Green vs. Conventional

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Abstract — *The research project was focused on the construction cost of an office building containing four (4) floors of office space and two (2) levels of parking area use the same building construction under the guidelines of USGBC (U.S. Green Building Council), also known as a LEED (Leadership in Energy and Environmental Design) Certified Building. The main purpose for this comparative is to determine which construction method is more practical due to today's economy. Parameter that wear used are Initial Cost (design and construction), Operation Cost (energy, water other utilities that apply), Maintenance Cost and Salvage Value at the end of the building life span. It was demonstrated in this research that all factors have to be considered because for a project to be of adequate use this analysis can mean the difference between a profitable or non-profitable project*.

Key Terms — *LEED Certified Building, Life Cycle Costs, Life Cycle Assessment, and Maintenance.*

INTRODUCTION

People have constructed building for decades, since the time of the Egyptian Era toward the 21-century, building bridges, dam, sky scrapers, pyramids and more. As new emerging ideas for different structure have also evolved the method and material, having structures built or sculpted form rocks, to concrete building, steel structure build to a new era, the Green Build Era (LEED Certified Building) Green Building requires a full, integrated approach but in practice depends on new strategies in the various aspects of design and construction.

The most frequent question is why green building? But to answer this question one first has to understand what green building is. Green Building is to be able to create a self and high performance building that mains objective is in minimizing environmental impact by reducing infrastructure and efficient building operations. This movement creates a permanent shift in the areas of design, planning, construction and operational practices. But how did we reach such "idea"? It is reached by determining the effects of today's conventional construction methods. Conventional construction has developed a practice that has created an intense effect for human health, the environment and the economy. For example [1]:

- Clearing of land for development causing destruction on wildlife habitat.
- Extraction, manufacturing, and transporting material, contribute to the pollution of water and air.
- Release of toxic chemicals, and emission of greenhouse gases
- Building operation require large inputs of energy and water.
- Building related transportation contributes to a wide range of impacts associated with vehicles use and energy consumption.

In all type of construction projects, regardless if they are conventional or sustainable, there are 2 basic types of cost related to the project: the project's hard costs and soft costs. With LEED, a third cost element, life cycle cost, is used for the purposes of factoring into the analysis the true value of a building over its lifetime.

Research Description

This research is based on a direct comparison of an existing building, constructed with the conventional method, and that same building transform into a LEED Certified building. Such building was evaluated in the following areas: initial investment, maintenance, and energy cost. This is to determine which method is more appropriate with today's economy down fall.

Research Objectives

This analysis will help understand the importance in determining the difference between a life cycle assessment and life cycle cost based on the method of construction. It will also demonstrate pros and cons of the method of construction based on the future investments.

LITERATURE REVIEW

The following literature review will provide us with a better understanding in determening if LEED is a good inverstment. At the same time determine when is a good time, during the construction phase o pre-construction, should we invest.

Life Cycle Assesment

Life Cycle Assessmet (LCA) or also known as cradle –to-grave analysis is a technique to assess enviromental impact associated with all the stages of a product's life from its raw material stage, from the earth (cradle), toward the disposal or recycle of the material (grave). There are three (3) types of LCA: Attributional LCA which seek to establish the burdens associated with the production and use of a product, or with a specific service or process at a point in time [2]. Consequential LCA seek to identify the enviromental consequences of a decision or a proposed change in a system under study, which means that market and economic implications of a decision may have to be taken into account, and Social LCA has a more different approach to the life cyce thinking, this concepts intends to assess social implications or potential impacts. In todays date, the LCA has been standarized by the Enviromental Standard Management System under the template ISO 14000. Enviromental Standard Management System evolved in the early 90's. In 1992 during the first Earth Summit the BSI Group published the wold's first enviromental management system standard BS 7750, which know a days is the template for the ISO 14000.

According to the ISO LCA is based on four (4) different stages, as shown on Figure 1. The stages are offten interdependent in that the results of one stage will inform how other stages or phase are completed.

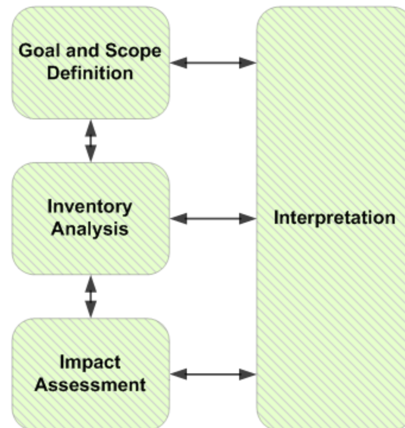


Figure 1
LCA Stages

Life cycle assessment is an informed choice of buidling material and system that minimizes the negative impacts of the building and land use on the people and the enviroment. The process begins as early as planning and design, analyzes construction activities and then goes beyond convention by including building operations and the eventual retirement and renewal of materials.

Life Cycle Cost

Life Cycle Cost (Whole Life Cost) is a method for assessing the total cost of ownership. It takes into account all costs, of acquiring, owning operating, and the eventual disposal of a building, as shown on Figure 2. Sustainable design requires an analysis of a building over its entire life and life cycle cost analysis identifies which high performance building system will save money over the life of the building. The main building expenses that are taken into account are: [2] [3]

- Initial Cost (Design and Construction).
- Operating Costs (Energy, water, gas and other utilities and personnel).

- Maintenance, Repair and Replacement Costs.
- Salvage value at the end of the building's life.

Whole Life Costing is a key component in the economic appraisal associated with evaluating asset acquisition proposals. An economic appraisal is generally a broader based assessment, considering benefits and indirect or intagible costs as well as direct costs. The whole-life costs and benefits of each option are considered and usually converted using discount rates into net present value costs and benefits. Asset investments have been based on expedient design and lowest cost construction. If such investment has been made without proper analysis of the standard of service required and the maintenance and invention options available, the initial saving may result in increased expenditure thoughout the asset's life.

By using whole-life costs, it avoids issues with decisions being made based on the short-term costs of design and construction. Often the longer-term maintenance and operation costs can be a significant proportion of the whole-life cost.

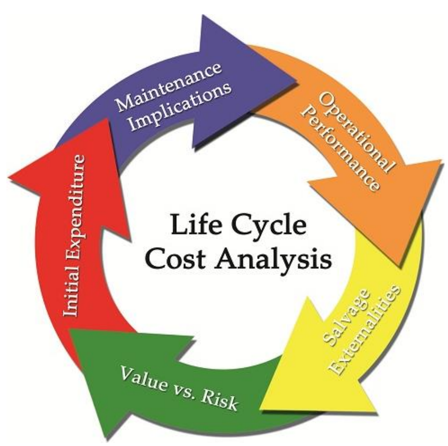


Figure 2
LCC Analysis

Asset Management

During the life of the asset, decisions about how to maintain and operate the asset need to be taken in context with the effect these activities might have on the residual life of the asset. If by investing 10% more per annum in maintenance costs the asset life can be doubled, this might be a worthwhile investment.

Other issues which influence the life cycle costs of an asset include:

- site conditions,
- historic performance of assets or materials,
- effective monitoring techniques, and
- appropriate intervention strategies.

Although the general approach to determining whole-life costs is common to most types of asset, each asset will have specific issues to be considered and the detail of the assessment needs to be tailored to the importance and value of the asset.

Green Building

Green Building is an integrative effort to transform the way built enviroments are designed, constructed and operated. The scope of green building reaches from the earliest stage of planning to beyond the end of the structure's life. Utilizing a holistic, or whole buildings, approach to the design and construction, green building produces high performance by focusing on sustainable categories as defined by LEED. With an itegrative and holistic approach, the interaction, or synergies and trade-offs, between construction stategies are managed to provide maximum performance results. LEED channels green design through sustainable categories as determined by the eviramental issues being addressed, such as: [4] [3]

- Economic benefits,
- Reduce operating cost,
- Enhance asset value and profit,
- Improve employee satisfaction and productivity,
- Optimize life cycle economic performance,
- Health and community benefits,
- Improve air, thermal and acoustic environments,
- Enhance occupant comfort and health,
- Minimize strain on local infrastructure,
- Contribute to overall quality of life,
- Environmental benefit,
- Improve air and water quality
- Reduce solid waste, and

- Conserve natural resources.

Green building is divided in six (6) major categories, as seen in Figure 3: [1] [4] [5] [6]

- Sustaianble Sites
- Water Efficiency
- Energy and Atmosphere
- Materials and Resources
- Indoor Enviromental Quality
- Innovation in Design

Figure 3
Green Building Categories

Sustainable Site

The selection and development of a building's site are fundamental components of sustainable building practices. The sustainability of a project site has several aspects: select and develop a site wisely, reduce emission (various transportation option), plant sustainable landscape, protecction of surrounding habitats, manage stormwater runoff, reduceheat island effects, and eliminate light pollution.

Water Efficiency

The common user use of the limited public water supply continues to increase as development expands, Municipally provided potable is delivered to users for domestic, commercial, industrial, and other purposes and is the primary source of water for most buildings, but high demand is creating limited supplies. Building use aproximately 14% of our potable water supply. The sustainability of a project water efficiency has several aspects: monitor water consumption performance, reduce indoor potable water cunsumption to save energy and, improve envromental well being, practicing water efficient landscaping.

Energy and Atmosphere

Energy has emerged as a critical economic issue and top priority for all nations. The importance of energy conservation is easy to understand given the fact buildings consume such a large precentage of the annual energy and electricity generated. The energy performance of a building depends on its design. The orientation of the building, the massing of the building's elements, material selections, contruction methods, building envelope, water efficiency, HVAC and lighting system determine how efficiently the building uses energy. The sustainability of a project energy and atmosphere has several aspects: energy demand, energy efficiency, ongoing energy performance and renewable energy.

Material and Resources

Thoughout their life cycles, building tend to generate a great deal of waste that goes directly into the waste stream. Material procurement, recycling programs and waste management can divert these materials and toxins from our landfills while improving the building enviroment. Sustainable design gives consideration to material selections as they relate to natural resources, occupant health and productivity and life cycle impacts. The sustainability of a project material and resources has several aspects: waste management (waste reduction), Material selection, and waste disposal.

Indoor Environmental Quality

After numerous evaluation EPA has designated indoor air apollution as a top enviromental risk to public health and recent increases in building related illnesses and related legal cases has heightened awareness of indoor air quality among building owners and occupants. To be able to improve indoor enviromental quality have the potential to enhance the lives of building occupants, increase the resale value of the building, and reduce liability for building owners. The sustainability of a project of indoor environmental quality has several aspects: improving ventilation, maniging air contaminants, specifying less harmful materials and, allowing occupants to control desired settings by providing proper daylight and view.

Innovation in Design

The innovation in design provides bonus for projects that incorporate innovative and sustainable building features that improve performance above and beyond expectention. With the innovation design there are two main stategies: to exceed in credits, and to cover topic not address by LEED.

METHODOLOGY

This research analyzed and compared two (2) types of construction methods, the conventional method and the green (LEED) method. The research is going to take an existing four-story build with two level of parking area and transform such construction into a LEED Certified building or a Green Building.

For this research the following two (2) steps were completed for the analysis.

Step I. Determine Hard Cost for the Project

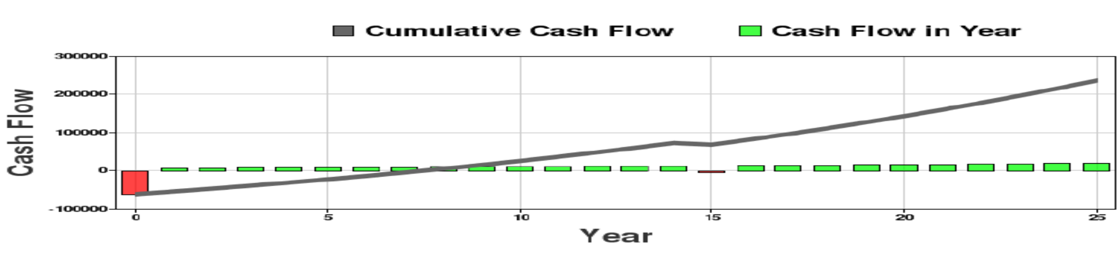
As mention previously hard costs of the actual construction phase of the project will be site work, concrete, masonry, roofing, interior finishes such as carpet, painting, and mechanical system. For instant the building, a 18,000 SFT, under evaluation as an estimate of 200$/SFT for the construction (civil, electrical, mechanical, and pluming), approximately has an annual spending of $66.9K on electrical bill, and annual spending of office maintenance 60K. In the first year the owner will spend 3,730K.

Step II. Recommendation

Since this analysis is based on an exsisting building and converting it to LEED or Green building a major component is the energy cosumption. The best recommendation is the installation of a 21 kW solar system with a light sensor system. Such recommendation has a soft cost of 8K and a 156K hard cost for a total of 165K

Table 1 summarizes the cash flow the owner can expect from the system quoted. As it can be seen due to the government incentive during the time of analysis the owner only has to provide $62K and the payback period is approxsmately 7 to 8 years with a rate of return on cash investment of 14.4%.

Table 1
Cash Flow Energy Cost



Financial Summary	
Utility Savings Over System Life	$316,751
Average Monthly Utility Savings	$1,056 (over system life)
Net Cost (In year of installation)	$62,000
Payback Period	7-8 years
Rate of Return on Cash Invested	14.4%
Total Life-Cycle Payback (Cash flow compared to Net Cost)	479%

Table 2

Cash Flow Behavior Years One through Nine

Year:	0	1	2	3	4
Installation, Operation & Maintenance Costs	($156,000)	($78)	($79)	($80)	($81)
PR State Rebate	$94,000	$0	$0	$0	$0
Net Energy Bill Savings (Reduced by lower income tax deduction)	$0	$7,161	$7,480	$7,812	$8,159
Total Annual Cash Flow	($62,000)	$7,083	$7,401	$7,732	$8,078
Cumulative Cash Flow	($62,000)	($54,917)	($47,516)	($39,784)	($31,706)

Year:	5	6	7	8	9
Installation, Operation & Maintenance Costs	($81)	($82)	($83)	($84)	($85)
PR State Rebate	$0	$0	$0	$0	$0
Net Energy Bill Savings (Reduced by lower income tax deduction)	$8,522	$8,901	$9,296	$9,709	$10,140
Total Annual Cash Flow	$8,441	$8,819	$9,213	$9,625	$10,055
Cumulative Cash Flow	($23,265)	($14,446)	($5,233)	$4,392	$14,447

Table 3

Cash Flow Behavior Years Ten through Twenty Five

Year:	10	11	12	13	14
Installation, Operation & Maintenance Costs	($86)	($87)	($87)	($88)	($89)
PR State Rebate	$0	$0	$0	$0	$0
Net Energy Bill Savings (Reduced by lower income tax deduction)	$10,592	$11,062	$11,554	$12,068	$12,604
Total Annual Cash Flow	$10,506	$10,975	$11,467	$11,980	$12,515
Cumulative Cash Flow	$24,953	$35,928	$47,395	$59,375	$71,890

Year:	15	16	17	18	19
Installation, Operation & Maintenance Costs	($17,505)	($91)	($92)	($93)	($94)
PR State Rebate	$0	$0	$0	$0	$0
Net Energy Bill Savings (Reduced by lower income tax deduction)	$13,165	$13,749	$14,361	$14,999	$15,666
Total Annual Cash Flow	($4,340)	$13,658	$14,269	$14,906	$15,572
Cumulative Cash Flow	$67,550	$81,208	$95,477	$110,383	$125,955

Year:	20	21	22	23	24	25
Installation, Operation & Maintenance Costs	($95)	($96)	($97)	($98)	($99)	($100)
PR State Rebate	$0	$0	$0	$0	$0	$0
Net Energy Bill Savings (Reduced by lower income tax deduction)	$16,362	$17,090	$17,849	$18,642	$19,471	$20,336
Total Annual Cash Flow	$16,267	$16,994	$17,752	$18,544	$19,372	$20,236
Cumulative Cash Flow	$142,222	$159,216	$176,968	$195,512	$214,884	$235,120

Tables 2 and 3 demostrate the cash flow behavior over a period of 25 years. On these table it can be seen more clearly why by the seventh (7) year, base on the earning, has reach the break even point. Also demostrate the behavior of the maintanenance cost will be in that same period of time.

DISCUSSION

The main objective of this project is to determine which method is more appropriate or more practical to consider during a new project. Green, LEED, Conventional all are methods that must be always in mind during the design phase. Studies have shown that the difference in hard cost is approximately 2% between each method. Such study does not apply to Puerto Rico, due to the high cost of gas, lack of experience, the lack of alternative energy source in Puerto Rico and the current economic depression the difference in Hard Cost can go as high as 10%. Even though one should considered Green or LEED method due to the little or no environmental impact, the conventional methods is looking more practical to the owners' eye. There is a different option, how about design and construct the conventional way and after a period of time inserts certain character, (ex. Solar or Wind) that will help transform the building in a Green Building? This method was applied to the example mentioned in this analysis. Such research helps us understand and determine that the investment can be considered practical if and only if the transformation can be done having the outcome is greater than 11% and the breakeven point is in a short period of time.

Conclusion

Whole-life cost analysis is often used for option evaluation when procuring new assets and for decision-making to minimise whole-life costs throughout the life of an asset, It is also applied to comparisons of actual costs for similar asset types and as feedback into future design and acquisition decisions.

The primary benefit is that costs which occur after an asset has been constructed or acquired, such as maintenance, operation, disposal, become an important consideration in decision-making. Previously, the focus has been on the up-front capital costs of creation or acquisition, and organisations may have failed to take into account on the longer-term costs of an asset. It also allows an analysis of business function interrelationships. Low development costs may lead to high maintenance or customer service costs in the future.

The general belief that green buildings add cost to new construction projects is often misunderstood. It is possible to design and construct green building with little or no extra cost with studies showing as little as a 2% cost increase for green building projects. That becomes more challenging, however, as the bar is raised for aggressively green, super-efficient buildings.

Many scenarios can be formulated to determine the net cost of green buildings compared to conventional building. Any effort to reduce energy consumption or improve indoor air quality above code complaint baselines is considered an added cost. Alone, this can lead to a conclusion that green buildings cost more than conventional building. However, when considering efforts to conserve energy as part of an integrative design approach, these added new savings often offsets costs. For instance, if the amount of insulation in the building is increased, the size of the HVAC system is reduced, as is the electrical amount consumed. In addition the proper location so the windows for the appropriate amounts of daylight enter the building is increased, it will reduce the amount of artificial lighting required. Daylight also increases occupant satisfaction and performance. The cost of building green can be compared to the cost of same class conventional building when considering an integrative design approach.

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