AN IMPACT OF COST ANALYSIS ON CONSTRUCTION OF GREEN BUILDING IN ETHIOPIA

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ABSTRACT

In this conceptual review that authors are focusing on Green Building which is also known as green construction or sustainable building, refers to both a structure and the application of processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from planning to design, construction, operation, maintenance, renovation, and demolition. Green building is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from sitting to design, construction, operation, maintenance, renovation and deconstruction. This practice expands and complements the classical building design concerns of economy, utility, durability, and comfort. Green building is also known as a sustainable or high performance building. The costs of greening buildings ultimately rely on changing attitudes among architects, builders, and owners, Pierson adds. "It will take the obsolescence of sustainable design as a different kind of building system," he explains "As soon as that becomes standard and we're approaching that – then we'll see the cost fall into place." Green Buildings provide financial benefits that conventional buildings do not. The financial benefits are in lower energy, waste and water costs, lower environmental and emissions costs, and lower operational and maintenance costs and increased productivity and health.

Key Words: *Green building –environment- renovation- demolition- construction- sustainable- life-cycle*

1. Introduction

In this study, authors would like to focus on cost benefits and savings of construction of green building and the effects on environment. Green building, or sustainable design, is the put into practice of escalating the effectiveness with which buildings and their sites use energy, water, and materials, and of tumbling impacts on human health and the environment for the complete lifecycle of a building. Green-building concepts enlarge beyond the walls of buildings and comprise site planning, community and land-use planning issues as well. Most frequently costs are connected with financial operating expense. However, there are a overabundance of other behavior, can associate cost with, such as environmental impact costs, resource use costs, human health costs, and time costs. When analyzing environmental impact costs the procedure is referred to as a Lifecycle Analysis, or Assessment (LCA).While producing energy on site is great and reduces costs, the math to determine the Return on Investment (ROI) for such sustainable design features is not as straightforward as the costs required to purchase and install a product.

Energy efficient technologies, and designs that reduce energy demands, are considered intelligent choices when considering investment and operation costs alone.

According to data compiled by the National Association of **Home** Builders (NAHB) from 2015 to 2017, the national **average** for **home construction costs** was about $99 per square foot. In other words, zero energy **homes cost** about 5% more than **homes** built to minimum code. **Green buildings**, on average, are 14 percent less **costly** to operate than traditional **buildings**, with most new builds today achieving significantly more energy savings than that. Market demand for **green building is** doubling every three years.

2. Objectives

1. To review cost benefits of building construction through the green building techniques
2. To judge an effective use of environmental resources for building construction.

3. Methodology

In this study, the researcher adopt the simple conceptual review method since the total population could not able to find out by the researcher, for the cost analysis and green building techniques which is applicable in Ethiopia. Data collected through the different secondary sources like, books, journals, internet, magazine and other secondary resources. In this study both qualitative and quantitative methods are adopted.

4. What is Green Building?

A green building is a building that, in its design, construction or operation, reduces or eliminates negative impacts, and can create positive impacts, on our climate and natural environment. Green buildings preserve precious natural resources and improve our quality of life.

There are a number of features which can make a building 'green'. These include:

1. Efficient use of energy, water and other resources
2. Use of renewable energy, such as solar energy
3. Pollution and waste reduction measures, and the enabling of re-use and recycling
4. Good indoor environmental air quality
5. Use of materials that are non-toxic, ethical and sustainable
6. Consideration of the environment in design, construction and operation
7. Consideration of the quality of life of occupants in design, construction and operation
8. A design that enables adaptation to a changing environment

Any building can be a green building, whether it's a home, an office, a school, a hospital, a community centre, or any other type of structure, provided it includes features listed above.

However, it is worth noting that not all green buildings are – and need to be - the same. Different countries and regions have a variety of characteristics such as distinctive climatic conditions, unique cultures and traditions, diverse building types and ages, or wide-ranging environmental, economic and social priorities – all of which shape their approach to green building. This is why World GBC supports its member Green Building Councils and their member companies in individual countries and across regions, to pursue green buildings that are best suited to their own markets. To get involved in your own country's transformation to green building, please contact or join your local Green Building Council.

5. Why go Green?

Now, let us take a look at why it is so important to go green. Most people will find when going green that they are able to reduce their carbon footprint and actually lend a helping hand to the environment, can go green in a variety of different ways, but builders and construction workers must do their part as well. If you haven't begun going green, then you will find that there are a variety of different things that you can do to help you get started, and don't have to jump in head first, and can actually take some baby steps along the way. Green buildings are designed in such a way to reduce overall impact on environment and human health by:

1. Reducing trash, pollution and degradation of environment.
2. Efficiently using energy, water and other resources.
3. Protecting occupant health and improving productivity.

How the work of our nonprofit, the Green Built Alliance, helps to advance the green-building movement.

In the United States, buildings account for:

1. 39% of total energy use
2. 68% of total electricity consumption
3. 30% of landfill waste
4. 38% of carbon dioxide emissions
5. 12% of total water consumption

Environmental benefits of green building:

1. Enhance and protect biodiversity and ecosystems
2. Improve air and water quality
3. Reduce waste streams
4. Conserve and restore natural resources

Economic benefits of green building:

1. Reduce operating costs
2. Improve occupant productivity
3. Enhance asset value and profits
4. Optimize life-cycle economic performance

Social benefits of green building:

1. Enhance occupant health and comfort
2. Improve indoor air quality
3. Minimize strain on local utility infrastructure
4. Improve overall quality of life

6. Green Home Building Ideas

1. Location: While buying property for yourself, take a note of couple of things that you must foresee before moving in. Firstly, avoid building west facing home. This will keep your home cool as it minimizes sun exposure. Secondly, avoid building home in environmentally sensitive locations such as earthquake or hurricane or flood prone areas. Thirdly, check if public transportation is easily available and local grocery shop is not that far away. This will help you avoid taking your own vehicle every time and will reduce your travel time.

2. Smaller is Better: A small home built with eco friendly techniques is going to have smaller environmental impact as against a large home. A house that is too large is likely to cost more to heat and cool. Try to keep the place manageable and cost effective. If you are planning to extend your family and bring in few relatives, you need to put proper resources and accommodation in place.

3. Energy Efficient Equipment: Energy Star label on a piece of equipment states that particular product has been deemed as energy efficient by the Environmental Protection Agency (EPA). ENERGY STAR is becoming well known label and consumers today choose energy star appliances for their homes. These appliances offer significant cost and energy savings without compromising performance.

4. Proper Insulation: Insulation is one of the most important ting that you need to consider while building a green home, An Heating and cooling account for 50% of your home's energy consumption. Air leaks such as around windows, door and duct work is responsible for building's heat loss. Don't let heating and cooling of your interior spaces air go waste through improper insulation. Proper insulation will not only reduce your energy consumption but will bring down your electricity bills substantially.

5. Reduce, Reuse, and Recycle: Reduce your need for buying new products that are not environment friendly. Reuse your old material such as wood floors, doors, windows in your next home. Recycled materials such as recycled glass, aluminum, recycled tile, reclaimed lumber, recycled plastic can be used in green home building.

6. Use Sustainable Building Materials: If building a green home is your goal, then using environmentally or eco-friendly products should be on your list which can reduce the impact of construction on the environment. Each and every part of your house such as roofing material, building material, cabinets, counters and insulation to your flooring should be environmentally friendly. Use products such as reclaimed lumber, recycled plastic, recycled glass or natural products such as bamboo, cork and linoleum which are made of natural, renewable materials.

7. Install Solar Panels: Solar energy is clean and renewable source of energy. Solar panels are an emerging and hot technology for people who want to utilize the natural power all around us, the sun. Solar panels may be expensive at first, but the long-term savings you can put into your pocket is a stunning example of the benefits of turning your life from black to green. The location of your house and the way you have constructed solar panels can determine how much power you can collect. By taking advantage of solar power you can bring down your energy consumption and supply excess energy, if any, to your utility company. Also, government grants, incentives and tax breaks are huge bonus to those who want to use solar power in their home.

8. Energy Star Windows: Energy efficient windows labeled as ENERGY STAR windows are new player in window market and are much more energy efficient than normal windows. The ratings for these windows determine how energy efficient they will be. The lower the rating, the more energy efficient is your windows. The energy savings provided by these windows are enough to cover the added cost per window.

9. Rainwater Harvesting Systems and Thankless Water Heaters: Install rainwater harvesting system while building your green home to collect rainwater from roofs and then storing it in a tank. The collected water can then be used for other purposes such as toilets and sprinkler systems. Rain barrels are one of the most common methods of rainwater harvesting being used today. With thankless water heaters, you need not wait for the water to get heated. Thankless water heaters heat only that much water that is needed as it is passed through electric coil. This gives you twin benefits. Firstly, it eliminates excess energy costs as it heats up only that much amount of water that is needed and secondly, you can get ample storage place by eliminating the hot water tank.

10. Eco-Friendly Lighting: Both LED and CFL cost more upfront but use less energy and last longer than traditional incandescent bulbs. Since they offer significant cost savings in the long run, they can be ideal for your new green home.

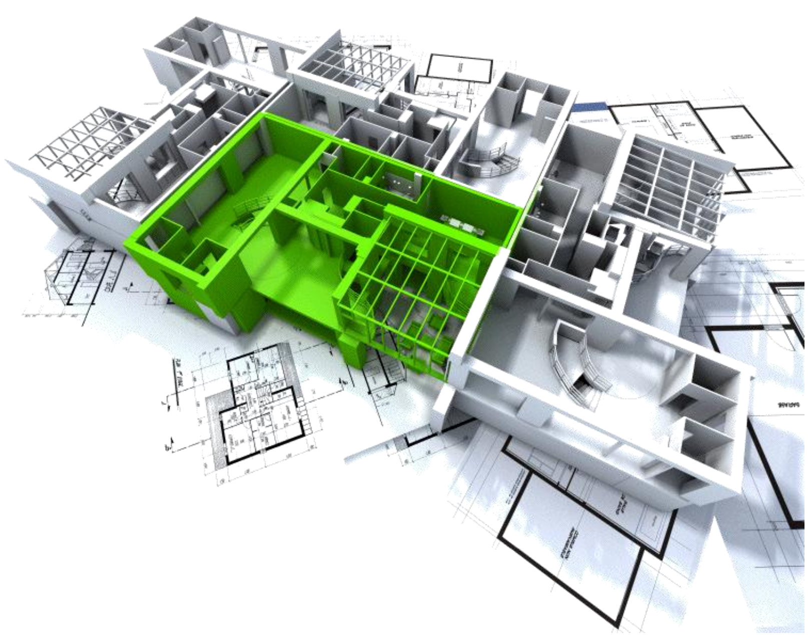
11. Leveraging Integrated Design

With integrated design, all stakeholders architect, mechanical engineer, contractor, preconstruction services consultant, cost estimator, building owner and operator, and other consultants collaborate early and often to understand how building systems link to one another and then use that knowledge to find efficiencies and tradeoffs. While this approach requires more planning on the front end, it often leads to free or passive solutions that reduce system loads and building costs. Integrated design might reveal, for example, how a slight modification to a building's orientation can reduce solar heat gain and increase natural day lighting, resulting in less expensive HVAC and lighting components.

Our work on the DC Consolidated Forensic Lab provides a real-world example of how integrated design can lead to first-cost savings. The LEED Platinum building in Washington, D.C., came in 17 percent under budget with much of the savings due to its sustainability. For instance, collaboration with the project's mechanical engineer, Vanderweil, resulted in outfitting the building with an active chilled beam system, heat shift chiller, enthalpy wheels and glycol energy recovery loops that reduced the mechanical load of the building and the number of chillers that would have been required with a traditional HVAC system. Because chilled beams are a hydronic system that do not require nearly as much plenum space as traditional air ducts, we were also able to reduce the floor-to-floor height of the building, which led to construction and material savings.

As part of the integrated design process, we knew that the building operator desired sustainable features to reduce long-term energy use and costs. This information allowed us to incorporate a dynamic glass louver wall along the building's south facade. The glass louvers (featuring a 50 percent ceramic frit pattern) serve as a solar shield, automatically adjusting, opening and closing depending on sun angle, wind and barometric pressure. Unlike a true double-skin facade, the louvers—set three feet off the curtain wall allow the airspace between the exterior wall and sunscreen to vent without impacting air pressurization requirements in the interior lab space while at the same time mitigating solar heat gain and glare along the south of the building.

11.1. Elements of Green Building



Green building offers you and your team a comprehensive set of best practices to help you design and construct efficient, healthy homes that benefit the community, the environment, and your bottom line. These nine "elements" are literally your green building blocks.

11.2. Site planning and design

Affordable housing works best when residents have easy access to key services and transit. Infill sites have these and many more environmental benefits. Design your site to fit into the surrounding neighborhood and to work with natural features to provide safe play spaces, shade your building, and naturally control stormwater runoff. Minimize site impacts by shrinking the physical footprint of your development with more compact building and parking lot layouts and by taking care of trees and soil conditions during construction. Go to the **Site page**.

11.3. Community

Green buildings and developments support strong communities by giving neighbors places to meet, establishing a sense of place and safety, and creating spaces for pedestrians and kids, rather than cars. Successful and sustainable designs involve residents and community members from the planning stage all the way through to operation and maintenance. Go to the **Community page**.

11.4. Indoor Air Quality

Indoor air quality significantly impacts resident health and comfort--essential goals for any building. Achieving a high quality indoor environment requires careful design, construction, and materials choices, and thus strong coordination among the building team. Indoor air quality centers on well-designed ventilation and moisture control, which goes hand in hand with energy efficiency and building durability. Ongoing maintenance is important, of course, as is a commitment to finding alternatives to toxic materials and finishes. Go to the **Indoor Air Quality page**.

11.5. Energy

Energy efficiency is the key to making your building a finely tuned, lean, green machine. Start using energy modeling software early in the design process to take advantage of the sun and wind to heat, light, and cool your building affordably. Modeling will show how a high performance building envelope and superior insulation can let you can choose smaller, efficient HVAC systems, lighting, and appliances. Renewable energy, where feasible, is the ideal next step. Go to the **Energy page**.

11.6. Materials

Green, high quality building materials that minimize or eliminate indoor air quality concerns, avoid toxics, and greatly reduce waste are now widely available, often from local manufacturers. Recycled-content and pre-fabricated products reduce material use, cut costs, and often perform better than traditional alternatives. To set criteria for purchasing, consult existing guidelines, standards, and certifications. Life cycle analysis has provided several rules of thumb for different categories of materials. Go to the **Materials page**.

11.7. Waste

Reduce, reuse, and recycle construction and demolition waste to cut costs and improve building quality. Design for efficient use of materials and for durability, avoiding future waste. Then identify goals in a waste management plan and work them into contract documents. With the right setup, you can recycle over 70 percent of some waste materials on the construction site, and residents can recycle 100 percent of others in their homes. Go to the **Waste page**.

11.8. Water

Conserve finite freshwater resources and reduce utility bills by installing water-efficient appliances and plumbing fixtures, landscaping with drought-resistant plants and efficient irrigation, and putting rainwater and greywater to use. To soak up more of the stormwater runoff that plagues rivers and streams in the Washington metropolitan area, replace asphalt and turf with porous pavement and trees; then consider rain barrels, rain gardens, and green roofs. Go to the **Water page**.

11.9. Commissioning

Commissioning is the process of making sure that a building works right. By systematically evaluating and adjusting building systems to function together as designed, commissioning optimizes efficiency, health, and comfort. A commissioning agent--often a third-party architect or engineer--gives advice during the design phase and follows through with testing during construction and training of operations and maintenance staff. Go to the **Commissioning page**.

11.10. Marketability

When architects use daylighting to flood an open floor plan with natural light; when residents open a window to let in fresh air and look out on thriving trees, green buildings don't just lower utility bills and keep residents healthy--they inspire. Distinctive and attractive design gives residents, developers, and neighbors a reason to take pride in a green development, to care for their homes, their community, and the environment. These values are the foundation of sustainability. By treating green design as an art, not just a science, we can elevate economic, aesthetic, community, and ecological values to serve future generations. Go to the Marketability page.

12. Ethiopia is Cheapest Emerging Market For Luxury Property

Fast-growing Ethiopia is the cheapest place in the world's emerging markets to buy luxury property, according to a new ranking from a specialist property company.

Top end real estate there costs around $448 per square metre, while luxury property in Angola is ten times more expensive, at over $4,500 per square metre, data from property portal Lamudi shows. Africa's second most populous country, Ethiopia is also one of Africa's top economic performers: its economy is expected to expand 8.6% this year and 8.5% in 2016, compared with 10.3% growth last year, the International Monetary Fund said in April.

A four-bedroom luxury house in Addis Ababa While Ethiopia comes top in the "cheap league", Ivory Coast is next in line, with a square metre of posh home there costing around $483, and third is Tanzania, where classy real estate costs $549 per sq m, says Lamudi. Prices for Angolan luxury property were pushed to extremes as a result of the country's oil boom after the civil war ended in 2002. African luxury prices still fall far below luxury prices in the developed world, however. The main properties **cost** around $ 448 per square meter, while luxury real estate in Angola is ten times more expensive at more than $ 4,500 per square meter, according to data from the Lamudi property portal. **Ethiopia** is the second most populous country in **Africa** and one of the main economies of **Africa**. As Ethiopia's property market matures, high-end real estate is increasingly in demand," said Lamudi Ethiopia managing director, Wunmi Osholake. At the same time, prices here remain low comparative to many of our neighbours, making Ethiopia the most affordable place to buy luxury real estate anywhere in the world."

Who is buying luxury property in Ethiopia? Lamudi told GCR that 43% are aged between 35 and 44, 66% are male, most (91%) speak English, and 34% are located in the US, while 37% hail from Ethiopia.

Safety is a concern in some areas, with terrorist group Al Shabaab reported to have planned attacks. The UK's Foreign and Commonwealth Office (FCO) advises against all travel to within

10km of the border with Eritrea, with some exceptions, and to regions bordering Somalia and Kenya. (See map.)

But the FCO says crime levels are low, and that around 20,000 British nationals visit Ethiopia every year with most reporting no trouble.

Latin America also has a strong showing in the "cheap league", Lamudi data shows.

Top image: Addis Ababa, capital and largest city in Ethiopia

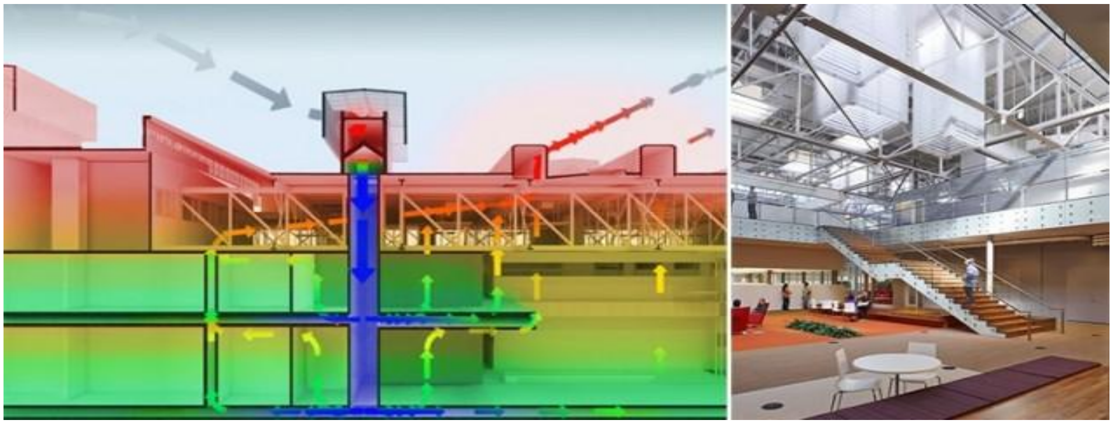
Figure-1 Energy modeling revealed how a passive cooling system could cut expenses at NOAA's Pacific headquarters

13. Energy Modeling

Energy modeling software simulation that provides detailed analysis of a building's energy use helps us understand long-term and short-term consumption costs. This crucial component of integrated design often leads to additional savings and helps justify the costs of sustainability features that might not be immediately apparent.

Energy and computational fluid dynamics (CFD) modeling of the National Oceanic and Atmospheric Administration Daniel K. Inouye Regional Center in Pearl Harbor, Hawaii, which was honored with an AIA COTE 2017 Top Ten Green Project award, showed how a passive cooling system would provide substantial operational and first-cost savings compared to other HVAC options. The novel cooling system we used on the building pumps cold seawater from a 1,300-foot-deep well to the buildings chillers where heat is rejected into the seawater, eliminating the need for traditional cooling towers. The seawater then flows into a series of chilled coils. The system takes advantage of the trade winds to drop chilled air passing over the coils into the building without using mechanical fans.

Figure-2 Deep seawater is pumped to the rooftop of NOAA's Inouye Center. Trade winds then send water-cooled air into the building



Savings from the cooling system allowed the design team to outfit the LEED-Gold project with additional sustainable design features, such as increased day lighting. Designers used small-scale mockups to test the size and spacing of daylight openings to provide even daylight levels across office work areas. As construction proceeded, full-scale mockups fine-tuned the team's initial daylight studies, ensuring that interior workplaces took advantage of the maximum amount of natural light while also blocking direct sun exposure. Once in operation, the NOAA Inouye Regional Center achieved 33 percent annual energy savings in addition to its first-cost neutral sustainable design. Energy modeling isn't just for building owners who care about sustainability or LEED certification. Energy modeling can often find savings that far exceed the costs of setting up and running the energy simulation software.

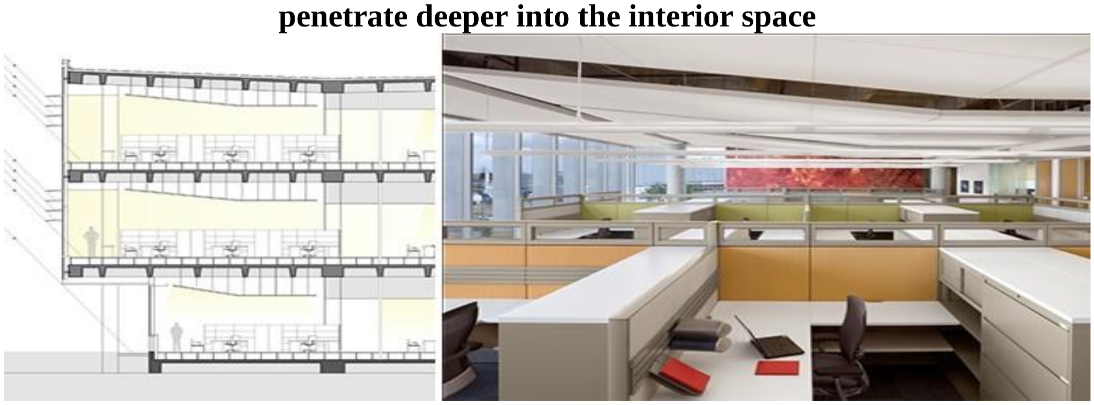
In Washington, D.C., we designed a multi-building commercial office project that achieved LEED Platinum status without additional building costs. For the final phase of that project, Constitution Square Building 4, the developer secured a full-building tenant and hoped to leverage building performance to position the structure for higher resale value without increasing first costs. Energy modeling on that project, however, revealed that by reducing the building's window-to-wall ratio from 56 percent to 51 percent and improving the window glazing, the design team could reduce the number of chillers that service the building. In this case, the energy model ROI was dramatic—an investment of $24,000 to perform iterative modeling at all design and Value Engineering stages netted approximately $500,000 in first-cost reduction, bringing the mechanical system back into budget while maintaining 35 percent energy savings. The developer has since sold the building (still under construction) at a price that reflects its high-performance design.

Figure-2 A review of how employees would use NASA Building 20 allowed HOK designers to reduce its size by 11 percent

14. Programming for Efficiencies

Taking a detailed look at how many people will occupy a building and how they will use the space can help teams design for efficiencies. HOK's work on NASA Johnson Space Center Building 20 in Houston shows how using this planning strategy can both reduce costs and improve a building's sustainability. In the RFP for the project, NASA specified it wanted a LEED-Silver building of approximately 93,000 square feet. In reviewing how the building's 520 employees would use the space, our team was able to reduce the overall building size by 11 percent while still meeting the requirements of the agency's occupants.

Figure-3 In reducing the square footage of NASA Building 20, the design team was able to add other sustainability features, such as a sloped ceiling that allows daylight to penetrate deeper into the interior space



Savings from the compact design opened the budget for additional sustainability features including exterior sun shading devices, advanced lighting controls, a building section optimized for day lighting and an under floor air distribution (UFAD) system that ultimately earned the project 57 percent energy savings and LEED-Platinum status without going over budget.

14.a. **Different Green Building Materials**

The aim of using green building materials is to construct energy-efficient structures and to build those structures one should be aware of different green building materials, their properties and how they contribute into saving energy.

Green Building Materials used in Construction

Following is the list of Green building materials used in construction :

1. Earthen Materials
2. Wood

3. Bamboo
4. SIPs
5. Insulated Concrete Forms
6. Cordwood
7. Straw Bale
8. Earth Bags
9. Slate/ Stone Roofing
10. Steel
11. Thatch
12. Composites
13. Natural Fiber
14. Polyurethane
15. Fiber Glass
16. Cellulose
17. Cork
18. Polystyrene and isocyanurate
19. Natural Clay
20. Non- VOC paint
21. Natural Fiber Floor
22. Fiber Cement
23. Stone

15. Costs Defined

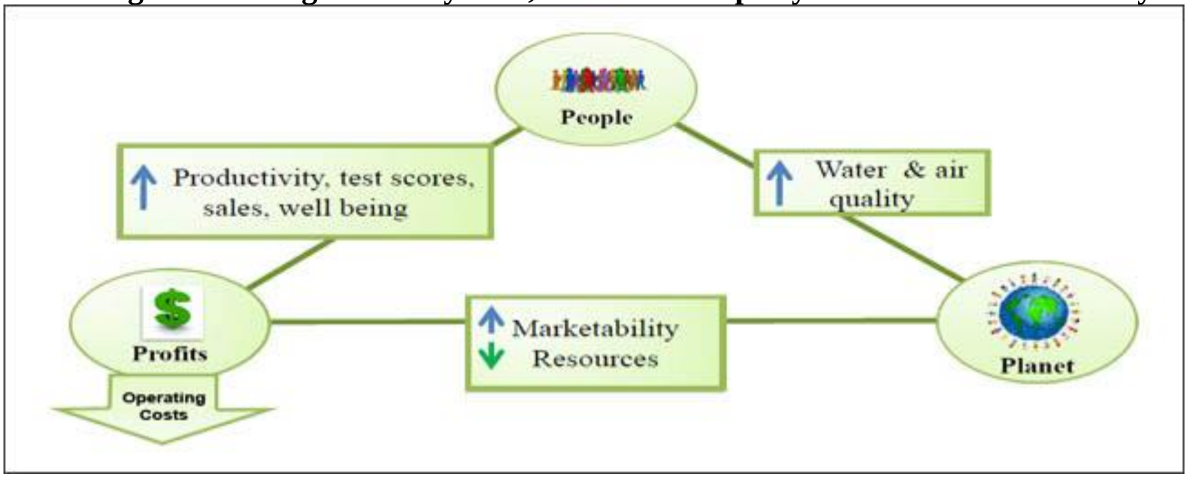
Most often costs are associated with monetary expenses. However, there are a plethora of other qualities we can associate ”cost” with, such as environmental impact costs, resource use costs, human health costs, and time costs. When analyzing environmental impact costs the process is referred to as a Lifecycle Analysis, or Assessment (LCA).

Isolating the analysis of monetary expenses is called a Lifecycle Cost Analysis (LCCA). In basic terms, LCCA classifies monetary costs into three categories. These are investment or initial costs, operation or ongoing costs, and return or residual costs. Initial costs include how much something costs to put into operation For example, the expense of purchasing a hot water solar panel and installing it on a building roof. The operation cost could be commissioning the water tank the solar panel is supplying heat to, and the return is the energy production that provides a positive monetary return because it reduces the amount of energy that must be supplied and paid for. While producing energy on site is great and reduces costs, the “math” to determine the Return on Investment (ROI) for such sustainable design features is not as straightforward as the costs required to purchase and install a product. Energy efficient technologies, and designs that reduce energy demands, are considered intelligent choices when considering investment and operation costs alone. But to truly get the full picture of a design project that decreases energy demands, a full LCCA should be considered.

16. Green Building Cost Analysis for Existing Buildings

There has been a misconception about the costs of green building design, LEED-certification, and construction. All these things stand as the greatest barriers to the adoption of sustainable development. There have been various studies conducted which suggests that sustainable buildings may incur increased prices beyond conventional construction costs. But the costs can be recovered over the short lifetime of the building with the help of savings in utility bills, increased property values and productivity gains.

Figure-4 Savings in Utility Bills, Increased Property Values And Productivity Gains



Source: facilities.ufl.edu

17. Cost of Green Building:

It has been observed that the cost of green building is generally lower if done from the initial stages of modeling, and design. But if green design has to be incorporated in the existing buildings then the costs of sustainable building may increase. This is an obvious fact. Another important point to note is that an additional 3% project costs in the design phase can reduce the cost of construction by 10% which is an advantage.

18. Payback Period for Green Building:

Through the initial cost of green building is higher than the conventional one, the savings obtained through energy, water, maintenance, operations and health costs offer quick investment returns, which ultimately results in revenues.

It has also been observed that the environmental and health benefits of sustainable building are tremendous. One more fact that goes in favor of eco-friendly building is that with minimal increase of 2% in support of green design can yield benefits of 20% of total constructions in total life cycle which is more than ten times the initial investment. So for example; if you have made an initial investment of $ 200,000for green building out of total investment of $ 10 million; project savings will be $ 2 million in today's dollars over the life time of the building.

LEED Analysis Services company provides green construction related modeling & analysis services for sustainable buildings. Its core strength lies in large sustainable building design projects, experienced designers and project managers from different fields such as HVAC, Plumbing, AHU, Electrical, CFD, Architecture, and Structural engineering. We offer an outsourcing firm comprising of Building Management Services experts, consultants for optimization of thermal efficiency of green projects and heat utility/recovery device designers.

LEED Consulting For Existing Building: Apart from new construction, our team is capable to analyze your existing building for LEED / green building conceptualization, modeling, facility-design, energy analysis, documentation, and building information modeling at most competitive cost for following areas.

1. Water Savings
2. Lighting & Energy Savings
3. Indoor Environment Quality
4. Green Equipment Selection
5. Sustainable Development

6. Waste & Recycling Options

13. Green Building Costs

Sustainability requires a systems-based approach to design iteration. It is important to accurately account for the financial impacts of a design proposal. Also, understanding how systems thinking can be applied to cost can develop a better idea of how investment costs can be offset with Lifecycle Cost Analysis. It is highly important not to omit the details of costs from the sustainable design conversation. Costs, translated at times as monetary economies, are the vehicle for supporting the execution of building projects. Everything has a financial value, and projects can only be realized when there is investment buy-in from stakeholders. Conducting building performance analysis is a valuable tool for filtering what design decisions can yield a more valuable economic return. Furthermore some building owners have very strict construction budgets, public elementary schools for example, that can cause the building design to remain within a firm financial budget that has been established in the pre-design phase of the project.

14. Full Lifecycle Cost Analysis

When buildings are not performing as efficiently as they could be, the ROI might be immediate, but not sustainable long term. It could go something like this…

A building cost "A" to be built and can be sold or rented for "B"

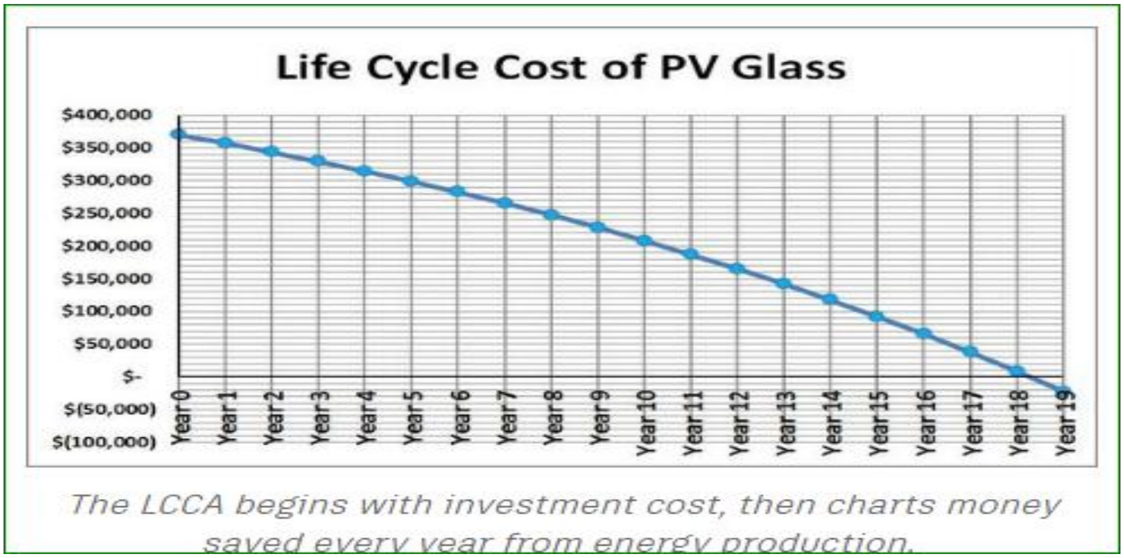
1. The difference between "B" and "A" is the ROI
2. As a result, much of the ROI is based on real estate projections, which can change dramatically

In this scenario "A," the investment cost, also dictates fifty percent of the equation, emphasizing the importance of the initial cost. For this reason the cost to erect a building has traditionally been the primary deciding factor in whether or not to build a particular design. For this reason, sustainable buildings may be more expensive to build, but it's the ROI that is key.

Historically, only the initial and sale prices of a building were considered in LCCA. However, in order to consider the benefits of sustainable design, the capacity a design has to return energy must be considered in the calculation. Additionally, since the capacity of technologies to create energy is based on environmental conditions and equipment, the ROI is also much more predictable. The solar rays from the sun will not be altered by the real estate market, for example. All of this requires a new way of considering the financial cost of a building. Because there are capabilities to receive financial returns at a time period away from the initial construction of a building, "A," LCCA must consider "C," a variable that accounts for recurring return.

Design decisions must weigh initial cost against time period of pay back when proposing concepts to a building owner. Below is a LCCA that was conducted for a proposed photovoltaic glass panel roof.

Chart-1 Life Cycle Cost of PV Glass- the LCCA begins with investment cost, and then charts money saved every year from energy production.



Here is another LCCA chart that uses traditional glazing that does not produce any energy.

Chrt-2 If maintenance was accounted for in this analysis, the cost would actually be a net gain each year

As can be observed, the PV glass pays for its self around year eighteen. In the year following the glass starts being completely profitable. Whether or not eighteen years is too long of an investment pay back is for the building owner to decide. But at least the designer related the proposed design to financial incentives and had an awareness of how economics fit into the sustainable goals of reducing energy consumption. If the building owner was only presented with the initial cost around $350,000 they might not be interested in this PV glass concept. This could cause the owner to potentially opt for the traditional glazing that could have as much as a thirty five percent reduced investment cost, but have no real capability to pay for itself. Sustainable design is not only good for the planet, but it also has sound economic rational.

15. Leveraging Cost in BPA

Building performance analysis makes LCCA more accessible to the design process. Through the combination of BPA methods, and BIM technologies, data is readily available for analysis. This data at any point in time can be run through LCCA of comparing investment, operation, and return. Time is also a cost that can be monetized with BPA techniques. Many BPA methods are targeted towards occupant satisfaction. When people are comfortable in their working environment, they tend to be more productive. The more someone accomplishes in an established period of time the more financially valuable they become. Additionally when buildings are designed to be green, less people experience a condition called sick building syndrome, which results in completely unproductive days of not working at all. It is important to consider all methods of financial payback when presenting designs that were arrived at with the use of BPA methods.

16. Conclusion

Finally, in the concluding part, some people feel that they just can't go green because it will cost them more money, but that is really a common misconception. While it may cost a bit more to get started when are going green, because green materials and products can be more costly, really have to consider the type of savings that will be able to reap. The person will be able to save on energy costs, because going green also means conserving energy. It should really look at the green building as more of an investment than anything else. An investment that will be able to save the money, as well as an investment that will be able to help the environment. It is a win-win situation for everyone.

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