

The financial benefits of building “green”

An analysis of New York City high-performance law

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Abstract

In New York City, in the United States as a whole, and in the rest of the world, there are many projects with high-performance features and environmental ambitions already completed or being built. Unfortunately, few projects are consistently followed-up and evaluated, which means that valuable information is lost.

For this reason, this research attempts to gather information from high-performance building projects in order to analyze and understand the impacts (e.g., both positive and negative) of adopting the Leadership in Energy and Environmental Design (LEED™) standards as the criteria of public buildings being planned and/or renovated.

The focus of this thesis is to identify the financial costs and benefits of high-performance building design prescribed by the proposed law Int. No. 0324-2004 in New York City, U.S.

The discussion in this study is based on how the public projects will be affected if the bill is passed by the City Council. The aim is to deliver information for the early stages of new building projects.

The analysis results are described in terms of the savings, payback time, and the process behind of project realization. The bill’s scenario has been analyzed and evaluated using methods such as life-cycle costing, net present value, and cost-benefit analysis. It is important to state that the study was not strictly focused on the environmental aspects described by LEED™ Silver certification. In fact, the impacts referred to by this thesis are divided into internal influence (i.e., running costs and maintenance) and the external influence (i.e., the public savings of reducing the water treatment costs).

Keywords: *Environmental design, design strategies, Int. No. 324, financial benefits, Leadership on Energy and Environmental Design, LEED™, high-performance buildings, New York City.*

Executive Summary

Nowadays, impacts on the environment such as waste, energy use, and indoor air quality problems can be drastically reduced by designing and operating buildings utilizing high-performance approaches. These high-performance practices include design strategies, material choices, and construction delivery method which focus on the efficient, sustainable, and environmentally suitable use of resources over the full life-cycle of a building.

The city of New York, aiming to reduce these impacts, has presented a local initiative, which is the proposed Local Law Int. No. 0324-2004. This bill is an attempt to implement high-performance measures in public buildings by proposing an amendment to the administrative code of the city, relating to requirements for city-owned and city-funded buildings.

The requirements adopted by the new regulation are based on the Leadership in Energy and Environmental Design (LEED™) Silver standards. As a result, the implementation of the bill would have a direct impact on the regional public construction sector.

Focus & Objectives

This thesis focuses on the city-owned and city-funded new office building in New York City, and the financial costs and benefits of high-performance practices, which are determined by LEED™ Silver requirements.

The objectives of the thesis are the identification of (i) the financial costs and benefits of the proposed law; (ii) when during the period of 20 years these costs and benefits are realized; and (iii) who may gain or lose with the high-performance bill in the public building sector.

Analysis presented

In the course of the analysis, literature was reviewed and information was gathered in relation to the three main objectives.

The information gathered was examined through a life-cycle costing analysis and placed into two scenarios, which are (i) conventional designed buildings and (ii) high-performance designed constructions. These scenarios were transferred to four theoretical investment alternatives.

The first alternative is the investment value for a building that is conventional designed. The second theoretical investment alternative is based on the current perception in the building industry that high-performance design costs are around 15 percent higher than a conventional building design.

The third and fourth investment alternatives are based on the results of the Sustainable Building Task Force report related to the average cost premium for a high-performance building. The third investment alternative is estimated as being approximately 2 percent higher than a conventional design. Finally, the fourth investment cost estimate is based on a LEED™ Silver building, which is 2.11 percent higher than a conventionally designed building.

The analysis considered five cost factors: Water consumption, energy usage, production of solid waste, emissions from energy generation, and productivity.

These cost factors were examined through a life-cycle costing study and placed into the cost-benefit analysis.

Results

In assessing the high-performance design costs the study identified that the bill’s financial cost versus benefit is that for every \$1 that the city spends to build a LEED™ Silver criteria public building, it will receive back more than \$3.

Conclusion

The cost to achieve LEED™ Silver certification required by the bill depends upon a variety of factors and assumptions such as (i) type and size of the project; (ii) timing of introduction of LEED™ as a design goal or requirement; (iii) level of LEED™ certification desired as well as how many points the project aims to earn; (iv) design and construction teams composition and structure; (v) the process used to select LEED™ credits; and, finally, (vi) clarity of the project implementation documents.

Interestingly, the savings provided by the implementation of LEED™ certification during the life-cycle of a building project creates itself an incentive to achieve the requirements, thereby offsetting higher investment costs. This is because that the investment rate of return is higher in a high-performance designed building than in a conventionally constructed building.

Consequently, the proposed law is judged as an important cost savings tool that could be available to the New York City local government. Furthermore, the bill presents a more efficient alternative of investments, which may bring benefits and satisfaction to the tax-payers.

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1 Introduction

The building industry includes a large number of actors such as material manufacturers, designers and engineers, material shipping businesses, construction companies, real estate firms, developers, and investors. In the United States (U.S.), this industry is responsible for 20 percent of the country’s economy¹ and it consumes approximately three billion tons of raw materials annually, which amounts to approximately 40 percent of the total national consumption of raw materials². The building operations consume roughly 16 percent of the potable water³ and the end-of-life produces demolition waste constitutes around 136 million tons⁴. Moreover, buildings consume significant amounts of energy for their maintenance; the consumption is around 36 percent of the total energy generated in the country⁵.

In the U.S., as in the rest of the world, the building industries’ impact is not just related to consumption as described previously. With people spending nearly 90 percent⁶ of their time indoors, buildings have also come to be recognized as an important factor affecting productivity, health, and well-being. Consequently, more efficient buildings can have a significant impact on reduction of resources, consumption as well as human health and productivity.

Impacts such as waste, energy use, and indoor air quality problems can be drastically reduced by designing and operating buildings utilizing high-performance approaches according to the United States Green Building Council (USGBC). The high-performance practices include design strategies, material choices and construction delivery methods, which focus on the efficient, sustainable and environmentally suitable use of resources over the full life-cycle of a building. These practices, as described by U.S. Department of Energy’s design approach, can create benefits for owners, occupants and the community since they are less expensive to operate and maintain.

On the other hand, it is still necessary to use and/or create incentives to encourage high-performance design. Various approaches are used to promote high-performance buildings and innovative construction. These can apply on both national and local levels. Two of these approaches are regulations and standards.

On the national level, the 20-Year Industry Plan for Commercial Buildings developed by the Representatives of the Commercial Building Industry (RCBI) is an example.

¹ National Institute of Standard and Technology & National Science and Technology Council. (1995). *Construction Industry statistics*.

² U.S Green Building Council (USGBC). (2004a). <http://www.usgbc.org/> [2004, May 4].

³ American Water Works Association (2004). <http://www.awwa.org/> [2004, August 7].

⁴ U.S. Environmental Protection Agency (EPA). (1998). *Characterization of Building-Related Construction and Demolition Debris in the United States*.

⁵ U.S. Department of Energy (DOE). (2001). *Energy Information Administration*.

⁶ EPA. (2004). *402-k-01-003: Healthy Buildings, Healthy People: A vision for the 21st Century*.

The plan is based on four interrelated strategies, which were considered as the keys to expand the concept of high-performance⁷. These strategies are:

- i. Establish core definitions and metrics for high-performance buildings;
- ii. Create models of collaborative buildings design and development, and establish the tools and professional education programs needed to support these processes;
- iii. Stimulate market demand for high-performance buildings by demonstrating and communicating compelling economic advantages; and
- iv. Develop systems integration, monitoring and other technologies that enable buildings to optimally achieve targeted performance levels over their life-cycles.

For this reason, achieving high-performance standards in buildings might require additional action at the policy level.

The city of New York has introduced just such an initiative at the local policy level. This initiative is the proposed Local Law Int. No. 0324-2004 or, simply, Int. No. 324. The bill⁸ is an attempt to implement high-performance measures in public buildings by proposing an amendment to the administrative code of the city, in relation to requirements for city-owned and city-funded buildings. The requirements adopted by the new regulation are based on the Leadership in Energy and Environmental Design (LEEDTM) standards. The bill's initiative provides an opportunity for researching the benefits of reducing operations and maintenance costs from the city-owned and city-funded building sector by complying with the obligations of the new standard.

1.1 Legislative framework

In 2002, the New York City Council proposed Int. No. 159, applying high-performance building⁹ requirements to city-owned and city-funded buildings. This bill requires that a minimum percentage of new and renovated city-owned properties be built according to high-performance criteria. Unfortunately, the bill never did have a hearing. However, it was a starting point for changes concerning high-performance measures. In fact, it was responsible for the development of the High-Performance Building Guidelines by the NYC Department of Design and Construction.

On 19th of April 2004, a new legislation proposed – Int. No. 324 – was presented to the City Council by the Speaker and Council Member Gifford Miller and Council Member James F. Gennaro. This bill aims to improve the steps made previously by adding a new chapter to the current building law. The modification requires that the high-performance building criteria be applied to all, instead of a minimum percentage of, new and renovated city-owned and city-funded buildings to be built.

⁷ Representatives of the Commercial Building Industry (RCBI). (2000). *High-performance commercial buildings: A technology roadmap*.

⁸ N.Y.C. Council (2004a). *Int. 0324-2004: Requirements for city-owned and city-funded green buildings*.

⁹ N.Y.C. Council (2002). *Int. 0159-2002: Requirements for high performance buildings*.

The high-performance building approach described within the Int. No. 159 is mainly a process of planning and construction through which a builder seeks to minimize the adverse environmental impact of a building. Typically, it aims to maximize energy efficiency; enhance indoor air quality; conserve materials and resources, and reduce water use.

Therefore the modification provided by the Int. No. 324 sets up a clear standard that is based on the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System™. The LEED™ criteria was developed by the United States Green Building Council¹⁰, a national non-profit entity. The criteria rates new and existing commercial, institutional and high-rise residential buildings according to their environmental attributes and sustainability features.

The LEED™ system utilizes a list of 34 potential performance-based “credits” or “points” worth up to 69 points, as well as seven prerequisite criteria, divided into six categories: (i) Sustainable Sites (SS); (ii) Water Efficiency (WE); (iii) Energy and Atmosphere (EA); (iv) Materials and Resources (MR); (v) Indoor Environmental Quality (EQ); and (vi) Innovation & Design Process (ID).

LEED™ allows the project team to choose the most effective and appropriate high-performance measures for a given location and/or project. These “points” are then tallied to determine the appropriate level of LEED™ certification. Four levels of LEED™ certification are possible; depending on the number of criteria met and points earned. They indicate increasingly high-performance practices: (i) Certified; (ii) Silver; (iii) Gold; and (iv) Platinum. The bill addresses only the Silver level in its requirements.

The choice of LEED™ as the standard to be required by the bill was not without merit. There is a general perception among local governments as well as developers that LEED™ is becoming the standard for U.S. high-performance design. And, it has rapidly become the largest and most widely recognized standard in the country. Consequently, this perception has facilitated LEED™ being chosen by the Int. No. 324 as the proposed local high-performance standard.

1.2 Problem description

The implementation of the Int. No. 324 would have a direct impact on the regional public construction sector, which would be obligated to comply with the criteria adopted in the alteration of the law. Consequently, the City’s Department of Housing, Building and Planning will have to draft the necessary adjustments to the standards and requirements in compliance with any new legislation.

In this case, the City would receive the onus of setting up the supply of high-performance techniques in order to meet the new minimum design requirements. The problem is that developers usually are skeptical to invest in high-performance technologies unless they make true economical sense¹¹.

In this cost- and risk-averse scenario, high-performance practices are still assumed to be radical. In fact, the current widespread perception in the construction field is that

¹⁰ USGBC. (2004a). <http://www.usgbc.org/> [2004, May 4].

¹¹ Cesano, D. (2002). *Market approaches for LEED and Green Design University*.

high-performance buildings or “green” designs in general are considerably more expensive than the conventional construction methods¹². This is because construction costs generally increase in direct relation to the complication of the building design, i.e. what additional features architects and engineers incorporate into a building.

This perception is essentially caused by three main reasons¹³:

- i. Incomplete integration within projects of the various actors. For example, a short-term focus of both engineers and contractors as compared to the long-term focus of the building owner;
- ii. Lack of life cycle costing or cost-benefit analysis for high-performance building construction; and
- iii. Insufficient technical information.

On the other hand, notwithstanding these barriers, the market of high-performance features, is still growing. Materials and technologies are becoming less expensive and are more commonly accessible¹⁴.

1.3 Research question

The research question is: *What are the financial costs and benefits to the proposed New York City Local Law Int. No. 324?*

In order to reach the objective of the thesis, this study is based on three main areas:

- i. The LEEDTM criteria: definition, enforcement and incentives;
- ii. The Int. No. 324: definition of the laws, obstacles, its interaction with LEEDTM, and what it requires;
- iii. The local city-owned building sector: definition, value chain description, analysis of direct and indirect costs.

1.4 Scope and limitations

The Int. No. 324 would require that a high-performance approach be applied to all new and renovated city-owned buildings. Furthermore all buildings would have to be at least LEEDTM 2.1 Silver certified.

The bill, however, exempts the following occupancy groups classified¹⁵ as: (i) Group A – High hazard buildings; (ii) Group D – Industrial buildings; (iii) Group F-2 – Outdoors

¹² Kats, G.H. (2003). *Green Building Cost and Financial Benefits*.

¹³ Sustainable Building Task Force (SBTF). (2003). *The Cost and Financial Benefits of Green Buildings*.

¹⁴ Brown, E.C. (2004). *Betting on Green Building Boom*.

¹⁵ N.Y.C. Council (2003). *Building code*.

assembly facilities such as stadiums; (iv) Group J – Residential buildings; and (v) Group K – Miscellaneous such as sheds.

The thesis covers a cost-benefit analysis of the proposed bill’s impacts on the New York City city-owned and city-funded building sector. The research focus area is justified by the fact that the implementation of the law could create a burden on the city budget. Consequently, this could become a strong barrier to the standard’s achievement.

The focus area lies predominantly in the study of new buildings. It is based on high-performance practices application which are determined in the design phase.

The geographical scope of this thesis covers the city-owned and city-funded building sector in New York City (see Figure 1-1).



Figure 1-1 New York City Map

The public building sector will be analyzed with respect to the most significant costs and benefits of high-performance building components. These are defined by the LEED™ 2.1 Silver criteria.

This thesis does not judge the high-performance criteria adopted in the local law; nor will it be technology-specific by describing and comparing different available alternatives of high-performance features.

This study essentially involves a cost-benefit analysis of high-performance features in new city-owned and city-funded buildings in New York City. The analyses presented focus on the requirements addressed by LEED™ and it includes the economic initiatives of the bill regarding water, solid waste, energy, emissions and productivity.

Furthermore, the actors discussed are those influenced directly by the LEED™ criteria: Primarily the architect, engineer, contractor, and developer (see Figure 1-2).

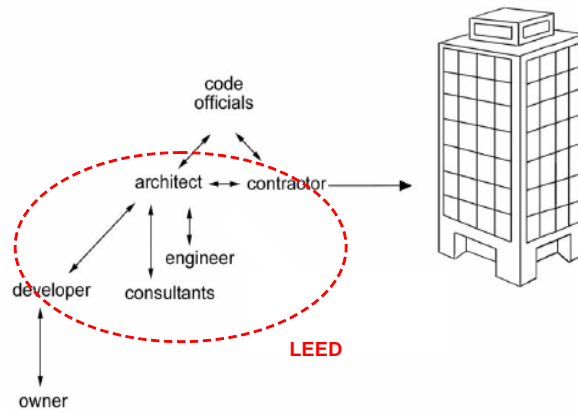


Figure 1-2 LEEDTM positioning in the building industry structure

It should be noted that this analysis does not cover the end-life of the building. Demolition costs for high performance buildings should be cheaper than conventional buildings. This is because the building components are generally recyclable. Consequently, including the building end life will support the results.

Buildings typically operate for over 25 years. In fact, a recent report for the Packard Foundation described by the SBTF report shows that building life increases proportionally to the increasing levels of high-performance.

According to the same study, a conventional building is expected to last 35 up to 40 years, a LEEDTM Silver level building for 60 years and Gold or Platinum level buildings even longer¹⁶. However, the thesis took in consideration the 20 years of the building life-span because of the fact that different features and technologies last different lengths of time.

This decision was based on the SBTF study, which shows that some energy equipment is upgraded every eight to 15 years, although sometimes building energy and water systems may last the life of a building. Thus, the analysis presumes that the high-performance features related to energy and water in buildings will last roughly 20 years¹⁷. Consequently, the life-span assumed in this study is 20 years.

1.5 Thesis outline

The thesis is divided into five main sections. Section 1 is the introduction. It introduces the scope, objectives and limitations. Section 2 presents the methodology used and background data applied in the calculations.

The Section 3 describes the core issues of the work including both the LEEDTM criteria and proposed law Int. No. 324. In addition, it presents a general overview of the building industry supply chain, which may facilitate the reader in further understanding while preparing him/her for the subsequent analytical sections.

The Section 4 it is the collected data analyses.

¹⁶ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*.

¹⁷ Ibid.

Finally, in Section 5 are the conclusions. Here the results are gathered from the analyses and recommendations are given towards potential future research.

2 Methodology and data background

In order to fulfill the objective of this thesis, various research steps were utilized and a number of different information sources have been explored. In the following sections, the main research steps are described as well as the data background.

2.1 Methodology

The study is processed with different categories of research methods: (i) literature review on high-performance buildings and relevant correlated issues; (ii) collection of secondary data, in order to identify drivers and influences related to high-performance building supply chain; (iii) primary data collection by personal communication and interviews in cooperation with Community Environmental Center¹⁸ (CEC) in New York City, U.S.; and (iv) analysis of the compiled information.

2.1.1 Literature review

The literature review was essentially based on high-performance buildings information and relevant issues regarding the analysis of their financial costs and benefits. Relevant information was found in hard copy publications, journal articles, electronic abstracts, and on the Internet.

Other areas covered by the literature review were the New York City proposed local law, Int. No. 324 and the LEEDTM rating system.

The literature review facilitates the definition of the scope of the thesis and to conduct the selection of data.

2.1.2 Data Collection

Different types of secondary data and information were collected. The main sources of data were (i) published articles, reports and documents by various authors, (ii) website information of organizations, companies, and governmental authorities, and (iii) statistic data from the Internet, statistic institutes webpage, and authorities. These data were utilized throughout the analysis section in order to identify the financial costs and benefits of high-performance designed.

Along with secondary data collection, interviews were conducted with various stakeholders in order to clarify and gather comprehensive information about high-performance building topic. Such primary data collection was made through e-mails; telephone conversations; and personal interviews conducted by both, CEC in New York City and the thesis author (see Table 2-1).

¹⁸ Community Environmental Center (CEC). (2004). <http://cecenter.org/> [2004, August 15].

Table 2-1 List of interviewees

Nome	Organization	Position	Data
<i>Abbey, Jason</i>	Fox & Fowle Architects	LEED Accredited Professional	May 17, 2004
<i>Balmori, Diana</i>	Balmori Associates	Architect and President	May 14, 2004
<i>Buisman, Floris K.</i>	Common Ground	Sustainability Director	July 23, 2004
<i>Gennaro, James F.</i>	NYC City Council	Council Member	July 26, 2004
<i>Greely, Douglas</i>	NYC Department of Environmental Protection	Deputy Commissioner	August 25, 2004
<i>Jacksy, Heather</i>	NYC Department of Housing and Development	"New Ventures Incentive Program"	August 11, 2004
<i>MacFarlane, Alexander T.</i>	Community Environmental Center	Project Manager	May 14, 2004
<i>Nasser, Terzah</i>	NYC Building Committee on Fire and Criminal Justice Services	Attorney	July 29, 2004
<i>Stine, James R.</i>	Los Alamos National Laboratory	Project Team Leader	May 14, 2004
<i>Sullivan, Kevin</i>	Habitat for Humanity	Director of Advocacy	August 19, 2004
<i>Unger, Russell</i>	NYC Committee on Fire and Criminal Justice Services	Attorney	July 29, 2004
<i>Wille, Roderick F.</i>	Turner Cosntruction Company	Senior Vice President	May 14, 2004

2.1.3 Analysis of the gathered information

The analysis of the gathered information consists in three main stages. The first stage is the collection of information. The gathered information is related to the construction, operation (i.e., lighting and water use consumption), and maintenance costs of both conventional and high-performance building. These data are the core stone of the analysis. The second is the life-cycle analysis, which sets a time period for the study.

The factors considered in the analysis are water, energy, solid waste, emissions from energy generation and productivity.

The life cycle-cost analysis' results, therefore, are transferred to the last stage: The cost-benefit analysis. This analysis is made by converting future values into present day currency. This is done in order to translate to the reader the tangible value created by showing the parallel between investment costs and savings produced throughout the building life-cycle.

These stages are described graphically in the Figure 2-1:

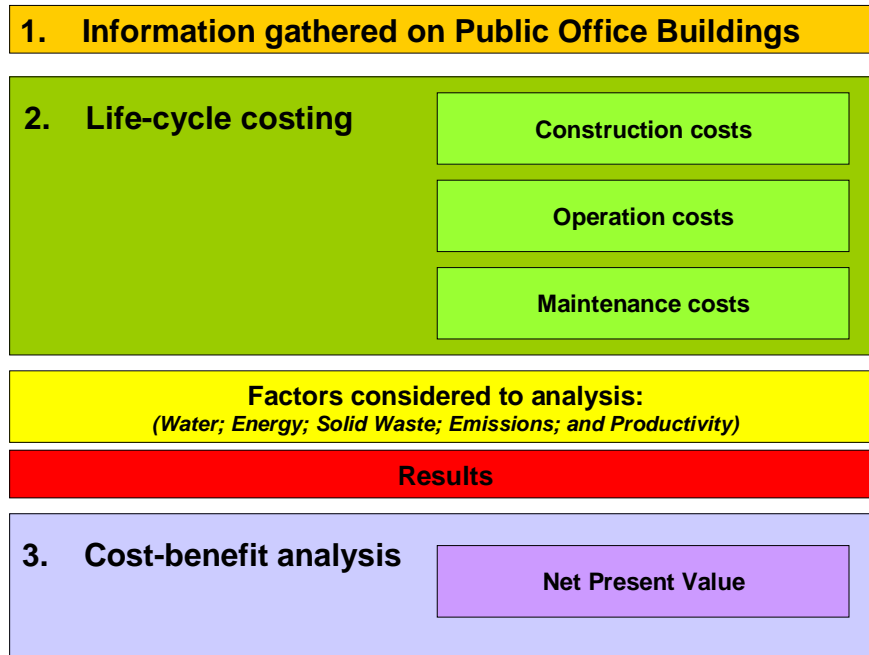


Figure 2-1 Analysis' description chart

The Life Cycle Costing (LCC) analysis is the technique used to establish the total ownership cost. This is done in order to take into consideration the cost of ownership over time.

As noted earlier, the time period is set as 20 years, which will not include building end of life.

The acquisition cost considered is the average value of construction costs per square foot (sq ft) in New York City, which is \$170 per square foot of construction¹⁹. This is followed by operational costs, which are incurred during the operational life of the building.

The operational costs are divided into five categories or cost factors: (i) water; (ii) solid waste; (iii) energy; (iv) emissions; and (v) productivity. This study does not analyze each LEEDTM credit separately. It utilizes the categories in order to achieve the full running cost.

The full running cost presented by the LCC analysis is important because purchasing decisions could be made based on the available options presented by the LEEDTM standard. These are in regard to water cost, solid waste generation, energy savings, emissions and productivity.

The running cost and financial savings identified by the LCC analysis are calculated on a present value basis and then combined in the conclusion with net costs to arrive at a net present value estimate. The advantages of discounting methods are²⁰:

- i. they give due weight to timing and size of cash flows;

¹⁹ R.S. Means Company Inc. (2004). Means Square Foot Cost Data 2002..

²⁰ Whole Building Design Guide. (2004).

- ii. they take the whole life of the project into account;
- iii. irregular cash flows do not invalidate the results obtained;
- iv. estimates of risk and uncertainty can be incorporated;
- v. use of discounting methods may lead to more accurate estimating; and
- vi. they rank projects correctly in order of profitability and give better criteria for acceptance or rejection of projects than other methods.

The *years to payback* method, determines the number of years for the earnings on a project to pay back the original outlay. When aggregate return and depreciation are roughly equal from year to year, the normal method for calculating payback is:

$$\frac{\text{Total Investment for Capital Expenditure}}{\text{Annual Savings} + \text{Annual Depreciation}} = \text{Years to Payback}$$

This method focuses on a project’s initial earnings. It does not take into account earnings made after repayment of the initial investment, and it does not include the time value of money. Therefore, it is not useful for comparing projects with different patterns of cash flow, or different lives.

The *rate of return* method is normally calculated by applying the average annual profit over the life of the investment to its initial capital cost.

Consequently, the investment decisions are made by considering what generates sufficient return for paying back the investments cost.

Finally, the last stage aims to facilitate decision makers choose between alternative solutions in a way that the chosen alternative is the most cost-effective within the context of budget and political considerations. Using the Cost Benefits Analysis tool the study can²¹:

- i. Evaluate the potential risks, fixed costs, operational costs and benefits of the project.
- ii. Compare the outcomes of two or more alternative cost/benefit scenarios of the same project.

For further information regarding the analytical tool, read Appendix A at the end of the thesis.

2.2 Data background

This subchapter deals with data description. It first presents the requirements for selection and then gives information about the source.

²¹ Boardman, Greenberg, Vining & Welmer. (1996). *Cost-Benefit Analysis: Concepts and Practice*. p. 7-21.

This study takes in consideration that building a comprehensive information framework can be a long process, which could take several years. Consequently, the calculations in the analysis section are based on gathering of secondary data from reliable source. The information, which are important to the analysis, range from water consumption to average absenteeism rate.

The thesis uses as baseline the following aspects:

- *Building type*: New standard commercial office building;
- *Building practices*: N.Y.C. Building code;
- *Average working days*: 260 days per year; and
- *Average daily working hours*: 8 hours per day.

The Table below present a list of data gathered in order to calculate the financial cost and benefits of the bill. Appendix B presented a list of high-performance building, used as baseline of calculation in this study.

Table 2-2 List of data gathered and used in the analysis

	Data	Value	Source
General	Number of Occupants	416 sq ft per occupant	DOE. (2004)
	Average construction costs:	\$170 per square feet	R.S. Means Company Inc. (2004)
	Average rent costs per year:	\$45 per square feet	Sumitomo Real Estate Sales. (2004)
	Discount rate:	5.24 percent	U.S. Federal Reserve. (2004)
	Inflation-indexed:	2.36 percent	U.S. Federal Reserve. (2004)
Water	Average projected water charge increase rate:	5.50 percent per year	DEP. (2004)
	Average water public cost:	\$3.8 per 100 cubic feet	Renzetti, S. (1999)
	Average sewage public cost:	\$12.10 per 100 cubic feet	Renzetti, S. (1999)
	Water charge:	\$1.52 per 100 cubic feet	DEP. (2004)
	Sewage charge:	\$2.42 per 100 cubic feet	DEP. (2004)
	Average indoor water usage per occupant:	171.5 gallons per day	Pacific Institute. (2004)
	Urban landscape water usage:	8 percent of total indoor water usage	deMonsabert, S. & Liner, B.L. (1996)
Solid Waste	Average generation of construction waste for non-residential buildings:	4 lbs per square feet of construction	EPA. (1998)
	Average generation of demolition waste for non-residential buildings:	155 lbs per square feet of construction	EPA. (1998)
	Average generation of solid waste per occupant:	13 lbs per day	DEP. (2004)
	Average disposal cost of construction solid waste:	\$67.74 per ton	SBTF. (2003)
	Average disposal cost of municipal solid waste:	\$15 per ton	ILSR. (2004)
	Average collection cost of municipal solid waste:	\$165 per ton	ILSR. (2004)

	Average export cost of municipal solid waste:	\$115 per ton	ILSR. (2004)
	Export and collection costs increment rate per year:	1 percent	ILSR. (2004)
	“Environmental Impact” benefits of diversion of construction waste:	\$47 per ton	SBTF. (2003)
	“Output Impact” benefits of disposal of construction solid waste:	\$289 per ton	SBTF. (2003)
	“Output Impact” benefits of diversion of construction solid waste:	\$564 per ton	SBTF. (2003)
Energy	Gas natural price:	\$8.8 per 1000 cubic feet	Naturalgas.org. (2004)
	Average natural gas consumption per occupant annually:	37.48 MBTU	Commercial Buildings Energy Consumption Surveys. (1999). p-79
	Average electricity consumption per occupant annually:	37.90 MBTU	Commercial Buildings Energy Consumption Surveys. (1999). p-50
	Electricity charge:	\$0.14 per kilowatts/hour	NYSERDA. (2004)
	Green Power added charge:	\$2 per 100 kilowatts/hour	Community Energy Inc. (2004)
Emissions	Clearing costs of SO ₂	\$174.97 per ton	EPA. (2004a)
	Clearing costs of NO _x	\$2,000 per ton	EPA. (2004b)
Productivity	Average wage:	\$23.10 per hour	BSL. (2004)
	Average absenteeism rate:	10.1 days per year	Adam Smith Institute. (2004)
	Average rate of decreasing absenteeism :	20 percent	Romm & Browning. (1998)
	Average rate of increasing productivity:	13 percent	Romm & Browning. (1998)

3 Descriptions

This chapter provides descriptions of the core issues of this thesis. It facilitates the reader’s further understanding and prepares him/her for the subsequent analytical sections, where a clear perception of the terms is highly beneficial.

3.1 High-performance building

There is no single definition of what constitutes a high-performance building, but it can be loosely defined as one in which all of the materials and systems are holistically designed. However, in any case its purpose is the minimization of their impacts on the occupants and on the environment. This includes such issues as:

- a. Durability;
- b. Use natural resources and materials efficiently;
- c. Conserve water usage and reduce stormwater runoff;
- d. Maximize energy conservation and efficiency;
- e. Reduce building footprints, simplify building shapes, and maximize space efficiency;
- f. Optimize building orientation; integrate natural daylight and ventilation;
- g. Eliminate toxic and harmful materials and finishes;
- h. Supports transportation alternatives;
- i. Reduce, reuse and recycle materials in all phases of construction and deconstruction;
- j. Implement maintenance and operational practices that reduce or eliminate harmful effects on people and the natural environment; and
- k. Design for future flexibility, expansion, and building deconstruction.

The terms “sustainable building” and “green buildings” are common phrases within literature as well as high-performance building. They address the same concept, which is to create buildings that can be constructed and operated in ways that reduce the impact of the building on the environment and on the building occupants. This study opted by using only the high-performance term since its aim is to identify the financial benefits of increasing the performance of a building.

These benefits of high-performance buildings can be measurable in terms of environmental, economic, and social impacts. The economic benefits come from reduced operating costs and improved occupant performance. The social benefits come from the improved health and comfort of the occupants. The environmental benefits derive from the reduced impact of the building’s construction and operations related to air, water, landfills, and non-renewable energy resources.

3.2 The LEED™ 2.1 criteria

The U.S. Green Building Council (USGBC), a national non-profit entity, developed the Leadership in Energy and Environmental Design (LEED™) Green Building Rating System™ to rate new and existing commercial, institutional, and high-rise residential buildings according to their environmental attributes and sustainability features.

The LEED™ Green Building Rating System™ is a voluntary, consensus-based national standard for developing high-performance buildings.

The system was created to²²:

- a. establish a common standard of measurement;
- b. promote integrated, whole-building design practices;
- c. recognize environmental leadership in the building industry;
- d. stimulate “green” competition;
- e. raise consumer awareness of high-performance building benefits; and
- f. transform the building market.

The core idea of LEED™ is to provide a complete framework for assessing building performance and meeting sustainability goals. The system utilizes a list of 34 potential performance-based “credits” or “points” worth up to 69 points in order to classify the certification level²³ (Table 3-1).

Table 3-1 The certification level

LEED™ certification level	
Rating	Earned Points
Certified	26-32
Silver	33-38
Gold	39-51
Platinum	52-69

These points are divided into strategies for sustainable site development, water savings, energy efficiency, materials selection and indoor environmental quality.

The credits consequently are set up into categories. There are six categories and each category holds a specific number of points (Table 3-2).

²² USGBC. (2004b). *Leadership in Energy and Environmental Design*.

²³ Ibid.

Table 3-2 The LEED™ categories

The LEED™ 2.1 categories and summary	
Category/possible points	
Sustainable sites 14	Requires the design of sedimentation and erosion plan. The site selection must follow some requisites such as not being on a protected habitat nor on public parkland. It offers points for: urban and brownfield redevelopment; alternative transportation incentives; limiting site disturbance; reducing the building footprint; implementing stormwater management plan and system; light pollution reduction; landscape and exterior design to reduce heat islands.
Water efficiency 5	Offers points for: reducing water consumption for irrigation by 50%; wastewater treatment system; use 20% or 30% less water; use only captured gray water or rain water to irrigation.
Energy and Atmosphere 17	Requires fundamental building systems commissioning, minimum energy performance, and CFC reduction in HVACR equipments. It offers points for: optimization of energy performance; use of renewable energy; additional commissioning; installing HVACR and fire-suppression systems that contain no HCHCs or halons; providing 50% of electricity from renewable sources over two-year contract.
Materials and resources 13	Requires an area for storage and collection of recyclables. It offers points for: using 20% or 50% of building materials that are manufactured within 800km (500 miles); using certified wood; implementation of construction waste management system; reusing material and using rapidly renewable material.
Indoor environmental quality 15	It must meet the minimum indoor air quality performance defined by legislation or standards such as ASHRAE 62-1999. Also, it requires environmental tobacco smoke control. It offers points for: Carbon Dioxide monitoring system; ventilation effectiveness; construction indoor air quality management plan during the construction and using phases; utilization of low-emitting material and components in the building; Thermal Comfort, Comply with ASHRAE 55-1992 and Permanent Monitoring System; Indoor Chemical & Pollutant Source Control; Controllability of Systems; Daylight & Views.
Innovation and design process 5	Offers points for having a LEED™-accredited professional in the project innovative. Also, the project can gain point for having innovative approaches for high-performance that are not described by the previous categories.

Source: USGBC

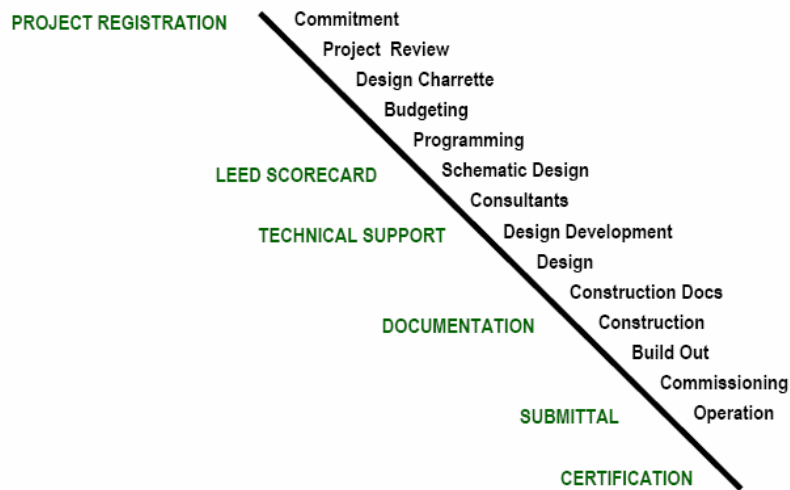
In order to receive the potential points related to the categories, the project has to fulfill the credits' requirements that are placed in certain categories. These prerequisite have to be met or the points of that specific category cannot be earned. Each category carries one or more possible points.

The project that covers the prerequisites/credits and earns enough points (i.e., 26 points) can become LEED™ certified by reducing around 30 percent of energy consumption and environmental impact²⁴.

Therefore, some categories such as “energy and atmosphere” and “indoor environmental quality” account together for nearly half of the 69 possible points and, improvements on these categories can facilitate achieving the lower certification levels.

The certification process is divided into six stages: (i) project registration; (ii) LEED™ scorecard or checklist for schematic design; (iii) technical support; (iv) documentation, (v) submittal; and, finally, (vi) certification (see Figure 2-1).

²⁴ USGBC. (2004b). *Leadership in Energy and Environmental Design*.

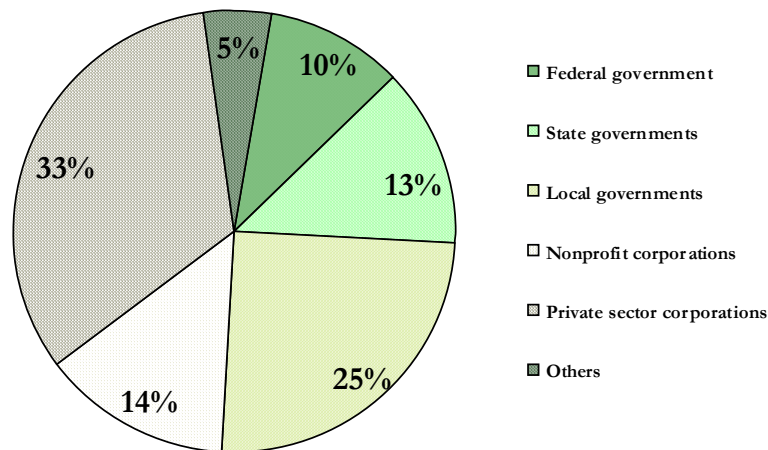


Source: Design Village. (2003).

Figure 3-1 The LEED™ process

The acceptance of the criteria is growing. This is because of the criteria provides verification and/or credibility for those wishing a formal third party verification of high-performance of their project.

In October 2003, 948 projects²⁵ were registered with LEED™. Cities, counties, and whole states have either adopted LEED™ or refashioning it to meet their local or regional needs. In fact public buildings represent 48 percent of the total registered projects (see Figure 3-2).



Source: Building Design & Construction. (2003).

Figure 3-2 Registration of LEED™ projects by ownership category

²⁵ USGBC. (2004a).

3.3 Public buildings

Public buildings are defined as a building or group of buildings owned and operated by a governing body, and are often occupied or managed by a government agency.

The thesis covers public buildings classified as city-owned and city-funded buildings in New York City. The city-owned buildings are the buildings occupied and maintained by the city government. And, city-funded buildings are any building or space whose construction, alteration, or design is paid for or financed in whole or in part directly by city funds which amount to at least 30 percent of the cost of the project²⁶.

3.4 The local law Int. No. 324

In 2000, Governor George Pataki signed into law a tax incentive providing \$25 million over five years to encourage developers to use advanced technologies such as fuel cells and photovoltaic panels and to use materials that improve air quality inside buildings and increase efficiency. The credit provides five percent of the capitalized cost of projects to builders and developers who meet energy, water, waste disposal, and air quality standards.

In the same year, the Battery Park City Authority, which is a semi-autonomous state entity, adopted some of the most stringent high-performance building requirements in the country. And most recently, a local proposed law to amend the administrative code of the city of New York has been introduced to the City Council.

This new administrative code will enter into force from January 1st, 2006 if the Int. No. 324 is approved. And, all new and/or renovated NYC public buildings will then have to be LEEDTM Silver certified.

The bill is an important step, since cities such as Portland, Austin, and San Francisco have long featured environmentally sound construction. The movement did not really begin in New York City until recently, when the state and city governments began getting involved²⁷.

3.4.1 The high-performance building legal framework in New York City

The involvement of the city is clearly shown by the high-performance building related legislations that were recently introduced to the City Council, such as:

- The Int. No. 375²⁸, which is a local law to amend the New York city charter, in relation to the creation of an energy office and public awareness city-wide of energy efficiency and conservation measures;
- The Int. No. 379²⁹ that requires the purchase of Energy Star certified appliances whenever appliances in rental apartments are replaced;

²⁶ N.Y.C. Council. (2004a). *Int. 0324-2004: Requirements for city-owned and city-funded green buildings.*

²⁷ Gennaro, James F. (2004). [Public Meeting]. *Int. 0324-2004: Requirements for city-owned and city-funded green buildings.* [2004, July 26].

²⁸ N.Y.C. Council. (2004b). *Int. 0375-2004: Public awareness city-wide of energy efficiency and conservation measures.*

²⁹ N.Y.C. Council. (2004c). *Int. 0379-2004: Requirements for replaced appliances in rental apartments.*

- The Int. No. 381³⁰ that is a local law to amend the administrative code of the city of New York, in relation to a survey regarding clean on-site power generation for city facilities; and
- The Int. No. 382³¹, which is a local law to amend the administrative code of the city of New York, in relation to the creation of a program regarding building commissioning and energy efficiency and conservation training.

The terms “law”, “legislation” and “bill” are used interchangeably through the thesis in order to present the *Int. No. 0324-2004: Requirements for city-owned and city-funded green buildings*.

³⁰ N.Y.C. Council. (2004d). *Int. 0381-2004: A survey regarding clean on-site power generation for city facilities*.

³¹ N.Y.C. Council. (2004e). *Int. 0382-2004: Requirements for education in energy efficiency and commissioning for city-employed building managers*.

4 The costs of the high-performance design

This chapter is the thesis’ backbone. It presents the analysis of gathered data by placing them into two scenarios: (i) conventional designed buildings versus (ii) high-performance designed constructions. This is necessary in order to identify the proposed law’s financial costs and benefits.

This section is divided into four sub-sections:

- i. *Construction costs*, which presents the differences in values of both design approaches (e.g., conventional and high-performance features);
- ii. *The cost of the local law Int. No. 324*, which identifies by literature review and data collected by interviews where the costs of adopting LEED™ Silver certification are placed;
- iii. *The cost analysis*, which is the presentation of the calculation results by five categories: (a) water, (b) solid waste, (c) energy, (d) emissions, and (e) productivity. The analysis is calculated using the English Measurement System (EMS); and, finally
- iv. *Main findings*, which displays all the overall results of the chapter using the International System (IS) of measurement and EMS.

Therefore, the study is focused on new construction; however, most of the strategies presented may also be applied to major renovations.

4.1 Construction costs

The first question often asked about high-performance design is what does it cost? Typically, high-performance approaches cost more, which raises the question: more than what? More than comparable buildings, more than the available funds, or more than the building would have cost without the “green” design features?³²

The Sustainable Building Task Force (SBTF) in California was the first organization to realize a report regarding a cost-benefit analysis of high-performance buildings in order to answer these questions.

The SBTF report gathered cost data on 25 office buildings and 8 school buildings. All of the 33 projects were LEED™ registered and 16 of them are certified as Silver. The projects actual or projected dates of completion are sited between 1995 and 2004 and all of them are listed at the Appendix B with name, location, building type, date of completion, cost premium, and certification level. These projects were chosen because the relatively solid cost data for both actual high-performance design and conventional design was available for the same building³³.

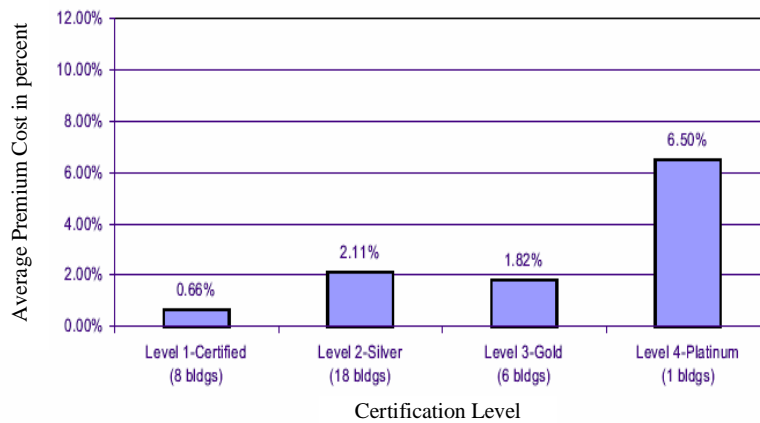
³² Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*. p.3.

³³ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*.

The SBTF report is an important step to change the widespread perception in the construction industry that building with high-performance design is significantly more expensive than traditional methods of development and design. The perception of developers is that high-performance buildings are estimated to be 10 to 15 percent more costly than conventional buildings³⁴.

The report has confirmed that high-performance design has more expensive initial cost in most cases more expensive but not as high as the current perception. In addition, another study prepared by the City of Boston Green Building Task Force confirmed that developers and/or investors often believe that high-performance design is not worth the extra cost³⁵.

However, the final result showed by both studies is that the average cost for these high-performance features is slightly less than two percent; in fact it is roughly 1.84 percent, which is substantially lower than it is commonly perceived (see Figure 4-1).



Source: SBTF. (2003).

Figure 4-1 Average premium cost vs. certification level

The cost of a project is most often interpreted and most easily understood by the public to be an amount of money that is spent on the project. Transferring this concept to the 4 Times Square office building, which is one of the buildings used in the SBTF report, the results are:

- Total project cost (land excluded): \$270,000,000³⁶;
- Current perception of premium cost: \$24,545,000 to 35,217,000;
- SBTF average premium cost: \$4,904,000; and

³⁴ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*. p.12.

³⁵ Kats, G.H. (2003). *Green Building Cost and Financial Benefits*.

³⁶ DOE. (2004c). http://www.eere.energy.gov/buildings/highperformance/case_studies/finance.cfm?ProjectID=32 [2004, July 27].

- SBTF Silver premium cost: \$5,579,000.

Looking at the numbers presented, this cost estimation demonstrates significant differences among the premium cost values.

In New York City, construction costs are considered among of the highest values in the U.S. The average construction cost in the city is \$170 per square foot³⁷. This price does not include the cost of land, or any unusual complex site preparation, or any office out-fitting above standard (i.e. the high-performance features).

The analysis utilizes a standard new commercial office building as the building type. The project follows the N.Y.C. Building code and its size is assumed as 100,000 square feet.

By multiplying the average construction price per total area built, this study determined the value of the conventional building cost.

$$\text{Building cost} = 100,000 \text{ sq ft} \times \$170 \text{ per sq ft} = \$17,000,000$$

This cost includes:

- i. Design;
- ii. Cost markups, which are defined as all of the percentages and adjustments added to the first-costs in an estimate. Markups can include overtime adjustments, taxes, and price adjustments, as well as contractor and owner cost markups; and
- iii. Bonding that is a three-party agreement between the surety (e.g., bonding) company, the principal (e.g., contractor) and the obligee (e.g., project owner). There are numerous types of surety bonds that cover a wide range of categories: (a) contract bonds; (b) license and permit bonds; (c) subdivision bonds; and (d) fidelity bonds.

Thus, the thesis can assume the values presented in the Table 4-1 as the scenarios, where the analysis is placed. There are four scenarios: (i) conventional costs, (ii) current perception of premium cost, (iii) SBTF average premium cost, and (iv) SBTF average Silver premium cost.

Table 4-1 Construction cost scenarios

Construction cost scenarios	
Conventional design	\$17,000,000
High-performance design by the current perception of premium cost	\$19,600,000
High-performance design by SBTF average premium cost	\$17,300,000
High-performance design by SBTF LEED™ Silver premium cost	\$17,400,000

³⁷ R.S. Means Company Inc. (2004). *Means Square Foot Cost Data 2002*.

As a result, the construction costs will differ among the high-performance premium costs. The values are:

- i. 10 to 15 percent added costs or roughly \$196 per square foot of construction by the current perception of high-performance premium cost;
- ii. 1.84 percent added costs or \$173 per square foot by the average premium cost defined by SBTF; and
- iii. 2.11 percent added costs or roughly \$174 per square foot by Silver premium cost.

4.2 The cost of the local law Int. No. 324

There is a consensus on the environmental and social benefits of high-performance building, which has led to the proposed bill. However, there is a consistent concern, both within and outside the “green” building community, over the lack of accurate and thorough financial and economic information³⁸.

The implementation of the bill will engage high-performance design in the local public construction sector. By setting the high-performance requirements, the uncertainty about the “costs” of the bill become an issue of growing importance.

Consequently, this sub-section identifies where the costs of adopting LEED™ Silver certification are placed.

The results of the study are divided into: (i) Sustainable site; (ii) water efficiency, (iii) energy and atmosphere, (iv) material and resources, (v) indoor environmental quality, and (vi) innovation and design process. This is because in this stage the study correlates the overheads found within the LEED™ Rating System criteria.

4.2.1 Sustainable sites

The Sustainable Sites (SS) section focuses on selecting, constructing, and modifying a site to avoid development on inappropriate sites. The objective is to make a site sustainable that will provide sound construction over the years while preserving the natural resource consumption in the process.

Proper site selection reduces costs for site preparation, infrastructure construction, and infrastructure maintenance, especially for stormwater, which can be managed using the natural landscape.

Also, building orientation can reduce energy consumption and costs. Natural landscapes are easier and less expensive to maintain than conventional turf grass lawn. They require less irrigation, fertilizer, pesticides, and mowing. Properly designed sites absorb and filter stormwater runoff, recharge groundwater aquifers, maintain habitat and biodiversity within developed areas reduce soil erosion, and protect air and water quality by preserving open space, natural areas, and water resources.

³⁸ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*.

Sustainable site costs can generally be assumed as the costs related to the decision of land acquisition. Furthermore in this criteria, the costs are placed in two categories: (i) site selection and (ii) site design, which can amount to nothing to as much as several thousands dollars.

A total of 14 possible points can be obtained by fulfilling every criteria within the sustainable sites section of the LEED™ Rating System. The Table 4-2 presents the credits included in the criteria.

Table 4-2 Sustainable sites list of credits

Sustainable Sites criteria	
SS 1.0	Site Selection
SS 2.0	Urban Redevelopment
SS 3.0	Brownfield Redevelopment
SS 4.1	Alternative Transportation, Public Transportation Access
SS 4.2	Alternative Transportation, Bicycle Storage & Changing Rooms
SS 4.3	Alternative Transportation, Alternative Fuel Vehicles
SS 4.4	Alternative Transportation, Parking Capacity
SS 5.1	Reduced Site Disturbance, Protect or Restore Open Space
SS 5.2	Reduced Site Disturbance, Development Footprint
SS 6.1	Stormwater Management, Rate and Quantity
SS 6.2	Stormwater Management, Treatment
SS 7.1	Landscape & Exterior Design to Reduce Heat Islands, Non-roof
SS 7.2	Landscape & Exterior Design to Reduce Heat Islands, Roof
SS 8.0	Light Pollution Reduction

The first four points, which are **SS 1.0, 2.0, 3.0,** and **4.1,** section have to do with site selection, urban density, brownfield reclamation, and proximity to mass transit. The ability of a project to get any of these points is usually unconnected to whether or not the project has a LEED™ goal; consequently, they may not include additional costs by complying with the bill.

One of the more prescriptive LEED™ point-getters is the **SS 4.2** (see Appendix C for detailed list of point-getters credits). It requires the provision of bike racks and showers. This

is a relatively inexpensive point with low design impact; and most projects target this point from the start.

The **SS 4.3** similarly has relatively low cost and design impacts; electric refueling stations can be added almost any time during design and construction. However, electric cars are not an available option in the current vehicle market. On the other hand, this credit has the option to use alternative fuel (e.g., natural gas or biodiesel) station by raising the cost and design impacts instead of installing useless electric refueling station.

The study prepared by Davis Langdon Adamson Consulting Firm³⁹ shows that most projects that achieved **SS 4.4** did so by making minimal design changes, which are low cost, such as adding striping and signage for car and vanpool parking.

Regarding the Prerequisites in terms of cost, they are related to the site selection and standard to most projects, or easily achieved at minimal added cost.

Unlike site selection, site design is often modified to meet LEED™ criteria. In general, most Certified projects achieve five or six of the total 14 available points with the higher LEED™ levels achieving nine or more points⁴⁰.

The site construction minimization is required by **SS 5.1** and **5.2**. In fact, it is usually achieved only where there is minimal construction cost implication (i.e., where substantial excavation is not required, or by restoring half of the non-building area to natural habitat)⁴¹. The **SS 5.2** is also typically achieved at minimal cost or not achieved at all by the projects as is revealed by the same study prepared by Davis Langdon Adamson⁴².

The **SS 6.1** and **6.2** are related to methods used to slow stormwater flow and to treat stormwater. In these credits the site size plays a significant role in whether or not the stormwater-related points result in additional cost.

Drainage tends to have a minimal cost impact when compared to retention or detention ponds, which are more expensive (i.e., installation of stormwater collection tanks can be very costly). In general, projects used the less costly approaches. However, projects can use the more costly underground tank approach to the first point because these projects also capitalized on opportunity for synergies between this point and other irrigation and water use reduction points.

The **SS 7.1** that is related to heat island effect can be achieved by changing the color of concrete paving and adding shade elements for relatively low cost, with design standards being the only impediment. The specification of high-emissivity roofing set by Energy Star®⁴³ for the second point addressed by **SS 7.2** can be costly. However, it can be reached via a green roof that may have a little to do with cost, but probably has more to do with perceived structural and maintenance issues. Consequently, it adds more design effort.

³⁹ Davis Langdon Adamson. (2004). <http://www.davislangdon-usa.com/> [2004, August 16].

⁴⁰ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

⁴¹ Ibid.

⁴² Davis Langdon Adamson. (2004). <http://www.davislangdon-usa.com/> [2004, August 16].

⁴³ Energy Star. (2004). http://www.energystar.gov/ia/partners/product_specs/eligibility/roofs_elig.pdf [2004, August 17].

The **SS 8.0** is generally not achieved. This is because project teams may be dissuaded because the standards are not always well understood and the required documentation is time consuming⁴⁴.

4.2.2 Water efficiency

The Water Efficiency (WE) criteria focuses on the sustainability and renewability of water. A total of five possible points can be obtained by fulfilling every criteria within the water efficiency section of the LEED™ Rating System. The LEED™ Program looks at water efficiency and focuses on three main areas that include:

- i. *Water efficient landscaping:* By using plants, flowers, shrubs, etc. that are indigenous to an area, you can limit the need for irrigation and reduce the amount of chemicals (e.g., fertilizers and pesticides) needed to maintain the landscape. Also, by using alternative forms of irrigation (i.e., collecting rainwater), will help to limit or eliminate the use of potable water. In the U.S., irrigation uses mostly potable water⁴⁵. However, a lesser quality of water such as graywater, which is the wastewater from lavatories, showers, bathtubs, washing machines, and sinks that are not used for disposal of hazardous or toxic ingredients or wastes from food preparation, would be adequate.
- ii. *Innovative wastewater technologies:* Currently, a large volume of potable water is used to convey waste to water treatment facilities. However, graywater could be used to accomplish this task. Additionally, it could be used high efficiency fixtures and dry fixtures (i.e., composting toilets and waterless urinals) to reduce water consumption.
- iii. *Water use reduction:* By maximizing water efficiency within buildings, (i.e., using water efficient toilets or faucets that restrict the flow of water or are equipped with sensors to automatically shut off) we will reduce the burden on municipal water supply and wastewater systems.

The Table 4-3 below presents the credits included in the criteria.

Table 4-3 Water Efficiency list of credits

Water Efficiency criteria	
WE 1.1	Water Efficient Landscaping, Reduce by 50%
WE 1.2	Water Efficient Landscaping, No Potable Use or No Irrigation
WE 2.0	Innovative Wastewater Technologies
WE 3.1	Water Use Reduction, 20% Reduction
WE 3.2	Water Use Reduction, 30% Reduction

⁴⁴ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*. p.8.

⁴⁵ DEP. (2004). <http://www.nyc.gov/html/dep/home.html> [2004, August 2].

The first credit is the irrigation point **WE 1.1** is typically easily achieved by designing high efficiency irrigation, at minimal cost, although this can be difficult to achieve if the landscaping includes the wrong vegetation such as water demanding species. The second credit **WE 1.2** is less popular because the decision to install no permanent irrigation, which mean no use of water that is not captured or recycle. This credit requires: (i) stronger commitment than many project developers feel and (ii) synergy among the LEED™ credits, such as **SS 6.2** (e.g., stormwater storage).

The study prepared by Davis Langdon Adamson⁴⁶ shows that most projects that achieved the second point has used reclaimed water and the costs were therefore low. Furthermore, where reclaimed water was available, project teams often elected to bring the water into the building for use at sewage conveyance, thus achieving several more points.

The credit **WE 2.0**, which is the wastewater point, can be achieved by installing waterless urinals and low-flow toilets. Usually, there is no cost impact to the use of the urinals however there may be difficulty in implementation. This is because they still unfamiliar technology in many areas, and resistance from users, operators, and code officials. This resistance can be a hurdle to achieving this point. As a result, in this case feasibility is therefore often a larger concern than cost.

On the other hand, the installation of low flow fixtures and other standard water saving devices such as faucet aerators or sensor flow controls in public bathrooms are more familiar technology and it facilitates achievement of the water use reduction point **WE 3.1**. The **WE 3.2** point is often more difficult to achieve and is usually only attempted by those projects reaching for a higher level of LEED™ certification (i.e., Gold and Platinum levels). This point is often achieved in conjunction with credit **WE 2.0** by the use of waterless urinals.

In general, Certified and Silver projects tended to achieve the first irrigation and water use reduction points, using standard technologies at no additional cost⁴⁷.

4.2.3 Energy and atmosphere

Energy consumption can be dramatically reduced through practices that are economical and readily achievable. Improving the energy performance of buildings reduces operations costs, reduces pollution generated by power plants and other energy producing equipment, and enhances comfort. Most energy efficiency measures have a rapid payback period due to the rising cost of energy.

Combining different LEED™ credits can help reduce a building's total energy load. An example would be to use geothermal features, overnight thermal ice storage for daytime air conditioning, and exterior and interior shading devices to downsize the buildings HVAC system.

⁴⁶ Davis Langdon Adamson. (2004). <http://www.davislangdon-usa.com/> [2004, August 16].

⁴⁷ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

A total of 17 possible points can be obtained in the Energy and Atmosphere (EA) section of the LEED™ Rating System. The Table 4-4 below presents the credits included in the criteria.

Table 4-4 Energy and Atmosphere list of credits

Energy and Atmosphere credits	
EA 1.0	Optimize Energy Performance
EA 2.1	Renewable Energy, 5%
EA 2.2	Renewable Energy, 10%
EA 2.3	Renewable Energy, 20%
EA 3.0	Additional Commissioning
EA 4.0	Ozone Depletion
EA 5.0	Measurement & Verification
EA 6.0	Green Power

The first credit **EA 1.0** aims to achieve increasing levels of energy performance above the current standard used by local or federal regulations in order to reduce environmental impacts associated with excessive energy use.

In many cases, projects can earn the first four energy use reduction points with relatively little changes to the existing design approach. Generally, the local code requirements often establish minimum levels of efficiency which allow a project to qualify for some of these LEED™ points described by the credit **EA 1.0** with low cost and very little additional effort (Table 4-5).

Table 4-5 Potential energy savings vs. possible points

The Criteria EA 1.0: potential savings vs. possible points

New buildings	Existing buildings	Points
15%	5%	1
20%	10%	2
25%	15%	3
30%	20%	4
35%	25%	5
40%	30%	6
45%	35%	7
50%	40%	8
55%	45%	9
60%	50%	10

Source: USGBC

In every case, an integrated design process and early commitment to high-performance design has facilitated high achievement. However, as energy use reduction requirements rise, the difficulty in reaching those levels also rises, and the last few energy use points are usually only attempted by projects hoping to qualify for the higher levels of LEED™. These points require a high level of integrated design and/or innovative technology. Consequently, the costs range widely.

On-site generation of renewable energy (e.g., **EA 2.1**, **2.2**, and **2.3**), which is generally by photovoltaic panels, has a substantial construction cost impact. However, installation of these systems usually provides a long term cost savings. Additionally, incorporating renewable energy into design will earn the project at least one additional energy use reduction point.

Many projects compensate costs through available incentives (i.e., The New York State Green Building Tax Credit⁴⁸), for instance through integration of photovoltaic into architectural features, and overall reduction of energy use requirements.

The additional commissioning described by the credit **EA 3.0** requires an early commitment. On the other hand, when it is compared to the substantial costs that come with attaining the commissioning prerequisite and the ozone protection requirements described by the credit **EA 4.0**, the points represent a considerable added cost⁴⁹.

Many projects attempt to qualify for the additional measurement and verification point **EA 5.0**. However, most of them do not achieve the requisites because this point requires a higher

⁴⁸ Available at: <http://www.dec.state.ny.us/website/ppu/grnbldg/grnbldgtcqap.html> [2004, August 18].

⁴⁹ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

level of monitoring than provided by most Building Control Management Systems, which results in substantial added costs.

The acquisition of offsite-generated renewable energy **EA 6.0** is typically considered an operational rather than construction cost, and it is usually found with reasonable purchasing price, which in some case can be cheaper than conventional electricity.

4.2.4 Material and resources

Materials and Resources is the section focused to facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.

A total of 13 possible points can be obtained by fulfilling every criteria within the Materials and Resources (MR) section of the LEED™ Rating System. The Table 4-6 presents the credits included in the criteria.

Table 4-6 Material and Resources list of credits

Material and Resources credits	
MR 1.1	Building Reuse, Maintain 75% of Existing Shell
MR 1.2	Building Reuse, Maintain 100% of Shell
MR 1.3	Building Reuse, Maintain 100% Shell & 50% Non-shell
MR 2.1	Construction Waste Management, Divert 50%
MR 2.2	Construction Waste Management, Divert 75%
MR 3.1	Resource Reuse, Specify 5%
MR 3.2	Resource Reuse, Specify 10%
MR 4.1	Recycled Content, Specify 5% or 10% post-construction (p.c.) + 1/2 post-industrial (p.i.)
MR 4.2	Recycled Content, Specify 10% or 20% p.c. + 1/2 p.i.
MR 5.1	Local/Regional Materials, 20% manufactured locally
MR 5.2	Local/Regional Materials, of 20% Above, 50% harvested locally
MR 6.0	Rapidly Renewable Materials
MR 7.0	Certified Wood

Certified and Silver projects tend to achieve four of the 13 points in this category. However, few projects incorporate the building reuse points (i.e., credits **MR 1.1**, **1.2**, **1.3**, **3.1**, and **3.2**)⁵⁰.

Credits **MR 2.1** and/or **MR 2.2**, construction waste management, are achieved at some level on almost every project. Costs can vary significantly depending on project location and availability of established construction waste recycling programs. Furthermore, waste management costs are greatly dependant on how familiar or comfortable the general contractor is with such practices. This is because the cost impact depends on contractor commitment.

The credits **MR 4.1** and **4.2** that describe the use of recycled content is usually not difficult for most projects, at minimal or no added cost. Steel framed buildings usually qualify for at least one point for recycled content with no additional cost impact⁵¹.

Use of locally produced materials described by credits **MR 5.1** and **5.2** is usually neither difficult nor costly for most projects to achieve.

Regarding credit **MR 6.0**, most projects are unable to meet both the rapidly renewable materials and reused materials points. The Davis Langdon Adamson⁵² report presents that while many applicable materials tend to be high-end finishes and therefore costly, projects tended to lose these points more because it is quite difficult to achieve the required percentage of building materials, rather than because of cost.

Certified wood is usually more expensive than non-certified wood, and prices tend to fluctuate. Knowledge of sources and prices is needed to establish actual cost impact on any individual project. As a result, the credit **MR 7.0** depends on the developer's commitment to high-performance issues.

4.2.5 Indoor environmental quality

Indoor environmental quality can be measured by the lack of contaminants within the indoor environment along with the effectiveness of indoor ventilation. Given the fact that people generally spend approximately 90 percent of their time indoors⁵³, the quality of the indoor environment has a significant influence on health, productivity and the quality of life.

Of all the sections, the points in the Indoor Environmental Quality section (EQ) tend to be the most often used. This is because so many of these points and prerequisites are already incorporated into normal designs, due to building codes and good availability of materials. The Table 4-7 presents its credit list.

⁵⁰ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

⁵¹ Ibid.

⁵² Davis Langdon Adamson. (2004). <http://www.davislangdon-usa.com/> [2004, August 16].

⁵³ EPA. (2004). *402-k-01-003: Healthy Buildings, Healthy People: A vision for the 21st Century*.

Table 4-7 Indoor Environmental Quality list of credits

Indoor Environmental Quality credits	
EQ 1.0	Carbon Dioxide (CO ₂) Monitoring
EQ 2.0	Ventilation Effectiveness
EQ 3.1	Construction IAQ Management Plan, During Construction
EQ 3.2	Construction IAQ Management Plan, Before Occupancy
EQ 4.1	Low Emitting Materials, Adhesives & Sealants
EQ 4.2	Low Emitting Materials, Paints
EQ 4.3	Low Emitting Materials, Carpet
EQ 4.4	Low Emitting Materials, Composite Wood
EQ 5.0	Indoor Chemical & Pollutant Source Control
EQ 6.1	Controllability of Systems, Perimeter
EQ 6.2	Controllability of Systems, Non Perimeter
EQ 7.1	Thermal Comfort, Comply with ASHRAE 551992
EQ 7.2	Thermal Comfort, Permanent Monitoring System
EQ 8.1	Daylight & Views, Daylight 75% of Spaces
EQ 8.2	Daylight & Views, Views for 90% of Spaces

The credit **EQ 2.0** depends a great deal on the climate. In areas where there is high humidity, this point is simply not feasible, since a two week flush-out with outdoor air in wetter climates is more likely to expose the interior of the building to mold and other problems.

Neither of the indoor air quality points needs to have a cost impact on a project if the project developer and construction team are committed from the start. However, these points may seem easy to achieve, but often turn out far more complicated, and thus less feasible, than anticipated. The materials points (i.e., **EQ 4.0, 4.1, 4.2, 4.3, and 4.4**), however, in this category are usually fairly easy to achieve.

In many cases, local or regional ordinances may already require that projects meet those standards⁵⁴. For example, in California, buildings are required to meet standards which allow projects built under those rules to qualify for most of the materials points without any impact

⁵⁴ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

to cost or design⁵⁵. Where local or regional regulations do not already establish the use of low emitting materials, making use of these should have only minimal or even none impact on cost, as these are usually widely available in New York State.

On the other hand, the credit **EQ 3.1**, which establishes an air quality plan during the construction process, is high on the list of points projects attempt to achieve, but most of the projects fail during qualification. This is because this point requires significant coordination and management not just on the part of the contractor but all members of the construction crew as well. In order to qualify for these points, construction must be carefully planned and sequenced, and crew members must be carefully trained and monitored to ensure that all criteria are met⁵⁶. The direct cost of this point is relatively low, but the impact on the contractor's bid can be very significant if the contractor views this as onerous and undesirable.

The credit **EQ 5.0** regarding pollutant control requirement can usually be met with little added cost.

Operable windows, which are one of potential strategies to achieve credit **EQ 6.1**, have a fairly low direct cost premium over fixed windows, but often have a significant added cost when combined with a traditional air conditioning system. Developers frequently require control interlocks between the air conditioning and the windows in order to ensure that the air conditioning not run while the window is open. Consequently, this adds controls, zones and ductwork, which can lead to a premium cost much greater than the cost of the windows.

Raised floor systems are the most common and economical way of achieving the thermal comfort described by **EQ 7.1** but few projects fulfill with the requirements of the subsequently point illustrated by **EQ 7.2**.

Concerning the last two credits, which are related to daylighting and views (e.g., **EQ 8.1** and **8.2**), projects attempt to qualify for the points. However, these points are based requirements that demands that the calculation should be based on mass and depth of the building and light actually entering the interior spaces. As a result, these conditions make these points more difficult to achieve than most people realize⁵⁷.

4.2.6 Innovation and design process

To provide design teams and projects the opportunity to be awarded points for exceptional performance above requirements set by the LEED™ Green Building Rating System and/or innovative performance in Green Building categories not specifically addressed by the LEED™ Green Building Rating System.

The Table 4-8 presents the credits included in the criteria.

⁵⁵ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*.

⁵⁶ Davis Langdon Adamson. (2004). <http://www.davislangdon-usa.com/> [2004, August 16].

⁵⁷ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

Table 4-8 Innovation and Design list of credits

Innovation and Design process credits	
ID 1.1	Innovation in Design: Specific Title
ID 1.2	Innovation in Design: Specific Title
ID 1.3	Innovation in Design: Specific Title
ID 1.4	Innovation in Design: Specific Title
ID 2.0	LEED™ Accredited Professional

The Innovation and Design (ID) section is a catch-all category, designed to allow projects to earn points for items that may not fall into any other designated point. Innovation points described by **ID 1.1**, **1.2**, **1.3**, and **1.4** can be achieved by either:

- i. Going over and above the required level of a specific point, such as establishing higher reductions in estimated energy or water use than specified by those points.
- ii. Incorporating something not already addressed into the design. In the past this has included things such as providing educational signage in the building which points out the high-performance features, or making use of innovative technologies, such as straw bale or rammed earth construction, fuel cells, and so on.

Most projects achieve at least one innovation point by: (i) simply capitalizing on measures already included in the project design at minimal added cost, which may include exemplary performance in water use reduction or construction waste management, (ii) or by pursuing one of several previously defined, low-cost innovation points that might include “green” housekeeping or educational signage, both reasonable cost adds. Both strategies are essentially already paid for in the base points⁵⁸.

The credit **ID 2.0** practically is achieved by all projects. This is because the point for including a LEED™ Accredited Professional usually does not add construction cost.

⁵⁸ Matthiessen, Lisa F. & Morris, Peter. (2004). *Costing Green: A comprehensive cost database and budgeting methodology*.

4.3 The cost analysis

This section presents an analysis of the potential influences of the proposed law in the public construction sector.

The analysis involves estimating the monetary values of streams of cost related to conventional design versus high-performance design described by LEED™ in order to measure the bill's impact. This cost analysis, consequently, is divided into five categories, which fully cover the requirements of the LEED™ criteria: (i) water; (ii) solid waste; (iii) energy; (iv) emissions; and (v) labor productivity.

The calculations are made using the English Measurement System (EMS). However, the results or “key points” of each cost factor are presented using International System (IS) of measurement and EMS (e.g., square foot and square meter).

The discount rate of 5.24 percent is used to estimate the future costs at present value. The rate is based on the U.S. Federal Reserve Statistical Release⁵⁹ of August 23rd, 2004. Also, it is stipulated for 20-year projected readjusted value of the Treasury Constant Maturities. The inflation is assumed as 2.36 percent per year, in line with most conventional inflation long-term average projections⁶⁰.

The number of occupants is derived by dividing total construction area, which is assumed in this thesis as 100,000 square feet, by 416 square feet, which is the area per occupant defined by DOE⁶¹:

$$\text{Number of occupants} = \frac{100,000 \text{ sq ft}}{416 \text{ sq ft per occupant}} = 240$$

As a result, the number of occupants is determined as 240 persons. Furthermore, the building type chosen is a standard new commercial office building, which follows the N.Y.C. Building code as the baseline, and its size is assumed as 100,000 square feet or approximately 9,300 square meters.

The key points within each cost factor section can be described as:

- i. *First year savings per square foot*: it is estimated by dividing the savings of the first year by the total construction area;
- ii. *Present value per square foot*: this value is estimated by discounting the long-run savings during the period (e.g., 10 and/or 20 years) to present day values.

⁵⁹ U.S. Federal Reserve. (2004). <http://www.federalreserve.gov/releases/H15/Current/> [2004, August 24].

⁶⁰ Ibid.

⁶¹ DOE. (2004). <http://www.eia.doe.gov/emeu/cbecs/pba99/office/officesubtable.html> [2004, August 24].

4.3.1 Water

New York City uses about 1.1 billion gallons or roughly 147 million cubic feet a day. The current rate charged for water use in the city is \$1.52 per 100 cubic feet and the sewer rate is calculated as 159 percent of the water charge, or \$2.42 per 100 cubic feet⁶².

On the other hand, the long-run marginal costs or “public costs” are much higher than the value charged. A recent empirical study in Canada⁶³ estimated that the price charged for fresh water was only one-third to one-half the long-run marginal supply cost, and that prices charged for sewage were approximately one-fifth of the long-run cost of sewage treatment⁶⁴.

Consequently, the long-run costs per 100 cubic feet of water or sewage for New York City can be assumed as:

- Water: \$3.04 to \$4.56;
- Sewage: \$12.10.

These higher values are caused by uncounted components such as, water supply expansion and treatment, expansion of wastewater capacity and treatment, water scarcity, the economic costs caused by environmental damage, and so forth.

Examples of these components are the severe droughts in 1980-81 and 1985 that the city has experienced, as well as water shortages throughout the 1990’s, 1999 being one of the worst, and again in late 2001 to early 2003⁶⁵. Also, given anticipated population growth and parallel escalating water demand, these costs are likely to be even more significant. As a result, the average projected water charge increasing rate is assumed as 5.50 percent per year⁶⁶

Thus, conservation and demand reduction are factors that need to be taken into consideration and used to encourage high-performance building features. This is because water saved does not need to be treated or disposed.

The high-performance design strategies for water conservation described by the Water Efficient (WE) category can reduce water, at least, by 20 percent indoors and 50 percent for landscaping.

The calculation for determining the savings needs first of all to determine the consumption water cost. The average commercial building consumption per occupant per day is estimated as 171.5 gallons⁶⁷. As a result, the total indoor water consumption per year is more than 15

⁶² N.Y.C. Department of Environment Protection (DEP). (2004). <http://www.nyc.gov/html/dep/> [2004, August 2].

⁶³ Renzetti, S. (1999). [Journal]. *Municipal Water Supply and Sewage Treatment: Costs, Prices, and Distortions*.

⁶⁴ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*.

⁶⁵ The New York League of Conservation Voters. (2004). *NYC Citizens’ Guide to Government and the Urban Environment*. Available at: <http://www.nylcv.org/guide/issues/dwthreats.html> [2004, August 16].

⁶⁶ DEP. (2004). www.nyc.gov/html/dep/pdf/croton/5-07socioeconomic.pdf [2004, August 2].

⁶⁷ Pacific Institute. (2004). *Industrial and Commercial Water Use*. Appendix C, p.13.

million gallons. Regarding irrigation, the study assumes eight percent of the indoor water usage as the average landscaping use⁶⁸.

Key points

The following tables present the water efficiency savings:

Table 4-9 Water user reduction 20% + Landscaping reduction of 50%

Running costs savings		
First year	Per 100 square feet	\$19
	Per square meter	\$2
LCC-10 years (Present Value)	Per square foot	\$2
	Per square meter	\$20
LCC-20 years (Present Value)	Per square foot	\$4
	Per square meter	\$40

Table 4-10 Water user reduction 30% + Landscaping reduction of 50%

Running costs savings		
First year	Per 100 square feet	\$19
	Per square meter	\$2
LCC-10 years (Present Value)	Per square foot	\$2
	Per square meter	\$20
LCC-20 years (Present Value)	Per square foot	\$4
	Per square meter	\$40

Table 4-11 Water full savings - Reduction 20% + Landscaping reduction of 50%

Full costs savings (Running + Public savings)		
First year	Per 100 square feet	\$112
	Per square meter	\$4
LCC-10 years (Present Value)	Per square foot	\$12
	Per square meter	\$129
LCC-20 years (Present Value)	Per square foot	\$22
	Per square meter	\$241

Table 4-12 Water full savings - Reduction 30% + Landscaping reduction of 50%

Full costs savings (Running + Public savings)		
First year	Per 100 square feet	\$158
	Per square meter	\$6
LCC-10 years (Present Value)	Per square foot	\$17
	Per square meter	\$183
LCC-20 years (Present Value)	Per square foot	\$32
	Per square meter	\$341

⁶⁸ deMonsabert, S. & Liner, B.L. (1996). *WATERGY: A water and energy conservation model for federal facilities*. p.3.

4.3.2 Solid Waste

The average generation of construction solid waste in U.S. is 4 lbs per square foot for construction of a non-residential building⁶⁹.

$$\text{Total construction solid waste} = 4.0 \text{ lbs/sq ft} \times 100,000 \text{ sq ft} = 181 \text{ tons}$$

The cost of construction waste disposal is \$44 per ton of construction solid waste⁷⁰, which is the average value in the country.

As a result, the construction solid waste disposal for a 100,000 square feet office building conventional designed is roughly \$8,000.

Furthermore, the building still generates solid waste during its life-cycle. The daily average of solid waste generation in commercial office buildings is roughly 3 lbs per occupant⁷¹.

As a result, the cost related to disposal of the solid waste generated in the building is roughly \$2,000 annually.

Key points

The key points related to the savings are present in the following tables:

Table 4-13 Construction solid waste: Divert 50% + 40% recycling of solid waste

Running costs savings		
First year	Per 100 square feet	\$9
	Per square meter	\$1
LCC-10 years (Present Value)	Per square foot	\$1
	Per square meter	\$11
LCC-20 years (Present Value)	Per square foot	\$2
	Per square meter	\$18

⁶⁹ EPA. (1998). *Characterization of building-related construction and demolition debris in the United States*. p.2-3.

⁷⁰ EPA. (2000). <http://www.ilsr.org/recycling/buildingdebris.pdf> [2004, September 28].

⁷¹ DEP. (2004). www.nyc.gov/html/dep/pdf/croton/7-18solidwaste.pdf [2004, August 2].

Table 4-14 Construction solid waste: Divert 75% + 40% recycling of solid waste

Running costs savings		
First year	Per 100 square feet	\$16
	Per square meter	\$1
LCC-10 years (Present Value)	Per square foot	\$1
	Per square meter	\$12
LCC-20 years (Present Value)	Per square foot	\$2
	Per square meter	\$19

Table 4-15 Full cost savings: Divert 50% + 40% recycling of solid waste

Full costs savings (Running + Public savings)		
First year	Per 100 square feet	\$14
	Per square meter	\$1
LCC-10 years (Present Value)	Per square foot	\$1
	Per square meter	\$12
LCC-20 years (Present Value)	Per square foot	\$2
	Per square meter	\$19

Table 4-16 Full cost savings: Divert 75% + 40% recycling of solid waste

Full costs savings (Running + Public savings)		
First year	Per 100 square feet	\$22
	Per square meter	\$2
LCC-10 years (Present Value)	Per square foot	\$1
	Per square meter	\$13
LCC-20 years (Present Value)	Per square foot	\$2
	Per square meter	\$20

4.3.3 Energy

For purposes of calculating the costs of energy consumption, it was initially necessary to determine the value of electricity and thermal energy used per square foot.

The estimative is based into two surveys prepared by DOE: (i) Commercial Buildings Energy Consumption Surveys in 1995⁷² related to the major sum fuels used to generate energy and (ii) Non-residential building survey in the 2002 - Annual Energy Review⁷³ related to consumption patterns.

The energy end uses are mainly space heating and cooling, water heating, and operations such as computer and other equipments.

⁷² DOE. (1999). *Commercial Buildings Energy Consumption Surveys*.

⁷³ DOE. (2002). *Energy Information Administration / Annual Energy Review 2002*.

The fuel is assumed to be natural gas. This is because it corresponds to the principal fraction of the major sum fuels (e.g.; 57 percent)⁷⁴. The other two sources are fuel oil and districted heating, when added together corresponds to 11 percent of the total energy sources.

The average consumption of natural gas in government buildings is 41.6 cubic meter⁷⁵ of natural gas per square foot (12.7 cubic meter per square meter, corresponding to 135 kWh). This value in a building of 100,000 square feet of area corresponds to more than 4 million of cubic meters per year of natural gas consumed.

Regarding electricity, the average consumption per square foot in government buildings is 13.7 kWh⁷⁶ (147.5 kWh per square meter).

As a result, a public office buildings with total area of 100,000 square feet this value corresponds to 1.37 Gigawatts-hour (GWh) per year.

Energy efficiency is one of the categories where buildings can earn a large number of points and save money by achieving a substantial reduction of consumption through energy efficiency and related measures that are part of the LEEDTM design criteria.

The energy costs are the sum of thermal energy and electricity costs.

The electricity charges in New York State are: (i) \$0.14 per kilowatts-hour (kWh) for conventional electricity⁷⁷ and (ii) green electricity that adds \$0.02 in average per kWh⁷⁸.

The natural gas price is \$8.8 per 1000 cubic feet⁷⁹.

The cost analysis considers a reduction of 30 percent of electricity consumption. This is because the Syska Hennessy survey⁸⁰ showed that 28 of 38 LEEDTM projects have chosen to reduce energy cost by 30 percent (see Appendix C).

Key points

The key points related to the savings are present in the tables below.

⁷⁴ Ibid.

⁷⁵ DOE. (1999). *Commercial Buildings Energy Consumption Surveys*. p.79

⁷⁶ DOE. (1999). *Commercial Buildings Energy Consumption Surveys*. p.50

⁷⁷ New York State Energy Research and Development Authority (NYSERDA). (2004). *New York State Commercial Energy Prices in Nominal Dollars, 1988-2002*.

⁷⁸ Community Energy Inc. (2004). http://www.newwindenergy.com/buywind/home/new_york/step2_supplier.html [2004, August 31].

⁷⁹ National Energy Information Center.(2004).

⁸⁰ Building Design & Construction. (2003). *White Paper on Sustainability: A Report on the Green Movement*. p. 8-12.

Table 4-17 Optimize energy performance (Reduction 30%)

Full costs savings (Running + Public savings)		
First year	Per 100 square feet	\$66
	Per square meter	\$7
LCC-10 years (Present Value)	Per square foot	\$6
	Per square meter	\$61
LCC-20 years (Present Value)	Per square foot	\$10
	Per square meter	\$106

Table 4-18 Optimize energy performance (Reduction 30%) + "Green" Power

Full costs savings (Running + Public savings)		
First year	Per 100 square feet	\$106
	Per square meter	\$11
LCC-10 years (Present Value)	Per square foot	\$9
	Per square meter	\$97
LCC-20 years (Present Value)	Per square foot	\$16
	Per square meter	\$170

4.3.4 Emissions

According to data published in 1998 by the EPA, the New York States' power plants generated approximately 513 Tera BTU or 150 Terawatts-hour (TWh). Most of the electricity generated is provided by fossil fuels consisting of 1.62 percent of oil, 10.55 percent of natural gas and coal, 42.19 percent of coal, and 45.68 percent of natural gas and coal. Their emissions are⁸¹:

- i. 304,000 tons of Sulfur Dioxide (SO₂), principal cause of acid rain;
- ii. 79,600 tons of Oxides of Nitrogen (NO_x), principal cause of smog; and
- iii. 45,500,000 tons of Carbon Dioxide (CO₂), the principal greenhouse gas and the major product of combustion.

It is important to note that this thesis does not cover all air pollutants that result from the burning of fossil fuels. The analysis is mainly based in the three principal pollutants described above.

In order to link the emissions with the energy consumption per square feet, this analysis identified the values of emissions by correlating emissions generated and energy consumption per square foot.

As a result, the emissions generated by consuming one kilowatt-hour of electricity are:

⁸¹ Environmental Advocates of NY (EANY). (2004). <http://www.eany.org/reports/dirtypower/dirty.html> [2004, August 30].

$$SO_2 \text{ emission per sq ft} = \frac{304,000 \text{ tons}}{150 \text{ TWh}} = 0.004 \text{ lbs per kWh}$$

$$NO_x \text{ emission per sq ft} = \frac{79,600 \text{ tons}}{150 \text{ TWh}} = 0.001 \text{ lbs per kWh}$$

$$CO_2 \text{ emission per sq ft} = \frac{45,500,000 \text{ tons}}{150 \text{ TWh}} = 0.667 \text{ lbs per kWh}$$

The results are placed in the Table 4-19.

Table 4-19 Emissions from electricity consumption

Emissions from electricity consumption		
Pollutant	lbs per kWh	kg per kWh
Sulphur dioxide	0.004	0.002
Nitrous oxides	0.001	0.001
Carbon dioxide	0.667	0.303

The emissions from natural gas consumption are described in the table below⁸².

Table 4-20 Emissions from natural gas consumption

Emissions from electricity consumption		
Pollutant	lbs per kWh	kg per kWh
Sulphur dioxide	0.002	0.001
Nitrous oxides	0.00001	0.00003
Carbon dioxide	1.03	0.47

The clearing costs of SO₂ and NO_x emissions in U.S. are respectively \$174.97⁸³ and \$2,000⁸⁴ per ton of pollutant. A reduction in electricity use per square feet means clearly lowering the overall emissions and, therefore, decreasing their clearing costs.

Regarding the “green” power, it is available in block of 100 kWh to be purchased. The benefits of purchasing one block are equivalent to not releasing per year 0.6 tons of CO₂ and

⁸² American Wind Energy Association. (2004). <http://www.awea.org/pubs/factsheets/EmissionKB.PDF> [2004, August 30].

⁸³ EPA. (2004a). http://www.epa.gov/region03/acidification/press_articles/acid_rain_3-29-01.htm [2004, August 31].

⁸⁴ EPA. (2004b). <http://www.epa.gov/boston/pr/1998/081398.html> [2004, August 31].

2 lbs of NO_x. The CO₂ reduction is equivalent more than 1142 miles not driven or more than 89 trees planted year⁸⁵.

The calculations for the environmental benefits of green power are based on the following steps:

- i. The calculations for carbon dioxide, sulfur dioxide, and nitrogen oxides not emitted are estimates based on a comparison to the average generation mix in the Mid-Atlantic power pool. The average emission factors respectively are 1,097.12 lbs/MWh, 7.65 lbs/MWh, and 2.49 lbs/MWh, respectively⁸⁶.
- ii. The calculation for the equivalent number of trees planted assumes that 14.7 pounds of carbon dioxide are absorbed during the annual growth of a typical North American tree⁸⁷.
- iii. The calculation for miles not driven assumes that 19.6 lbs of carbon dioxide is released per gallon of gasoline consumed when driving the average U.S. automobile, which is described by the Energy Information Association's Fuel and Energy Source Codes and Emission Coefficients, on 2000, and that the average mileage for U.S. automobiles is 17.0 miles per gallon⁸⁸.

The benefits of purchasing green power for a 100,000 square feet office building are equivalent to not releasing per year 275 tons of CO₂ and 445 kilograms of NO_x per year.

The CO₂ reduction per year is equivalent to more than 500,000 miles not driven, which is equal to 20 times around the Earth at the Equator, or more than 41 thousand trees planted⁸⁹.

Key points

The key points related to the savings of reducing emissions are present in the following tables:

⁸⁵ Community Energy Inc. (2004). http://www.newwindenergy.com/buywind/home/new_york/step2_supplier.html [2004, August 31].

⁸⁶ EPA. (2004c). <http://www.epa.gov/cleanenergy/egrid/samples.htm> [2004, August 31].

⁸⁷ DOE. (1994). *Voluntary Reporting of Greenhouse Gases Under Section 1605(b) of the Energy Policy Act of 1992: General Guidelines, and Sector-Specific Issues and Reporting Methodologies Supporting the General Guidelines for the Voluntary Reporting of Greenhouse Gases Under Section 1605(b) of the Energy Policy Act of 1992*.

⁸⁸ U.S. Department of Transportation. (2004). <http://www.fhwa.dot.gov/ohim/vm194.pdf> [2004, August 31].

⁸⁹ Community Energy Inc. (2004). http://www.newwindenergy.com/buywind/home/new_york/step2_supplier.html [2004, August 31].

Table 4-21 Emissions savings: 30% reduction of electricity consumption

Costs savings		
First year	Per 100 square feet	\$66
	Per square meter	\$7
LCC-10 years (Present Value)	Per square foot	\$6
	Per square meter	\$61
LCC-20 years (Present Value)	Per square foot	\$10
	Per square meter	\$106

Table 4-22 Emissions savings: 30% reduction + “Green” Power

Costs savings		
First year	Per 100 square feet	\$66
	Per square meter	\$7
LCC-10 years (Present Value)	Per square foot	\$6
	Per square meter	\$61
LCC-20 years (Present Value)	Per square foot	\$10
	Per square meter	\$106

4.3.5 Labor productivity

The relationship between occupant comfort/productivity and building design/operation is complex. Consequently, there are a great number of studies, reports and articles on the subject.

This thesis relies to a large part on the study about increasing productivity through energy-efficient design prepared by Rocky Mountain Institute and DOE⁹⁰. The survey describes that improvements in the design features such as lighting can result in an increase of approximately 13 percent in labor productivity and a decrease of roughly 20 percent in absenteeism, which is the rate of occurrence of habitual absence from work or duty.

Labor productivity is defined as output, measured by the Gross Domestic Product (GDP), per unit of labor input or working-hours⁹¹, expressed in U.S. dollars.

In the public sector, the absenteeism rate is considered higher than in the private sector. The staff within the public sector takes an average of 10.1 days sick-leave or non-productive days per year. Sick-leave average in the private sector just 6.7 days⁹².

For purposes of calculating the costs related to the absenteeism, it is first necessary to determine an average wage. The average hourly payment in New York City is \$23.10⁹³. This value does not include the indirect costs, such as Employee Assistance Program (EAP) for example.

⁹⁰ Romm, J.J. & Browning, W.D. (1998). *Greening the building and the bottom line: Increasing productivity through energy-efficient design*.

⁹¹ International Labour Organization (ILO). (2004). <http://www.ilo.org/public/english/bureau/stat/> [2004, September 6].

⁹² Adam Smith Institute. (2004). <http://www.adamsmith.org/> [2004, September 6].

⁹³ U.S. Department of Labor. (2004). *Occupational Employment and Wages in New York Area, May 2003*.

The first step is to identify the direct costs or direct labor costs. By multiplying the hourly remuneration by the number of working hours, and then multiplying the result by the number of working days the study can estimate the average direct cost per employee, which is \$48,000 per year.

Key points

The key points related to the savings of direct labor productivity are present in the following table:

Table 4-23 Labor Productivity direct savings

Labor Productivity direct savings		
First year	Per square foot	\$24
	Per square meter	\$258
LCC-10 years (Present Value)	Per square foot	\$203
	Per square meter	\$2,182
LCC-20 years (Present Value)	Per square foot	\$355
	Per square meter	\$3,826

When it comes to Full Labor costs, approximately, 33 percent of the direct cost are considered the value of total fringe benefits. Fringe benefits correspond to days paid but not worked (i.e., vacation, sick days, personal days, and holidays) and “out-of-pocket” fringe costs such as health insurance, pension, education, parking, child care, elder care, EAP, taxes, unemployment insurance, workers compensation, and etc. As a result, the value of total fringe benefits is \$15,840 per employee⁹⁴.

The overhead costs, which are all indirect costs of work such as manager’s and support staff salaries, office rental, heat, light, technology, office supplies, repairs, legal expenses, accounting, insurance, interest on debt, public relations, advertising, and so on and so forth. They correspond to 110 percent of direct labor and fringe cost together or roughly \$70,000 per employee⁹⁵.

Consequently, the full labor cost is estimated by adding all together the direct labor cost (e.g., salary), fringe benefits, and overhead costs.

$$Full\ Labor\ Cost = \$48,000 + \$15,840 + \$70,000 = \$133,840\ per\ employee/year$$

The full direct labor productivity savings are presented in the following table:

⁹⁴ CCH Incorporated. (2004). *2002 CCH Unscheduled Absence Survey*.

⁹⁵ Ibid.

Table 4-24 Labor Productivity full savings

Labor Productivity full savings		
First year	Per square foot	\$44
	Per square meter	\$478
LCC-10 years (Present Value)	Per square foot	\$347
	Per square meter	\$3,696
LCC-20 years (Present Value)	Per square foot	\$551
	Per square meter	\$5,936

4.4 Costs and Benefits: Main findings

The aim of this subchapter is to combine all the results described in each category in a single overall result.

The overall result is presented into four scenarios:

- *Scenario A - Running cost:* the overall result does not include public costs or savings, such as emissions cost and long-run cost for water. Also, the productivity benefits are not included;
- *Scenario B - Total cost:* the overall result includes the public costs and savings but not the labor productivity benefits;
- *Scenario C – Total Cost + Direct Labor Costs:* this scenario adds to the Total Cost the Direct Labor Benefits; and
- *Scenario D – Full Cost:* this is the final overall result scenario includes the full savings and benefits.

The building features are set equally for all scenarios and they include: (i) landscaping irrigation reduction of 50 percent, (ii) indoor water consumption reduction of 20 percent, (iii) construction solid waste diversion of 50 percent, (iv) office solid waste recycling of 40 percent, and (v) energy consumption reduction of 30 percent. These features were selected due to their interaction among the other LEED™ Silver credits to accomplish their points and targets of savings.

For each scenario it will be presented the life-cycle costing analysis and the rate of return of the investments.

The Life-Cycle Costing (LCC) analysis presents in present value the amount of future cost the building will face during its life-span. This study does not consider the end-life phase and it is based on 20 years as the period of analysis.

The LCC analysis is estimated by:

$$LCC_{20} = \frac{\text{Total investment} + \text{Total Costs in present values}}{\text{Total area of construction}}$$

The Rate of Return (RoR) is based on a simple calculation:

$$\text{Rate of Return} = \frac{\text{Total Discounted Savings} - \text{Total Discounted Costs}}{\text{Total Discounted Costs}}$$

If the rate of return is greater than the required discount rate, then the design chosen can be accepted. Consequently, the higher rate of return presents the better investment choice.

The analysis in each scenario covers four theoretical investment costs:

- i. first is the investment value for a building which is conventional designed;
- ii. the second theoretical investment cost is for the current perception in the building industry for a high-performance design;
- iii. the third investment cost is based on the results of the SBTF report showing the average cost premium for a high-performance building; and
- iv. the last value is the investment cost estimated for a LEED™ Silver building, which is also based on the SBTF study.

The investments costs are:

- i. Conventional design (Conv.): \$17,000,000;
- ii. High-performance building A (HP-A): \$19,600,000;
- iii. High-performance building B (HP-B): \$17,300,000
- iv. High-performance Silver building (HP-Silver): \$17,400,000.

The different values are based in the different premium cost added to the construction cost (see Table below)

Table 4-25 Investment cost background

List of alternative investments			
	Per square foot	Premium cost	Premium cost
Conv.	\$170	\$1,830	0%
HP-A	\$196	\$2,100	10 to 15%
HP-B	\$173	\$1,860	1.84%
HP-Silver	\$174	\$1,870	2.11%

The income value used in the calculations is based on the average annual value paid for rent in New York City, which is estimated as \$45 per square foot⁹⁶.

All the results for each scenario are presented in the following tables.

Scenario A

The scenario A presents the following LCC₂₀, RoR, and Payback:

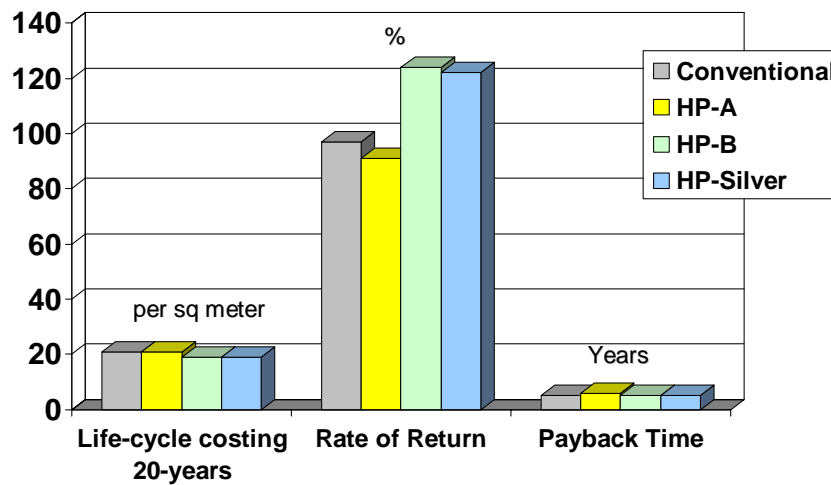


Figure 4-2 Cost Scenario A: Running cost

Table 4-26 Running cost A: Life-cycle costing (20 years)

Life-cycle costing	Per square foot	Per square meter	
Conv.	\$220	\$20	
HP-A	\$226	\$21	Higher cost
HP-B	\$203	\$19	Lower cost
HP-Silver	\$204	\$19	Lower cost

Table 4-27 Running cost A: Rate of Return

Rate of Return		
Conv.	103%	
HP-A	94%	Lower rate
HP-B	127%	Higher rate
HP-Silver	126%	

⁹⁶ Sumitomo Real Estate Sales. (2004).

Table 4-28 Running cost A: Payback time

Payback	
Conv.	5 years
HP-A	6 years
HP-B	5 years
HP-Silver	5 years

(-)

Scenario B

The results are:

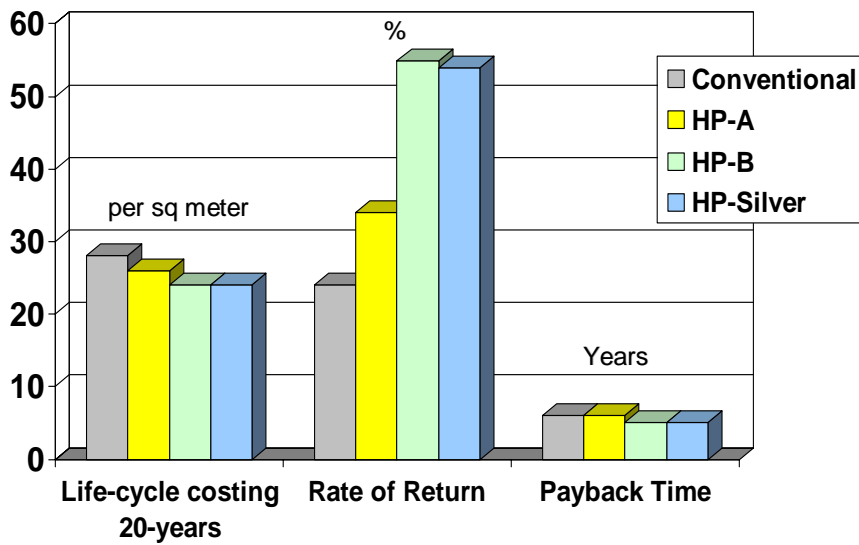


Figure 4-3 Cost scenario B: Total cost

Table 4-29 Running cost B: Life-cycle costing (20 years)

Life-cycle costing	Per square foot	Per square meter
Conv.	\$292	\$27
HP-A	\$282	\$26
HP-B	\$259	\$24
HP-Silver	\$260	\$24

Higher cost
Lower cost
Lower cost

Table 4-30 Running cost B: Rate of Return

Rate of Return		
Conv.	28%	Lower rate
HP-A	36%	
HP-B	57%	Higher rate
HP-Silver	57%	Higher rate

Table 4-31 Running cost B: Payback time

Payback		
Conv.	6 years	(-)
HP-A	6 years	(-)
HP-B	5 years	
HP-Silver	5 years	

The overall result in this scenario includes the public costs and savings and clearly demonstrates that high-performance designed buildings are a suitable choice among the presented options for public investment.

Scenario C

This scenario includes the productivity benefits related to the direct labor benefits. The results show The LEED™ Silver high-performance building is the most suitable choice of investment in this scenario. The conventional designed buildings, however, are not an appropriate choice. This is because of its negative rate of return the 20 year evaluation period.

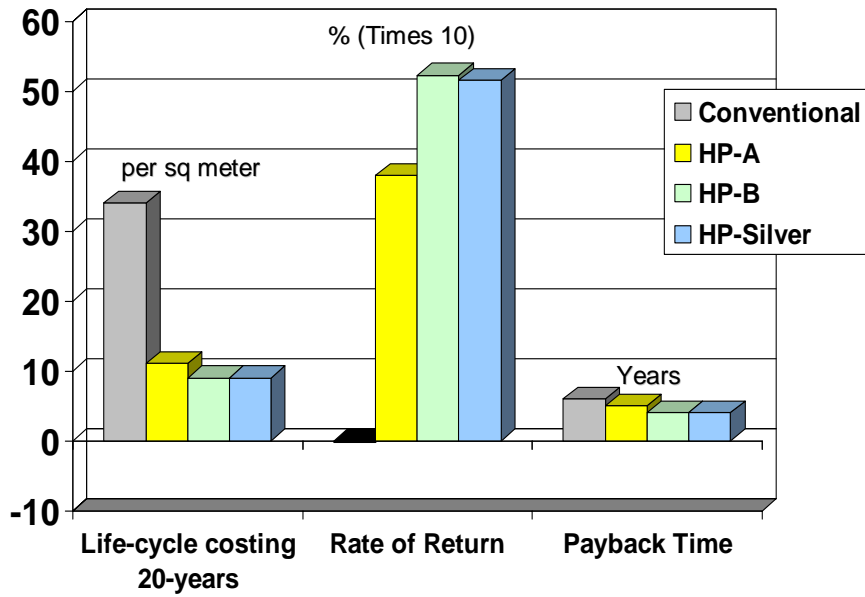


Figure 4-4 Cost scenario C: Total cost + direct labor costs

Table 4-32 Running cost C: Life-cycle costing (20 years)

Life-cycle costing	Per square foot	Per square meter	
Conv.	\$358	\$33	Higher cost
HP-A	\$113	\$10	
HP-B	\$90	\$8	Lower cost
HP-Silver	\$91	\$8	Lower cost

Table 4-33 Running cost C: Rate of Return

Rate of Return		
Conv.	-14%	Lower rate
HP-A	391%	
HP-B	554%	Higher rate
HP-Silver	534%	

Table 4-34 Running cost C: Payback time

Payback		
Conv.	6 years	(-)
HP-A	5 years	
HP-B	4 years	
HP-Silver	4 years	

Scenario D

This last scenario confirms that the LEED™ Silver high-performance building is the most appropriate investment choice in all scenarios. Moreover, the conventional designed building has the least attractive in the long-run in any circumstance.

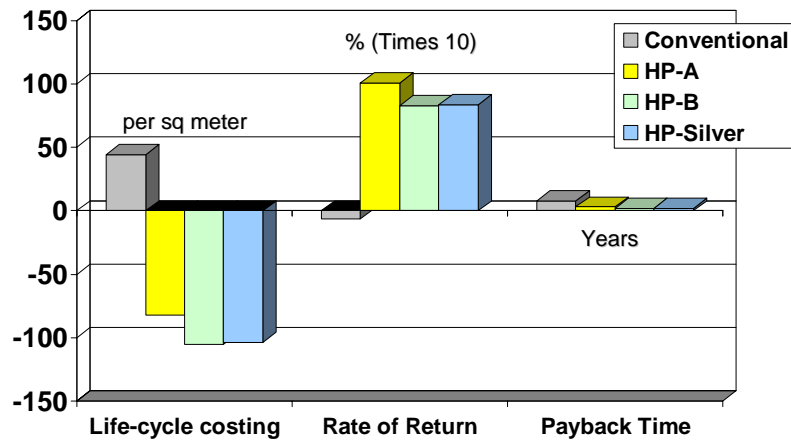


Figure 4-5 Cost scenario C: Full costs

Table 4-35 Running cost D: Life-cycle costing (20 years)

Life-cycle costing	Per square foot	Per square meter	
Conv.	\$477	\$44	Higher cost
HP-A	-\$82	-\$8	Lower cost
HP-B	-\$105	-\$10	
HP-Silver	-\$104	-\$10	

Table 4-36 Running cost D: Rate of Return

Rate of Return		
Conv.	-61%	Lower rate
HP-A	1009%	Higher rate
HP-B	832%	
HP-Silver	838%	

Table 4-37 Running cost D: Payback time

Payback		
Conv.	8 years	(-)
HP-A	3 years	
HP-B	3 years	
HP-Silver	3 years	

4.4.1 Cost-benefit analysis

Cost-benefit Analysis (CBA) aims to facilitate decision related to alternative solutions. This study presents four alternative solutions or alternative ways of fulfilling a building project.

A CBA application includes the following stages⁹⁷: (i) general description of the project, (ii) list of alternative scenarios, and (iii) identify benefits and costs.

The *general description of the project* was presented in the introduction of this study. The analysis is based in a new public office building located in New York City. The total constructed area of the building is 100,000 square feet.

The *list of alternative scenarios* includes four theoretical investment scenarios: (i) a conventional designed building, (ii) a high-performance designed building with overestimated designed investments, (iii) a high-performance building with the average cost premium for high-performance design, and (iv) a LEEDTM Silver high-performance building. The aim is to consider the costs and the benefits for each of these options.

Finally, *identify benefits and cost*. In order to identify the benefits and costs of each investment scenario, this study relates the long-run costs with the long-run savings. The following calculations are based on return on investment:

$$\text{Total Discounted Savings} = \text{Total Discounted Income} - \text{Total Discounted Cost}$$

$$\text{Financial Benefits} = \frac{\text{Total Discounted Savings}}{\text{Construction Investment}}$$

4.4.1.1 Key points of the Cost-Benefit Analysis

Scenario A

In this scenario the values are:

- Conventional building returns **\$3** per dollar invested;
- The overestimated designed high-performance building returns \$2 per dollar invested;
- The average premium cost high-performance building return more than **\$3** per dollar invested; and
- The LEEDTM Silver high-performance building returns more than **\$3** per dollar invested.

⁹⁷ Boardman, et al. (1996). *Cost-Benefit Analysis: Concepts and Practice*. p. 7-21.

In this scenario the LEED™ Silver high-performance building is one of the top performers.

Scenario B

The values in this scenario are:

- Conventional building returns approximately \$2 per dollar invested;
- The overestimated designed high-performance building returns \$2 per dollar invested;
- The average premium cost high-performance building returns **\$3** per dollar invested; and
- The LEED™ Silver high-performance building returns roughly **\$3** per dollar invested.

Although the LEED™ Silver high-performance building is not clearly the top performer in this scenario, it is still one of the most beneficial investment alternatives.

Scenario C

The scenario presents the following values:

- Conventional building returns around \$2 per dollar invested;
- The overestimated designed high-performance building returns circa \$3 per dollar invested;
- The average premium cost high-performance building returns more than **\$3** per dollar invested; and
- The LEED™ Silver high-performance building returns more than **\$3** per dollar invested.

In this case the LEED™ Silver high-performance building is the top performer.

Scenario D

In this final scenario the values are:

- Conventional building returns \$1 per dollar invested;
- The overestimated designed high-performance building returns \$4 per dollar invested;
- The average premium cost high-performance building returns more than **\$4** per dollar invested; and

- The LEED™ Silver high-performance building returns more than **\$4** per dollar invested.

The top performers in this scenario are any high-performance designed building.

4.4.2 Cost-benefit factors considerations

This section presents where these costs and benefits are realized during the 20 year building life-cycle.

The cost-benefit factors are considered as the elements that add cost and savings to high-performance building projects. They are grouped in categories relating to (i) local conditions, (ii) the building project, (iii) design, (iv) construction, and (v) operation.

State and local laws are already fairly inflexible with regard to energy use as well as air and water pollution. In addition, energy efficiency, alternative power production and buy-down programmes for solar photovoltaic systems are broadly promoted, for example the New York State Green Building Initiative⁹⁸. The benefits are quite clear at this stage and they are mainly described as financial incentives that can lower the construction costs.

The cost factors associated with high-performance projects cover a large group of issues from decision maker buy-in to contracting and project management. Therefore generally, the high-performance design leads to higher soft costs. This is a result of additional design analysis, computer modeling, commissioning, product research and lifecycle cost analysis for alternative materials or building systems.

The construction savings produce the greatest direct financial benefits of high-performance design. This is because of the additional time spent on the integrated design and commissioning processes, which usually requires fewer future changes, and results in significant cost savings in both materials and working-hours⁹⁹.

Regarding operation, the startup and operation of a high-performance building should be smoother than that for a conventional building because of the comprehensive commissioning involved, in theory. However, the reality clearly depends on how well the process was managed and the complexity of the building¹⁰⁰.

Moreover, throughout the life-cycle of the high-performance building, there are likely to be some additional costs from maintenance of systems and the continuous commissioning process. However, these costs should not be more than the values recovered through savings related to more efficient systems¹⁰¹. This statement, it is clearly confirmed by the rate of return presented earlier in this subchapter.

As a result, the analysis identified that in any circumstances the high-performance design is the most suitable choice.

⁹⁸ N.Y. State Department of Environmental Conservation. (2004). <http://www.dec.state.ny.us/website/ppu/grnbldg/> [2004, September 8].

⁹⁹ Syphers, G., Baum, L., Bouton, D. & Sullens, W. (2003). *Managing Costs of Green Buildings*.

¹⁰⁰ Ibid.

¹⁰¹ Ibid.

Taking this in consideration, the LEEDTM Silver high-performance building can be viewed as significant instrument of returning the investment without adding higher construction costs.

For example, when it is compared to a conventional building that represents the lowest investment cost, the LEEDTM Silver high-performance building is still being the most appropriated choice for return back the investment in the same time period or even earlier than other alternative designs. This is because the lowest cost investment is not always the highest rate of return.

However, achieving LEEDTM Silver certification can depend upon a variety of circumstances and assumptions¹⁰² such as:

- i. Decision about type and size of project;
- ii. Timing of introduction of LEEDTM as a design goal or requirement;
- iii. Level of LEEDTM certification desired and how many points the project aims to earn;
- iv. Composition and structure of the design and construction teams;
- v. Experience and knowledge of designers and contractors and their willingness to learn;
- vi. Process used to select LEEDTM credits;
- vii. Clarity of the project implementation documents;
- viii. Base case budgeting assumptions.

Clearly, the costs will vary depending upon whether only capital costs are considered or if costs are calculated over the life of the building. Finally, successful enforcement of a policy LEEDTM adoption will depend upon the level of up-front financial commitment to internal program support, policy implementation and external market transformation.

Each of these aspects will contribute to the overall implementation cost of the bill because each aspect can vary significantly on a project-by-project basis. The cost of each LEEDTM Silver project may be different from the very first moment. However, as more and more projects go through the LEEDTM rating process, a general and tangible picture of costs begins to emerge.

¹⁰² Syphers, et al. (2003). *Managing Costs of Green Buildings*.

5 Conclusions and recommendations

This work has analyzed the impact of the proposed law Int. No. 324, with respect to the new public office building projects in New York City. This final section provides the conclusions and recommendations, based on the financial costs and benefits of the bill.

5.1 Conclusions

Many building industry professionals in the private and public sector maintain that if the developer is committed at the project conception and the design and construction team has moderate sustainable design and construction experience, a LEED™ Certified building can be achieved on a conventional building budget¹⁰³. On the other hand, it is clear that this could not be achieved for a building certified as LEED™ Silver, which may cost roughly two to up five percent higher than a conventional building¹⁰⁴.

The bill clearly defines for whom the costs are responsible. The city's taxpayers are responsible to cover the high-performance premium costs. As a result, the city should demonstrate clearly the required rate of return for that investment.

The results in the analysis section have shown that the LEED™ Silver certified building is the best choice among the alternative scenarios to satisfy the taxpayer's wish for responsible public investment.

The bill creates a win-win situation between the local government and the taxpayers. This is because the local city government is driven by the need to demonstrate efficiency to the taxpayer. It can be clearly demonstrated that the money invested in public construction in this manner is efficiently used.

Concisely, the bill's financial costs and benefits can be described as follows: For each \$1 that the city spends to build a public building designed by the requirements of the LEED™ Silver criteria, it will receive back approximately \$3. This value corresponds to around \$0.30 to \$1 more than the amount that the conventional designed building can return.

5.2 Recommendations

Implementing the high-performance features to reach LEED™ Silver can be accomplished within project budgets, especially if the Silver goal is set prior to the schematic design phase¹⁰⁵.

Therefore, during project design, it is important to consider that several credits can create synergy among each other, which results in "multiple credits". This is because by designing for one credit, the project meets requirements for other credits as well. For example, selecting materials with low emissions that also have recycled content or selecting material that are manufactured locally can achieve materials credits and indoor environmental quality credits at the same time.

¹⁰³ Syphers, et al. (2003). *Managing Costs of Green Buildings*.

¹⁰⁴ SBTf. (2003). *The Cost and Financial Benefits of Green Buildings*.

¹⁰⁵ Syphers, et al. (2003). *Managing Costs of Green Buildings*.

Furthermore, using locally produced materials is usually neither difficult nor costly for most projects to achieve. The difficulty of these points lies more with the documentation than with the actual specification; once the contractor develops a documentation procedure, meeting the points becomes relatively straightforward¹⁰⁶. As with recycled content, these points are typically earned using standard materials.

Regarding the waste management costs, they are greatly dependant on how familiar or comfortable the general contractor is with such practices. This is because the cost impact is dependent on contractor commitment. Thus, in order to understand the potential cost impact of achieving these points, the project team must not only be familiar with the programmes available within the area, but also with the ability and willingness of the contractors to comply.

A number of strategies can be incorporated at every level, from policy through design and public construction, to help limit costs on high-performance projects.

- i. The bill should be considered as a starting point and not as a solution in itself; It is a step forward to a more efficient performance future. Adjustments are needed in the long-run such as raising the standards targets.
- ii. Therefore, the extension of the requirements to the private sector seems a logical next step.
- iii. Project teams should comprehensively understand how the high-performance construction is regulated in their local jurisdiction. Districts should hire architects and other consultants who know the rules and interpretation of the bill. One suggestion is that consultants should submit their complete work for reviews instead of drafts¹⁰⁷. Also, the purchasing department should know how to negotiate and find the high-performance features economically within the public supply chain.
- iv. Finally, articulation of the designers is important to the project development in order to defend its scope. The design team must be able to defend their “green” ideas and articulate the financial reasons for their designs, such as correlating daylighting elements with productivity.

Furthermore, independent of which delivery system is chosen, achieving high-performance qualities in the public construction sector will demand suppliers’ involvement in the process.

The suppliers need to increase the limited variety and quantity of high-performance building materials and products. Therefore, it is absolutely essential that the local administration work with the existing suppliers in order to help them move from their conventional products to more high-performance products and materials.

¹⁰⁶ Syphers, et al. (2003). *Managing Costs of Green Buildings*.

¹⁰⁷ Ibid.

5.3 Future developments

The proposed law¹⁰⁸ is a first attempt to amend the administrative code of the city in relation to requirements for city-owned and city-funded buildings.

The requirements proposed for adoption are based on the LEEDTM standards and provide an opportunity for researching the benefits of reducing operations and maintenance costs of city-owned buildings. And, if it becomes extended, it may facilitate local improvement of the affordable housing sector, which consists of 8,400 units in 2003¹⁰⁹.

The low-income housing sector is one of the most difficult areas to achieve LEEDTM criteria. This difficulty is due to the fact that typical construction methods are very low-priced. And, the widespread perception in the construction field that high-performance practices are considerably more expensive than the conventional construction methods becomes a strong barrier. This barrier can only be broken by innovative public policy.

Potentials for future research

Given the limitations of this thesis, there are several avenues for continuing research. Such avenues for future studies may include considerations of:

Verification procedures: analyzing the certification schemes of high-performance buildings regarding credibility and maintenance of the certification level.

Insurance benefits of high-performance features: The thesis has presented the various benefits, including direct and indirect savings of high-performance measures. On the other hand, it has not covered a range of high-performance technologies, which reduce the likelihood of physical damages and losses in facilities, and their impacts on insurance premium costs. One example is the Liability Loss Prevention. This is because we can assume that high-performance buildings may interrupt risks of unplanned power outages and /or reduce them by providing on-site energy resources and/or have energy-efficiency features¹¹⁰.

Synergy or “multiple credits” effect: The study did not look at the synergy among credits, which results in “multiple credits”. Consequently, the scope of future research may be extended to include the “multiple credits” effect. This can constitute an important factor for achieving high-performance standards by lowering costs.

Occupants’ behavior: In this thesis, only the construction, operation and maintenance phase of a new public office building is analyzed for high-performance costs and savings. A life-cycle cost (LCC) approach utilized in this analysis should be further extended to the scope for researching occupants’ behavior. This is because it is important to assess the specific behaviors from the occupants regarding their correct and/or not correct use of the high-performance features. Their activities may lower the savings, decrease the benefits of high-performance, and consequently jeopardize the feasibility of the project.

¹⁰⁸ N.Y.C. Council (2004a). *Int. 0324-2004: Requirements for city-owned and city-funded green buildings*.

¹⁰⁹ N.Y.C Department of Housing Preservation and Development. (2004). *Housing Operation Management System Report*.

¹¹⁰ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*.

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Abbreviations

ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
CBA	Cost-Benefits Analysis
CBD	Commerce Business Daily
CBS	Cost Breakdown Structure
CEC	Community Environmental Center
CER	Cost Estimating Relationships
CFR	U.S. Code of Federal Regulations
CIEE	California Institute for Energy Efficiency
CM-Agent	Construction Manager
CM-Contractor	Construction Manager -Contractor
CO ₂	Carbon Dioxide
Conv.	Conventional Designed Building
DEP	N.Y.C. Department of Environmental Protection
DOE	U.S. Department of Energy
EA	Energy & Atmosphere section
EANY	Environmental Advocates in NY
EAP	Employee Assistance Program
EMS	English Measurement System
EPA	U.S. Environmental Protection Agency
EQ	Indoor Environmental Quality section
ETS	Environmental Tobacco Smoke
FEMA	Federal Emergency Management Agency
FEMP	Federal Energy Management Program
GDP	Gross Domestic Product
GSA	U.S. General Services Administration
GWh	Gigawatts-hour → 10 ⁹ watts-hour
HPB	High-Performance Buildings
HP-A	High-Performance Designed Building A
HP-B	High-Performance Designed Building B
HP-Silver	High-Performance Building Silver Certified
HPD	N.Y.C. Department of Housing Preservation and Development
HUD	U.S. Department of Housing and Urban Development
HVAC&R	Heating, Ventilation, Air Conditioning & Refrigeration
IAQ	Indoor Air Quality
ID	Innovation & Design Process section
IESNA	Illuminating Engineering Society of North America

ILSR	Institute for Local Self-Reliance
ILO	International Labor Organization
IS	International System of measurement
kW	Kilowatt → 10 ³ watts
kWh	Kilowatt-hour → 10 ³ watts-hour
LCC	Life-cycle Costing
LCC ₂₀	Life-cycle Costing during the period of 20 years
LEED™	Leadership in Energy and Environmental Design
MR	Materials & Resources section
MMBTU	Million British thermal unit
MWh	Megawatt-hour → 10 ⁶ watts-hour
NO _x	Nitrogen Oxides
NPV	Net Present Value
NYSERDA	New York State Energy Research and Development Authority
OGC	U.K. Office of Government Commerce
OMB	Office of Management and Budget
OM&R	Operation, Maintenance & Repair
PBS	Public Building Service
PDS	Prospectus Development Study
PV	Present Value
RCBI	Representatives of the Commercial Building Industry
RoR	Rate of return
SBTF	Sustainable Building Task Force
SCAQMD	South Coast Air Quality Management District
sq ft	Square feet
SS	Sustainable Sites section
SO ₂	Sulfur Dioxide
TWh	Terawatts-hour → 10 ¹² watts-hour
UPC	Unit Production Cost
U.S.	United States of America
USGBC	U.S. Green Building Council
VOC	Volatile Organic Compound
WE	Water Efficiency section

Appendices

Appendix A. Review of existing tools for assessing cost management

Appendix B. List of high-performance projects

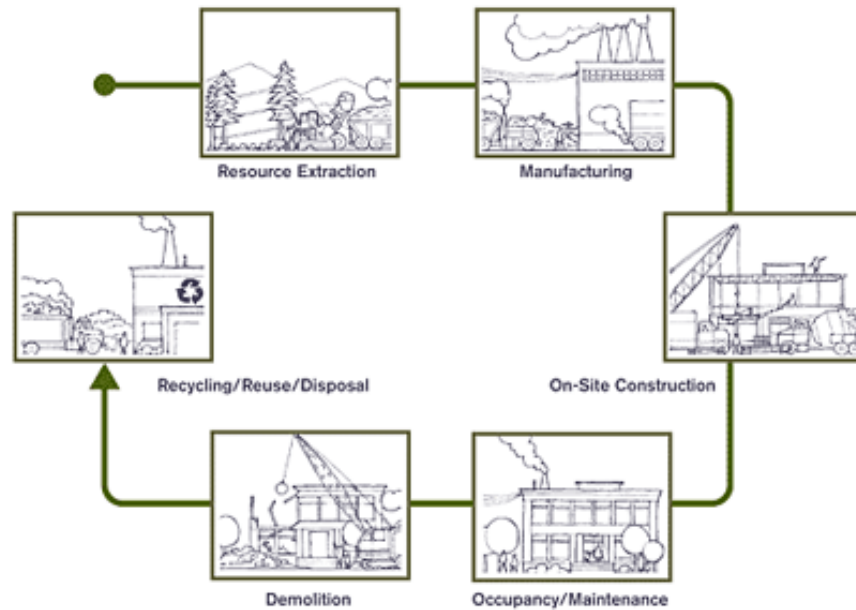
Appendix C. The high-performance features to the public buildings

Appendix A: Review of existing tools for assessing cost management

This section provides a review of most accepted existing tools that are currently used for the assessment of costs management.

A. Life Cycle Costing Analysis

Life Cycle Costing (LCC) also called “whole life costing” (see Figure¹¹¹ bellow) is a technique to establish the total cost of ownership.



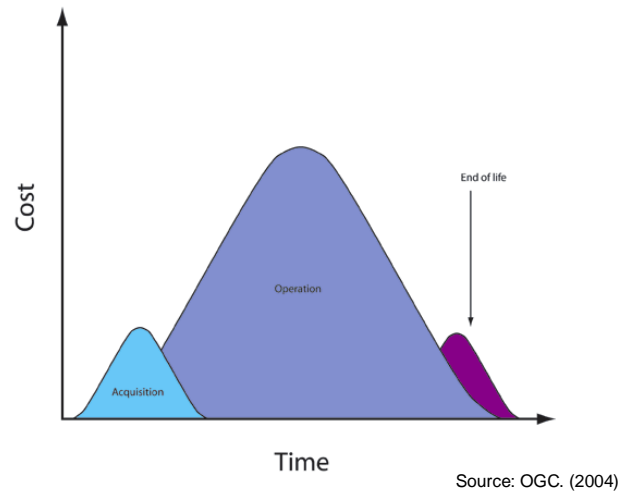
Source: Whole Building Design Guide. (2004).

The results of an LCC analysis can be used to assist management in the decision-making process where there is a choice of options such as high-performance features. However, the accuracy of LCC analysis diminishes as it projects further into the future, so it is most valuable as a comparative tool when long term assumptions apply to all the options and consequently have the same impact.

The delivery methods have demonstrated that, generally, the public construction sector is divided into many departments. Since the responsibility for acquisition cost and subsequent support funding are held by different areas, there is little or no incentive to apply the principles of LCC to purchasing policy. Hence, the application of LCC requires management support because purchasing units are unlikely to apply the rigors of LCC analysis unless they see the benefit resulting from their efforts.

City-owned buildings have to take in consideration the cost of ownership over time. For example, the cost of ownership of an asset or service is incurred throughout its whole life and does not all occur at the point of acquisition (see Figure bellow). The figure gives an example of a spending profile, showing how the costs vary with time.

¹¹¹ Whole Building Design Guide. (2004). <http://www.wbdg.org/> [2004, July 16].



The acquisition costs are those incurred between the decision to proceed with the procurement and the entry of the goods or services into operational use. This is followed by operational costs which are incurred during the operational life of the asset or service.

Finally, the end life costs are those associated with the disposal, termination or replacement of the asset or service. In the case of assets, disposal cost can be negative because the asset has a resale value. In some instances the disposal cost will be negative because the item will have a resale value.

The planning and design phases lead to the next important step, which is the purchasing decision. The purchasing decision is important since it usually commits over 95 percent of the through-life costs, and there is very little possibility to change the cost of ownership after the item has been delivered.

LCC involves identifying the individual costs relating to the procurement of the product or service. These can be either “one-off” or “recurring” costs. It is important to understand the difference between these cost groupings because one-off costs are sunk once the acquisition is made, whereas recurring costs are time dependent and continue to be incurred throughout the life of the product or service. Furthermore, recurring costs can increase with time, for example, through increased maintenance costs as equipment ages.

The principle on which LCC is based is that to arrive at important purchasing decisions, full account must be taken of each available option. All significant overheads which are likely to arise should be addressed. Straight forward attention should be given to all relevant costs for each option from initial consideration through to disposal.

The sophistication degree of LCC varies according to the complexity of the features chosen to be procured. The cost of collecting necessary data can be considerably high but when the same items are procured frequently a cost database should be developed. The complexity of the analysis has direct influence on the Cost Breakdown Structure (CBS).

The CBS is the base of LCC analysis. Its aim is to identify all the relevant cost elements. As a result, it needs to have well defined boundaries in order to avoid omission or duplication. No

matter how complex the LCC analysis is presented, the CBS should have the following basic characteristics¹¹²:

- i. it must include all cost elements that are relevant to the option under consideration including internal costs;
- ii. each cost element must be well defined so that all involved have a clear understanding of what is to be included in that element;
- iii. each cost element should be identifiable with a significant level of activity or major item of equipment or software;
- iv. the cost breakdown should be structured in such a way as to allow analysis of specific areas. For example, the purchaser might need to compare spares costs for each option; these costs should therefore be identified within the structure;
- v. the CBS should be compatible, through cross indexing, with the management accounting procedures used in collecting costs. This will allow costs to be fed directly to the LCC analysis;
- vi. for programmes with subcontractors, these costs should have separate cost categories to allow close control and monitoring; and
- vii. the CBS should be designed to allow different levels of data within various cost categories. For example, the analyst may wish to examine in considerable detail the operator manpower cost whilst only roughly estimating the maintenance manpower contribution. The CBS should be sufficiently flexible to allow cost allocation both horizontally and vertically.

There are numerous costs associated with acquiring, operating, maintaining, and disposing of a building or building system. Building-related costs usually fall into the following categories¹¹³:

- Initial Costs—Purchase, Acquisition, Construction Costs
- Fuel Costs
- Operation, Maintenance, and Repair Costs
- Replacement Costs
- Residual Values—Resale or Salvage Values or Disposal Costs
- Finance Charges—Loan Interest Payments
- Non-Monetary Benefits or Costs

¹¹² OGC. (2004).

¹¹³ Whole Building Design Guide. (2004).

Only those costs within each category that are relevant to the decision and significant in amount are needed to make a valid investment decision. Costs are relevant when they are different for one alternative compared with another. Indeed, costs are significant when they are large enough to make a credible difference in the LCC of a project alternative.

All costs are entered as base-year amounts in today's chosen currency; the LCC method escalates all amounts to their future year of occurrence and discounts them back to the base date to convert them to present values.

Initial costs may include capital investment costs for land acquisition, construction, or renovation and for the equipment needed to operate a facility.

Land acquisition costs need to be included in the initial cost estimate if they differ among design alternatives. This would be the case, for example, when comparing the cost of renovating an existing facility with new construction on purchased land.

Initially construction costs are estimated by reference to historical data from similar facilities. Alternately, they can be determined from government or private-sector cost estimating guides and databases. LCC analysis can be repeated throughout the design process if more detailed cost information becomes available.

Operational expenses for energy, water and other utilities are based on consumption, current rates, and price projections. Because energy, and to some extent water consumption, and building configuration and building envelope are interdependent, energy and water costs are usually assessed for the building as a whole rather than for individual building systems or components.

Energy costs are often difficult to predict accurately in the design phase of a project. Assumptions must be made about use profiles, occupancy rates, and schedules, all of which impact energy consumption. Data on the amount of energy consumption for a building can come from engineering analysis or from computer programs such as (i) DOE-2¹¹⁴, (ii) Energy-10¹¹⁵, and (iii) ENERGY PLUS¹¹⁶. When selecting a program, it is important to consider whether you need annual, monthly, or hourly energy consumption figures and whether the program adequately tracks savings in energy consumption when design changes or different efficiency levels are simulated.

Quotes of current energy prices from local suppliers should take into account the rate type, the rate structure, summer and winter differentials, block rates, and demand charges to obtain an estimate as close as possible to the actual energy cost.

Energy prices are assumed to increase or decrease at a rate different from general price inflation. This differential energy price escalation needs to be taken into account when estimating future energy costs. Energy price projections can be obtained either from the supplier or from energy price escalation rates published annually on April 1 by U.S.

¹¹⁴ Available at <http://www.doe2.com/> [2004, July 19].

¹¹⁵ Available at <http://www.nrel.gov/buildings/energy10/> [2004, July 19].

¹¹⁶ Available at <http://www.energy-plus.org/english/> [2004, July 19].

Department of Energy (DOE) in *Discount Factors for Life-Cycle Cost Analysis, Annual Supplement to NIST Handbook 135*¹¹⁷.

Regarding water costs, it should be handled much like energy costs. There are usually two types of water costs: (i) water usage costs and (ii) water disposal costs.

The operation costs are divided into (i) non-fuel operating, (ii) maintenance and (iii) repair costs, which are often more difficult to estimate than other building expenditures. Operating schedules, standards of maintenance vary from building to building; there is great variation in these costs even for buildings of the same type and age. It is therefore especially important to use engineering judgment when estimating these costs.

Supplier quotes and published estimating guides sometimes provide information on maintenance and repair costs. Some of the data estimation guides derive cost data from statistical relationships of historical data and reports. For example, average owning and operating costs per area, by age of building, geographic location, and number of stories in the building. The Whitestone Research *Building Maintenance and Repair Cost Reference*¹¹⁸ gives annualized costs for building systems and elements.

The replacements costs should be carefully considered. This is because of the number and timing of capital replacements of building systems depend on the estimated life of the system and the length of the study period.

A good starting point for estimating future replacement costs is to use their cost as of the base date. The LCC method will escalate base-year amounts to their future time of occurrence.

The residual values can be based on (i) value in place, (ii) resale value, (iii) salvage value, or (iv) scrap value, net of any selling, conversion, or disposal costs. As a rule of thumb¹¹⁹, the residual value of a system with remaining useful life in place can be calculated by linearly prorating its initial costs. For example, for a system with an expected useful life of 15 years, which was installed 5 years before the end of the study period, the residual value would be approximately $2/3 = (15-5)/15$ ¹²⁰ of its initial cost.

Furthermore, there are other costs to be estimated such as (i) finance charges, (ii) taxes, and (iii) non-monetary benefits or costs.

Having produced a CBS, it is necessary to calculate the costs of each category. These are determined by one of the following methods¹²¹:

- i. Known factors or rates: they are inputs to the LCC analysis which have a known accuracy. For example, if the Unit Production Cost (UPC) and quantity are known, then the procurement cost can be calculated. Equally, if costs of different grades of

¹¹⁷ Available at <http://www.eere.energy.gov/femp/pdfs/ashb04.pdf> [2004, July 27].

¹¹⁸ Whitestone Research. (2004). <http://www.whitstoneresearch.com/book-specs.html> [2004, July 16].

¹¹⁹ Definition available at: <http://www.worldwidewords.org/qa/qa-rul1.htm> [2004, July 22].

¹²⁰ Whole Building Design Guide. (2004).

¹²¹ OGC. (2004).

staff and the numbers employed delivering the service are known, the staff cost of service delivery can be calculated;

- ii. Cost Estimating Relationships (CER): are derived from historical or empirical data. For example, if experience had shown that for similar items the cost of Initial Spares was 20 percent of the UPC; this could be used as a CER for the new purchase. CER can become very complex but, in general, the simpler the relationship the more effective the CER. The results produced by the CER must be treated with caution as incorrect relationships can lead to large LCC errors. Sources can include experience of similar procurements in-house and in other organizations. Care should be taken with historical data, particularly in rapidly changing industries such as IT where can soon become out of date; and.
- iii. Expert opinion: although open to debate, it is often the only method available when real data is unobtainable. When expert opinion is used in an LCC analysis it should include the assumptions and rationale that support the opinion.

Moreover, it is necessary to compare costs and benefits that occur in different time periods. As a result, discounting is useful technique to be used.

This is because discounting is a separate concept from inflation, and is based on the principle that, generally, people prefer to receive goods and services now rather than later. This is known as “time preference”.

This thesis does not cover the topic in great detail since it is a procedure common to many cost appraisal methods. However, it agrees that when comparing two or more options, a common base is necessary to ensure fair evaluation. As a result, the present is the most suitable time reference; all future costs must be adjusted to their present value. Consequently, discounting refers to adjust each future cost to present time, when the decision is made.

In spite of that, it is important not to confuse discounting and inflation. The discount rate is not the inflation rate but is the investment “premium” over and above inflation. Provided inflation for all costs is approximately equal, it is normal practice to exclude inflation effects when undertaking LCC analysis.

On the other hand, if the analysis is estimating the costs of two very different commodities with differing inflation rates, for example oil price and man-hour rates, then inflation would have to be considered. However, one should be extremely careful to avoid double counting of the effects of inflation.

After identifying all costs by year and amount and discounting them to present value, they are added to arrive at total life-cycle costs for each alternative:

$$LCC = I + Repl - Res + E + W + OM\&R^{122}$$

- **I** = Present Value (PV) investment costs (if incurred at base date, they need not be discounted)
- **Repl** = PV capital replacement cost

¹²² Whole Building Design Guide. (2004).

- **Res** = PV residual value (resale value, recover value) less disposal costs
- **E** = PV of energy cost
- **W** = PV of water costs
- **OM&R** = PV of non-fuel operating, maintenance and repair costs

B. Net Present Value Evaluations

Typically, financial benefits are calculated on a present value basis and then combined in the conclusion with net costs to arrive at a net present value estimate. This section contains a brief description of some techniques for evaluating net present value.

The recommended method of evaluating investment proposals is the *discounted cash flow* method. In this method, the incremental costs and benefits of proposals are discounted by a required rate of return in order to obtain the net present value of the proposal.

The advantages of discounting methods are¹²³:

- i. they give due weight to timing and size of cash flows;
- ii. they take the whole life of the project into account;
- iii. irregular cash flows do not invalidate the results obtained;
- iv. estimates of risk and uncertainty can be incorporated;
- v. use of discounting methods may lead to more accurate estimating; and
- vi. they rank projects correctly in order of profitability and give better criteria for acceptance or rejection of projects than other methods.

Another method is the *internal rate of return*. This method uses the same techniques as the discounted cash flow method, but instead of using a predetermined discount rate, it calculates the discount rate which would give a net present value of zero. If the internal rate of return is greater than the required discount rate, then the proposal should be accepted.

The *years to payback* method, however, determines the number of years for the earnings on a project to pay back the original outlay. When aggregate return and depreciation are roughly equal from year to year, the normal method for calculating payback is:

$$\frac{\text{Total Investment for Capital Expenditure}}{\text{Annual Savings} + \text{Annual Depreciation}} = \text{Years to Payback}$$

This method focuses on a project's initial earnings. It does not take into account earnings made after repayment of the initial investment, and it does not include the time value of money. Therefore, it is not useful for comparing projects with different patterns of cash flow, or different lives.

¹²³ Whole Building Design Guide. (2004).

The *accounting rate of return* method is normally calculated by applying the average annual profit over the life of the investment to its initial capital cost.

It does not take into account fluctuations in benefits during the life of the project, any subsequent capital expenditure, any residual value the investment may have, or the time value of money. .

Finally, the *discount rate* method helps to choose between the best alternative investment opportunities. For example, all departments, even small ones, have money tied up in assets and working capital. The value of the government's investment in a department is the value of all assets owned by the department, minus any money it owes to third parties¹²⁴.

When the Government invests in a department, it has to choose between alternative investment opportunities. Should it invest in Department A or Department B? The Government does not expect a return on its investment. On the other hand, it is driven by the need to demonstrate efficiency to the taxpayer, which will take into consideration the required rate of return of that investment.

In order to be able to add and compare cash flows that are incurred at different times during the life cycle of a project, they have to be made time-equivalent. To make cash flows time-equivalent, the LCC method converts them to present values by discounting them to a common point in time, usually the base date. The interest rate used for discounting is a rate that reflects an investor's opportunity cost of money over time, meaning that an investor wants to achieve a return at least as high as that of her next best investment. Hence, the discount rate represents the investor's minimum acceptable rate of return.

The discount rate for federal energy and water conservation projects is determined annually by the Federal Energy Management Program (FEMP)¹²⁵; for other federal projects not primarily concerned with energy or water conservation the discount rate is determined by the Office of Management and Budget (OMB)¹²⁶. These discount rates are real discount rates, not including the general rate of inflation.

The investment decisions are taken by considering which generate sufficient return for them to pay a "return on capital" to the Government. While the capital charge for each department may be used as the discount rate when evaluating investment, different rates may be more appropriate for specific investments. The rate chosen will depend on the risk of the investment. The important thing is that the department can pay the capital charge. How it generates a return in order to pay the capital charge is a matter for internal administration.

It is necessary to set time boundaries and the parameter responsible for this is the cost period(s). As a result, the study period begins with the base date, the date to which all cash flows are discounted. The study period should include any planning/construction period and the occupancy or service period. The study period has to be the same for all alternatives considered.

¹²⁴ Whole Building Design Guide. (2004).

¹²⁵ DOE. (2004b). <http://www.eere.energy.gov/femp/> [2004, July 17].

¹²⁶ Office of Management and Budget. (2004). <http://www.whitehouse.gov/omb/> [2004, July 17].

The service period begins when the completed building is occupied or when a system is taken into service. This is the period over which operational costs and benefits are evaluated. In FEMP analyses, the service period is limited to 25 years.

C. Cost-benefit Analysis

Cost-benefit Analysis aims to facilitate decision makers choose between alternative solutions in a way that the chosen alternative is the most cost-effective within the context of budget and political considerations. Using the Cost Benefits Analysis tool you can¹²⁷:

- iii. Evaluate the potential risks, fixed costs, operational costs and benefits of the project.
- iv. Compare the outcomes of two or more alternative cost/benefit scenarios of the same project.

Cost-benefit analysis (CBA) provides a means for systematically comparing the value of outcomes with the value of resources achieving the outcomes required. It measures the economic efficiency of the proposed technology or project.

Although CBA has definite limitations, it has become widely accepted among business and governmental organizations. This is because CBA is used to make decisions more rational and it is comforting to those who must make the decisions. In situations in which large amounts of money are at stake, the presentation of a cost-benefit analysis is the preferred way to demonstrate the reasoning behind investments.

For the application of CBA, inputs may be divided into (i) parameter values and (ii) benefit and cost values. Parameters include the discount rate, the future rates of economic growth, the future rates of inflation and the estimations about the future rates of technological change.

There are some specific necessary components for a reliable CBA. Initially, the analysis time period should match the system life cycle.

The system life cycle includes the following stages/phases: (a) feasibility study (b) design (c) development (d) implementation (e) operation and (f) maintenance. A system life cycle ends when the system is terminated or is replaced by a system that has significant differences in processing, operational capabilities, resource requirements, or system outputs.

Subsequently, the CBA has to include at least three alternative solutions that consider alternative ways of fulfilling the demanded project.

In the end of the analysis the decision maker should do a sensitivity analysis for the costs and the benefits considered during the previous steps. Sensitivity analysis identifies those input parameters that have the greatest influence on the outcome, repeats the analysis with different input parameter values, and evaluates the results to determine which, if any, input parameters are sensitive. If a relatively small change in the value of an input parameter changes the alternative selected, then the analysis is considered to be sensitive to that parameter.

¹²⁷ Boardman, Greenberg, Vining & Welmer. (1996). *Cost-Benefit Analysis: Concepts and Practice*. p. 7-21.

A CBA application includes the following stages¹²⁸: (i) general description of the project, (ii) list of alternative scenarios, and (iii) identify benefits and costs.

The *general description of the project* includes an explanation on the environment under which each analysis is done such as the objectives, the assumptions, the project/decision life and so forth.

The *list of alternative scenarios* helps to decide which is the best option in the CBA. It aims to consider the costs and the benefits for each of these options. In fact, it lists the options considered during the analysis. The scenarios are important because they are essential to compare the alternative decisions. The comparison facilitates the decision making.

Finally, *identify benefits and cost*. In this part, the application lists the exact benefits and costs met in each of the alternative scenarios. The application divides these into two kinds: (i) the ones that are relatively straightforward to be measured and (ii) the ones that are not very easy to be measured. Many factors must be considered during the process of estimating the costs associated with competing alternatives in a CBA.

All costs for the full system life cycle for each competing alternative must be included during the identification phase. The process must identify: (i) activities and resources, (ii) cost categories, (iii) personnel costs, (iv) direct and indirect costs (overhead), (v) depreciation, and (vi) annual costs.

In order to estimate benefits, first it is necessary to identify the benefits for both the customers/users and the organization/owner that provides the service(s) or product to the customers/users. Benefits are the services, capabilities, and qualities of each alternative system, and can be viewed as the return from an investment.

After the benefits are identified, it is necessary to establish performance measures for each benefit. The final step is to estimate the value of the benefits. If a benefit cannot reasonably be assigned a monetary value, it should be valued using a more subjective, qualitative rating system, which assigns relative numerical values for the competing alternatives. All benefits for the full system life cycle for each competing alternative must be included.

Since the CBA is normally the key document in the investment review process, reviewers want assurance that the analysis is reliable. Consequently, it is indispensable to have a sensitivity analysis¹²⁹.

The sensitivity analysis identifies those input parameters that have the greatest influence on the outcome, repeats the analysis with different input parameter values, and evaluates the results to determine which, if any, input parameters are sensitive. If a relatively small change in the value of an input parameter changes the alternative selected, then the analysis is considered to be sensitive to that parameter. If the value of a parameter has to be doubled before there is a change in the selected alternative, the analysis is not considered to be sensitive to that parameter. The estimates for sensitive input parameters should be re-examined to ensure that they are as accurate as possible.

¹²⁸ Boardman, et al. (1996). *Cost-Benefit Analysis: Concepts and Practice*. p. 7-21.

¹²⁹ Ibid. p. 18.

Appendix B: List of high-performance projects¹³⁰

A. List of high-performance buildings from the Community Environment Center

LEED™ Certified Project

NEW YORK CITY PROJECTS

1024 DEAN ST.
1400 FIFTH AVE
CEC HPD BLDG
SOLAIRE
THE HELENA (DURST ORG)

OUTSIDE NYC PROJECTS

168 PERSON DORM (AIR FORCE)
BEQ NAVY PENDLETON,CA
BLACKBIRD ARTISTS LOFT
BLOCK 5, BREWERY BLOCKS
BROADWAY HOUSING (dorm)
BROOKSIDE MILL RE-DEV (mixed 9 affordable)
CHPC YOUTH HOUSING PROJECT
DOMINICAN SISTERS HOUSE OF FORMATION
EASTERN VILLAGE COHOUSING
EGLESTON CROSSING
EGLESTON CROSSING II
FOLLY CREEK POINT
GIRL SCOUTS TOTEM
GYM LOFTS AT ALBERQUEQUE
HENDERSON HALL
HIGH PRAIRIE APTS
HOMESTEAD APTS, PHASE II
HUMAN SERVICE GROUP HOME
KILGO DORM RENOVATION
LOYOLA HALL
MCGINNIS EDUCATION HALL
MEDICAL & DENTAL ARTS BLDG
NAVY BEQ REPLACEMENT
NEW YASUI BUILDING
NORDHEIM COURT STUDENT HOUSING
NORTHERN MI UNIV MAGERS
NRNRC WEST END SENIOR HOUSING
OBLUCK CONDOS
P-301 BEQ NAVAL STATION
PALOLO CHINESE HOME
PORTLAND AIR NATL GUARD
RAINBOW HOUSE
ROSEWOOD HOUSE OF RECOVERY
ROYAL INLAND HOSP--MENTAL HEALTH

¹³⁰ SBTF. (2003). *The Cost and Financial Benefits of Green Buildings*. p. 98.

FACILITY
RTC RECRUIT BARRACKS
SCSU RESIDENCE HALL
SEATTLE UNIV GRAD HALL
SOUTH CAMPUS HOUSING
SOUTH RESIDENTIAL VILLAGE
STEPHEN EPLER HALL
SUNY PLATTSBURGH
SWARTHMORE COLLEGE RES HALL
TAHOE BEACH CLUB (mixed 13 affordable)
TAI GE APARTMENTS
VILLAGE AT NORTHSTAR
WASHINGTON AT MCBEE
WAVERLY GARDENS (moderate income)
XANTERRA PARKS

B. List of high-performance buildings from the Sustainable Building Task Force Report

It is important to address here that many of these buildings have not yet been certified by the USGBC at the completion of the Sustainable Building Task Force Report. In these cases, the LEED™ level was indicated is an assessment by the architect and/or client team reflecting very detailed analysis and modeling – this is viewed as a relatively accurate prediction of final LEED™ certification level (see Table below).

Project	Location	Type	Date Completed	Green Cost Premium	Green Standard
Energy Resource Center ¹	Downey, CA	Office	1995	0.00%	Level 1-Certified
KSBA Architects ¹	Pittsburgh, PA	Office	1998	0.00%	Level 1-Certified
Brengel Tech Center ¹	Milwaukee, WI	Office	2000	0.00%	Level 1-Certified
Stewart's Building ²	Baltimore, MD	Office	2003	0.50%	Level 1-Certified
Pier One ³	San Francisco, CA	Office	2001	0.70%	Level 1-Certified
PA EPA S. Central Regional ¹	Harrisburg, PA	Office	1998	1.00%	Level 1-Certified
Continental Towers ¹¹	Chicago, IL	Office	1998	1.50%	Level 1-Certified
Cal EPA Headquarters ³	Sacramento, CA	Office	2000	1.60%	Level 1-Certified
EPA Regional ¹	Kansas City, KS	Office	1999	0.00%	Level 2-Silver
Ash Creek Intemed. School ¹⁰	Independence, OR	School	2002	0.00%	Level 2-Silver
PNC Firstside Center ¹	Pittsburgh, PA	Office	2000	0.25%	Level 2-Silver
Clackamas High School ¹⁰	Clackamas, OR	School	2002	0.30%	Level 2-Silver
Southern Alleghenies Museum ⁷	Loretto, PA	Office	2003	0.50%	Level 2-Silver
DPR-ABD Office Building ⁵	Sacramento, CA	Office	2003	0.85%	Level 2-Silver
Luhrs Univ. Elementary ²	Shippensburg, PA	School	2000	1.20%	Level 2-Silver
Clearview Elementary ²	Hanover, PA	School	2002	1.30%	Level 2-Silver
West Whiteland Township ²	Exton, PA	Office	2004	1.50%	Level 2-Silver
Twin Valley Elementary ²	Elverson, PA	School	2004	1.50%	Level 2-Silver
Licking County Vocational ²	Newark, OH	School	2003	1.80%	Level 2-Silver
3 Portland Public Buildings ¹	Portland, OR	Office	since 1994	2.20%	Level 2-Silver
Nidus Center of Science ¹	Creve Coeur, MO	Office	1999	3.50%	Level 2-Silver
Municipal Courts ¹	Seattle, WA	Office	2002	4.00%	Level 2-Silver
St. Stephens Cathedral ¹²	Harrisburg, PA	School	2003	7.10%	Level 2-Silver
4 Times Square ⁶	New York City	Office	1999	7.50%	Level 2-Silver
PA DEP Southeast ²	Norristown, PA	Office	2003	0.10%	Level 3-Gold
The Dalles Middle School ¹⁰	The Dalles, OR	School	2002	0.50%	Level 3-Gold
Dev. Resource Center ⁸	Chattanooga, TN	Office	2001	1.00%	Level 3-Gold
PA DEP Cambria ²	Ebensburg, PA	Office	2000	1.20%	Level 3-Gold
PA DEP California ²	California, PA	Office	2003	1.70%	Level 3-Gold
East End Complex-Blk 225 ⁷	Sacramento, CA	Office	2003	6.41%	Level 3-Gold
Botanical Garden Admin ⁹	Queens, NY	Office	2003	6.50%	Level 4-Platinum

Appendix C: The high-performance features to the public buildings

The bill requires that all new construction of city-owned and/or city-funded buildings has to be certified as LEED™ 2.1 Silver. In order to achieve this level of certification, the project has to earn between 33 points and 38 points. All the prerequisites and criteria described in this subchapter were extracted from the *Leadership in Energy Environmental Design* guide produced by USGBC.

A. The prerequisites

In order to receive the potential points included in the silver category, the project has to fulfill prerequisites¹³¹ placed in certain categories in order to earn the credits. In fact, most of the prerequisites will be met in any case. This is because they are, normally, the same requirements set by local, regional, and/or national governments.

(i) Erosion & Sedimentation Control

The main intention is to create an erosion control to reduce negative impacts on water and air quality. The requirements design a sediment and erosion control plan, specific to the site. The project has to conform to:

¹³¹ USGBC. (2004b). *Leadership in Energy and Environmental Design*.

- United States Environmental Protection Agency (EPA) Document No. EPA 832/R-92-005; or
- Storm Water Management for Construction Activities, Chapter 3; or
- Local erosion and sedimentation control standards and codes, whichever is more stringent.

Also, the plan shall meet the following objectives such as: (i) Preventing loss of soil during construction by stormwater runoff and/or wind erosion, including protecting topsoil by stockpiling for reuse. (ii) Preventing sedimentation of storm sewer or receiving streams; and (iii) preventing polluting the air with dust and particulate matter.

(ii) Fundamental Building Systems Commissioning

The prerequisite intends to verify and ensure that fundamental building elements and systems are designed, installed and calibrated to operate as intended.

It requires implementing the following fundamental best practice commissioning procedures:

- Engage a commissioning team that does not include individuals directly responsible for project design or construction management;
- Review the design intent and the basis of design documentation;
- Incorporate commissioning requirements into the construction documents;
- Develop and utilize a commissioning plan; and
- Verify installation, functional performance, training and operation and maintenance documentation.

(iii) Minimum Energy Performance

This prerequisite establishes the minimum level of energy efficiency for the base building and systems.

It requires design the building to comply with the American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) and the Illuminating Engineering Society of North America (IESNA). The requirements are set by ASHRAE/IESNA Standard 90.1-1999 (without amendments) or the local energy code, whichever is more stringent.

(iv) Chlorofluorocarbons Reduction in Heating, Ventilation, Air-Conditioning & Refrigeration Equipment

The intention is to reduce ozone depletion. The prerequisite requires zero use of CFC-based refrigerants in new base building HVAC&R systems.

When reusing existing base building HVAC equipment, it is necessary to complete a comprehensive CFC phase-out conversion of the equipment. During this process the project

team needs to conduct an inventory to identify equipment that uses CFC refrigerants and adopt a replacement schedule for these refrigerants.

(v) Storage & Collection of Recyclables

The purpose is to facilitate the reduction of waste generated by building occupants that is hauled to and disposed of in landfills.

The requirements demand that the project provides an easily accessible area. The area will serve the entire building and it is dedicated to the separation, collection and storage of materials for recycling including at least paper, corrugated cardboard, glass, plastics and metals.

(vi) Minimum Indoor Air Quality Performance

This prerequisite establishes minimum Indoor Air Quality (IAQ) performance to prevent the development of indoor air quality problems in buildings, thus contributing to the comfort and well-being of the occupants.

The requirements are: (i) Meet the minimum requirements of voluntary consensus standard ASHRAE 62-1999; (ii) Ventilation for Acceptable Indoor Air Quality using the Ventilation Rate Procedure approved by the amendment described in ASHRAE 62-2001, Appendix H.

(vii) Environmental Tobacco Smoke Control

The intention is to prevent the building occupants from exposure of Environmental Tobacco Smoke (ETS).

It requires zero exposure of non-smokers to ETS by:

- a. Prohibiting smoking in the building and locating any exterior designated smoking areas away from entries and operable windows; or providing a designated smoking room designed to effectively contain, capture and remove ETS from the building. At a minimum, the smoking room must be directly exhausted to the outdoors with no recirculation of ETS-containing air to the non-smoking area of the building, enclosed with impermeable deck-to-deck partitions and operated at a negative pressure compared with the surrounding spaces of at least 7 Pascal (i.e., 7×10^{-5} atmosphere or 0.03 inches of water gauge);
- b. Performance of the smoking rooms shall be verified by using tracer gas testing methods as described in the ASHRAE Standard 129-1997;
- c. Acceptable exposure in non-smoking areas is defined as less than one percent of the tracer gas concentration in the smoking room detectable in the adjoining non-smoking areas. Smoking room testing as described in ASHRAE Standard 129-1997 is required in the contract documents and critical smoking facility systems testing

results must be included in the building commissioning plan and report or as a separate document.

B. The “low-hanging fruits” credit points¹³² or point-getters credits

It is obvious that there are “low-hanging fruits” or points that are much easier to achieve in the criteria, such as hiring a LEED™ accredited professional and using locally manufactured products and materials.

A survey prepared by Syska Hennessy Group in August 2003 has provided a confirmation of the achievement of the low-hanging fruits. The study analyzing 38 early LEED™ projects showed that all of them earned point by hiring a LEED™ accredited professional. But, only a few have applied for more challenging measures such as significant energy savings (i.e., more than 50 percent energy reduction) or brownfield redevelopment¹³³.

The project can earn points using these “low hanging fruit” credits. Choosing the top 14 point-getters credits, for example, the project can earn 17 points that correspond to approximately half of needed points to become LEED™ 2.1 Silver certified with 33 points.

(i) LEED™ Accredited Professional - 1 point

The intention is to support and encourage the design integration required by a LEED™ Green Building project and to streamline the application and certification process.

This credit requires at least one principal participant of the project team that has successfully completed the LEED™ Accredited Professional exam.

(ii) Regional Materials: 20% manufactured regionally – 1 point

This credit aims increasing demand for building materials and products that are extracted and manufactured within the region, thereby supporting the regional economy and reducing the environmental impacts resulting from transportation.

It requires using a minimum of 20 percent of building materials and products that are manufactured regionally within a radius of 500 miles (804.6 kilometers). The manufactured products in the requirements refer to the final assembly of components into the building product that is furnished and installed by the tradesmen. For example, if the hardware comes from Dallas, Texas, the lumber from Vancouver, British Columbia, and the joist is assembled in Kent, Washington; then the location of the final assembly is Kent, Washington.

(iii) Low-Emitting Materials: Carpet - 1 point

The intention is to reduce the quantity of indoor air contaminants, which are odorous, potentially irritating and/or harmful to the comfort and well-being of installers and occupants.

¹³² Building Design & Construction. (2003). *White Paper on Sustainability: A Report on the Green Movement*. p. 8-12.

¹³³ USGBC. (2004b). *Leadership in Energy and Environmental Design*.

The requirement is that the carpet systems must meet or exceed the requirements of the Carpet and Rug Institute’s Green Label Indoor Air Quality Test Program.

(iv) Water Efficient Landscaping: Reduce by 50% - 1 point

The credit attempts to limit or eliminate the use of potable water for landscape irrigation. Therefore, it requires the use high-efficiency irrigation technology or use captured rain or recycled site water to reduce potable water consumption for irrigation by 50 percent over conventional means.

(v) Alternative Transportation: Bicycle Storage & Changing Rooms - 1 point

The credit’s requirements are:

- For commercial or institutional buildings, provide secure bicycle storage with convenient changing/shower facilities (within 200 yards or 182 meters of the building) for five percent or more of regular building occupants.
- For residential buildings, provide covered storage facilities for securing bicycles for 15 percent or more of building occupants in lieu of changing/shower facilities.

(vi) Recycled Content: 5% (post-consumer + 1/2 post-industrial) – 1 point

This credit aims to increase demand for building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials.

The requirement is using materials with recycled content such that the sum of post-consumer recycled content plus one-half of the post-industrial content constitutes at least five percent of the total value of the materials in the project.

The value of the recycled content portion of a material or furnishing shall be determined by dividing the weight of recycled content in the item by the total weight of all material in the item, then multiplying the resulting percentage by the total value of the item. However, mechanical and electrical components shall not be included in this calculation. Also, recycled content materials shall be defined in accordance with the Federal Trade Commission document, *Guides for the Use of Environmental Marketing Claims*, 16 CFR 260.

(vii) Low-Emitting Materials: Adhesives & Sealants - 1 point

The requirements of this credit is that the Volatile Organic Compounds (VOC) content of adhesives and sealants used must be less than the current VOC content limits of South Coast Air Quality Management District (SCAQMD) Rule #1168. Also, all sealants used as fillers must meet or exceed the requirements of the Bay Area Air Quality Management District Regulation 8, Rule 51.

(viii) Site Selection - 1 point

The intention is to avoid development of inappropriate sites and reduce the environmental impact from the location of a building on a site.

It requires to not develop buildings, roads or parking areas on portions of sites that meet any one of the following criteria:

- a. Prime farmland as defined by the United States Department of Agriculture in the United States Code of Federal Regulations, Title 7, Volume 6, Parts 400 to 699, Section 657.5 (citation 7CFR657.5).
- b. Land whose elevation is lower than five feet (1.54 meters) above the elevation of the 100-year flood as defined by the Federal Emergency Management Agency (FEMA).
- c. Land which is specifically identified as habitat for any species on Federal or State threatened or endangered lists.
- d. Within 100 feet (30.48 meters) of any water including wetlands as defined by United States Code of Federal Regulations (CFR) in the code number 40, Parts 22 and Parts 230-233, and isolated wetlands or areas of special concern identified by state or local rule, or greater than distances given in state or local regulations as defined by local or state rule or law, whichever is more stringent.
- e. Land which prior to acquisition for the project was public parkland, unless land of equal or greater value as parkland is accepted in trade by the public landowner. Exemptions are made to Park Authority projects.

(ix) Optimize Energy Performance - 4 points

The intention is to achieve increasing levels of energy performance above the prerequisite standard to reduce environmental impacts associated with excessive energy use.

The requirements are:

- a. Reduce design energy cost compared to the energy cost budget for energy systems regulated by ASHRAE/IESNA Standard 90.1-1999 (without amendments), as demonstrated by a whole building simulation using the Energy Cost Budget Method described in Section 11 of the Standard.
- b. Regulated energy systems include HVAC (heating, cooling, fans and pumps), service hot water and interior lighting. Non-regulated systems include plug loads, exterior lighting, garage ventilation and elevators (vertical transportation).

Two methods may be used to separate energy consumption for regulated systems. The energy consumption for each fuel may be prorated according to the fraction of energy used by regulated and non-regulated energy.

Alternatively, separate meters (accounting) may be created in the energy simulation program for regulated and non-regulated energy uses.

If an analysis has been made comparing the proposed design to local energy standards and a defensible equivalency (at minimum) to ASHRAE/IESNA Standard 90.1-1999 has been established, then the comparison against the local code may be used in lieu of the ASHRAE Standard.

Project teams are encouraged to apply for innovation credits if the energy consumption of non-regulated systems is also reduced.

This credit has 10 possible points. However, the Syska Hennessy survey¹³⁴ showed that 28 of 38 projects have chosen to reduce design energy cost by 30 percent. As a result, the new project can earn four points (see Table below).

The Criteria EA 1.0: potential savings vs. possible points		
New buildings	Existing buildings	Points
15%	5%	1
20%	10%	2
25%	15%	3
30%	20%	4
35%	25%	5
40%	30%	6
45%	35%	7
50%	40%	8
55%	45%	9
60%	50%	10

Source: USGBC

(x) Construction Waste Management: Divert 50% from Landfill – 1 point

The credit intends to divert construction, demolition and land clearing debris from landfill disposal by redirecting recyclable recovered resources back to the manufacturing process and reusable materials to appropriate sites.

This requires developing and implementing a waste management plan, quantifying material diversion goals. Therefore, it needs to recycle and/or salvage at least 50 percent of construction, demolition and land clearing waste. Calculations can be done by weight or volume, but must be consistent throughout.

(xi) Low-Emitting Materials: Paints and Coatings – 1 point

The credit requires that VOC emissions from paints and coatings must not exceed the VOC and chemical component limits of Green Seal’s Standard GS-11 requirements.

(xii) Daylight and Views: Views for 90% of Spaces – 1 point

The objective is to provide for the building occupants a connection between indoor spaces and the outdoors through the introduction of daylight and views into the regularly occupied areas of the building.

¹³⁴ Building Design & Construction. (2003). *White Paper on Sustainability: A Report on the Green Movement*. p. 8-12.

The requirement is to achieve direct line of sight to vision glazing for building occupants in 90 percent of all regularly occupied spaces. Examples of exceptions include copy rooms, storage areas, mechanical, laundry and other low occupancy support areas. Other exceptions will be considered on their merits.

(xiii) Reduced Site Disturbance: Development Footprint - 1 point

The purpose is to conserve existing natural areas and restore damaged areas to provide habitat and promote biodiversity.

The credit requires reducing the development footprint to exceed the local zoning's open space requirement for the site by 25 percent. The footprint is defined as entire building footprint, access roads and parking. For areas with no local zoning requirements (e.g., some university campuses and military bases), designate open space area adjacent to the building that is equal to the development footprint.

(xiv) Water Efficient Landscaping: No Potable Use or No Irrigation – 1 point

The objective is to limit or eliminate the use of potable water for landscape irrigation. Therefore, it requires only the use of captured rain or recycled site water to eliminate all potable water use for site irrigation, or do not install permanent landscape irrigation systems. Exception is made for initial watering to establish plants.

C. The last required credit points

The project which has chosen the point-getters credits previously listed still needs to earn 16 points to become Silver certified.

The standard is user-friendly; consequently, it gives the opportunity to design teams to choose among the credits those correlated to the local necessities. For example, regions that do not have a shortage of water could focus on energy savings as an alternative.

The main idea, therefore, is that it is economic feasible to achieve the Silver level of certification without having to make radical changes to the building design and/or utilize costly high-performance features.