2.09	$ 2.07	$ 2.05	**$ 40.78**
Cummulative Benefits				$ (1.62)	$ 0.82	$ 3.22	$ 5.61	$ 7.96	$ 10.30	$ 12.61	$ 14.90	$ 17.17	$ 19.42	$ 21.64	$ 23.85	$ 26.03	$ 28.20	$ 30.34	$ 32.46	$ 34.57	$ 36.66	$ 38.73	**$ 40.78**	

APPENDIX S: Cost-Benefit Analysis of Different Campus Facilities

Auditorium		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (Auditorium)	$ (3.89)	$ (3.89)
Net Financial Benefits	**$ (1.38)**	**$ 40.96**

College Dormitory 2-3 Story		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (College Dormitory, 2-3 Story)	$ (4.29)	$ (4.29)
Net Financial Benefits	**$ (1.78)**	**$ 40.57**

College Dormitory 4-8 Story		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (College Dormitory, 4-8 Story)	$ (4.19)	$ (4.19)
Net Financial Benefits	**$ (1.68)**	**$ 40.67**

College Laboratory		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (College Laboratory)	$ (4.18)	$ (4.18)
Net Financial Benefits	**$ (1.67)**	**$ 40.68**

College Student Union		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	$ -	$ 0.26
Cost of Green (College Student Union)	$ (3.71)	$ (3.71)
Net Financial Benefits	**$ (1.20)**	**$ 41.14**

Computer Data Center		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	-	$ 0.26
Cost of Green (Computer Data Center)	$ (6.62)	$ (6.62)
Net Financial Benefits	**$ (4.11)**	**$ 38.23**

Gymnasium		
	Annual ($/SF)	20-year ($/SF)
Direct Energy Savings	$ 1.03	$ 15.43
Indirect Energy Savings	$ 0.77	$ 15.13
Water & Wastewater Savings	$ 0.05	$ 1.07
Future Earnings	$ 0.33	$ 6.66
Employment Impact - Increased Productivity	$ 0.32	$ 6.30
Employment Impact - Recycling	-	$ 0.26
Cost of Green (Gymnasium)	$ (3.53)	$ (3.53)
Net Financial Benefits	**$ (1.01)**	**$ 41.33**

APPENDIX T: LEED Premium Calculuations

Calculations for the Average Square Footage of Academic Facilities on Campus		
Building Name	**Gross S.F.**	**Occupancy**
Atwater Kent	74,517	Classrooms, Labs
Boynton Hall	33,204	Offices, Administration
Fuller Labs	73,250	Classrooms, Auditorium
Goddard Hall	61,301	Classroom/Lab/Offices
Higgins Labs	76,422	Classrooms/Labs
Kaven Hall	39,055	Classrooms/Labs
Olin Hall	36,534	Classrooms
Project Center	9,660	Offices, Classrooms
Salisbury Labs	69,830	Classrooms/Labs
Stratton Hall	24,380	Classrooms, Offices, Phys. Plant Workshops & Storerooms
Washburn	42,606	Classrooms/Labs
Total Gross SF:	**540,759**	
Average SF/Building:	**49,160**	

	USGBC Membership (1-2 Univ. Campuses)	LEED Registration	LEED Certification		
			Less than 50,000 SF	50,000-500,000 SF	More than 500,000 SF
USGBC Member	-	\$450.00	\$1,750.00	\$0.035/SF	\$17,500.00
USGBC Non-Memer	\$750.00	\$600.00	\$2,250.00	\$0.045/SF	\$22,500.00
Per SF of Average WPI Academic Building	-	\$0.01	\$0.0467	-	-

EQUATIONS:

$$\text{LEED Registration Per SF of Average Academic Building} = \frac{\text{USGBC Non-Member LEED Registration}}{\text{Average SF/Building}}$$

$$\text{LEED Certification Per SF of Average Academic Building} = \frac{\text{USGBC Non-Member Less than 50,000 SF}}{\text{Average SF/Building}}$$

APPENDIX U: Age Analysis of WPI Facilities

Building Name	Street Address	City	YR Built	YR Major Renovation	# Stories Incl. Bsmt	Gross S.F.	Calculations for Average Age/SF	Average Age Since Last Major Construction/SF
(DiMauro 2008)								
Alden Hall	Campus	Worcester	1939	1992	3	34,794	67465566	69309648
Atwater Kent	Campus	Worcester	1907	1981	4	74,517	142103919	147618177
Fuller Labs	Campus	Worcester	1989		5	73,250	145694250	145694250
Goddard Hall	Campus	Worcester	1965		3	61,301	120456465	120456465
Higgins Labs	Campus	Worcester	1942	1995	4	76,422	148411524	152461890
Kaven Hall	Campus	Worcester	1954		3	39,055	76313470	76313470
Olin Hall	Campus	Worcester	1959		3	36,534	71570106	71570106
Project Center	Campus	Worcester	1902		2	9,660	18373320	18373320
Salisbury Labs	Campus	Worcester	1883	1976	5	69,830	131489890	137984080
Stratton Hall	Campus	Worcester	1894		4	24,380	46175720	46175720
Washburn	Campus	Worcester	1868	1984	4	42,606	79588008	84530304
Bartlett Center	Campus Quad	Worcester	2006		3	16,200	32497200	32497200
Boynton Hall	Campus	Worcester	1866	1978	4	33,204	61958664	65677512
Higgins House	Campus	Worcester	1923		4	15,883	30543009	30543009
Higgins House Garage	Campus	Worcester	1923		2	3,500	6730500	6730500
Morgan Daniels Wedge	Institute Road	Worcester	1976		1	6,123	12099048	12099048
Alumni Gym	Campus	Worcester	1916		4	34,056	65251296	65251296
Alumni Gym Extension	Campus	Worcester	1958		2	15,416	30184528	30184528
Harrington	Campus	Worcester	1968		4	89,675	176480400	176480400
Gordon Library	Campus	Worcester	1967		5	69,516	136737972	136737972
Daniels Hall	Institute Road	Worcester	1963	1998	5	57,760	113382880	115404480
Morgan Hall	Institute Road	Worcester	1959	2000	5	62,200	121849800	124400000
Sanford Riley	Institute Road	Worcester	1927	1996	5	46,646	89886842	93105416
Campus Center		Worcester	2000		3	70,300	140600000	140600000
Skull Tomb	Institute Road	Worcester	1886		1	750	1414500	1414500
Powerhouse	Campus	Worcester	1894	2006	2	8,810	16686140	17672860
Average Year of Construction/Renovation							**1943**	**1976**
Average Years Since Construction/Renovation							**65**	**32**

<u>EQUATIONS</u>:

$$\text{Average Year of Construction} = \frac{\sum \text{Year Built} * \text{Square Footage of Building}}{\text{Square Footage of all Buildings}}$$

$$\text{Average Year of Major Renovations} = \frac{\sum \text{Year of Renovations} * \text{Square Footage of Building}}{\text{Square Footage of all Buildings}}$$