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Evaluation and Comparison of Energy savings & Water savings in Green Building over Conventional Building based on Life Cycle Cost Analysis

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Abstract - *We live in a modern, consumerist and largely urban world consuming more energy and resources than we can replenish. Increasing global population, urbanization, rising income level and the resultant increase in consumption has resulted in unprecedented environmental damage shifting the global focus towards sustainable development. Green building can effectively solve the problem of resource shortage; however the Green Buildings in India is very slow because of its higher cost, compared with conventional Buildings. In this paper, I analyze the construction and life cycle cost of Conventional building and Green Building based on Life-Cycle cost Analysis Method. Objective of this study is to find out the cost of Energy savings and Water savings in Green Building over Conventional Building. Also this study gives Cost-Benefits Green Buildings.*

A comparative analysis between a Green Building and Conventional Building is adopted for this study. From previous literature review, the analysis shows that the construction cost of Green industrial manufacturing building is about 2-12 % higher than that of a Conventional building. However, operation, maintenance and end life cycle costs are in the range of 35 to 41 %, 26 to 30%, and 6 to 18 % respectively. It is expected that the outcome of this research would contribute to the organizational learning of Green built environment and there by uplift the use of sustainable construction in India.

Key Words: **Green Building, Green Materials, sustainable Energy, Green rating system in India, cost-Benefit analysis, Life cycle cost, and Life cycle cost Analysis.**

1. INTRODUCTION

Building facility has been a human need for some activities platform such as social, economic and environmental. In the other hand, building construction has both positive and negative impacts that there are not only on construction phase but also on operational and maintenance phase. The building projects have cost associated with land, designing and planning, execution and operational, maintenance, which extend over its lifetime. Cost of operations and maintenance is intimately linked to the technology and materials chosen for construction. This is especially true for fully air-conditioned buildings that require continuous energy use over its life cycle. It is generally belief that the construction cost of a green building will be much more than conventional building, but some middle way is required to be found out how the cost of lifecycle is usually less than the cost of conventional building by analyzing the real situation and condition in the construction and operational phase throughout the green building.

Green building thought in broader terms is a building which is planned, built, operated, maintained or reused with objectives to defend inhabitant health, improve employee efficiency, use wisely natural resources and reduce the environmental impact. Green construction or sustainable building which complements the building plan with concerns of economy, utility, durability and comfort. In other words the green building procedure incorporates environmental considerations into every phase of the building structure. This process focuses on the design, construction, process and maintenance phases and takes into account the lot design and development effectiveness, energy and water effectiveness, resource efficiency, indoor environmental excellence, building-owner maintenance and the building‘s overall impact on the environment. A Green Building is one which utilizes fewer water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier space for occupants as compared to conventional buildings.

1.1 Green Building Concept

A green building is one, which uses less water, optimizes energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants, as compared to a conventional building. It is also known as a sustainable or ‘high performance’ building. It brings together a vast array of practices, techniques, and skills to reduce and ultimately eliminate the impact of buildings on the environment and human health. It often emphasizes taking advantage of renewable resources, e.g. using sunlight through passive solar, active solar and

photovoltaic equipment, and using plants and trees through green roofs, rain gardens, and reduction of rainwater runoff.

In general, costs of green buildings can be divided into two categories: pre-construction costs and post construction costs. Pre-construction costs include soft costs and hard costs. Soft costs are the costs related to design, commissioning, and documentation fees. Hard costs are construction, materials, and building services costs.

Post-construction costs are building operating costs of energy consumption, water use, maintenance, and management. Benefits though, include differing savings and financial gains during building construction and post construction phases such as higher property market value, higher rents, fewer vacancies, and marketing opportunities resulting from social benefits, lower carbon taxes, higher energy savings, less sick leave, and higher productivity.

From the literature survey, Conventional buildings worldwide consumes-

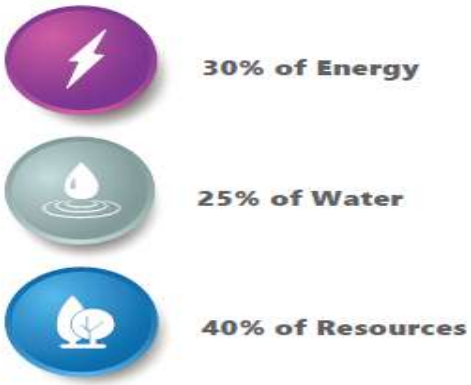


Fig. 1 Conventional building's Worldwide Consumes.

And Conventional buildings Worldwide Produces-

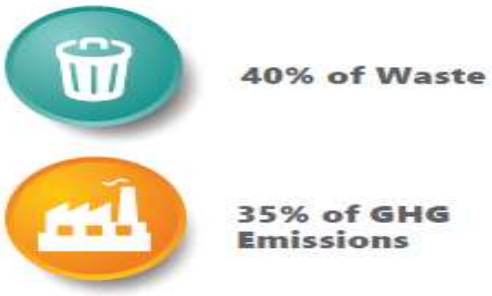


Fig. 2 Conventional building's Worldwide Generates.

1.2 Life Cycle Cost Analysis

LCCA is a process of evaluating the economic performance of a building over its entire life. Sometimes known as "whole cost accounting" or "total cost of ownership," LCCA balances initial monetary investment with the long-term expense of owning and operating the building.

The purpose of an LCCA is to estimate the overall cost of the project alternatives and to select the design that ensures the facility will provide the lowest overall cost of ownership consistent with its quality and function. The LCCA should be performed early in the design process while there is still a chance to refine the design to ensure a reduction in life cycle costs [LCC]. The costs associated with LCCA are the initial cost of construction, energy and water cost, operation cost, maintenance cost, repair cost, replacement costs and residual costs.

1.3 Rain water Harvesting

For our water requirement we entirely depend upon rivers, lakes and ground water. However rain is the ultimate source that feeds all these sources. Rain water harvesting means to make optimum use of rain water at the place where it falls i.e. conserve it and not allow to drain away and cause floods elsewhere. The rain water harvesting may be defined as the technique of collection and storage of rain water at surface or in sub-surface aquifer before it is lost as surface run off. The augmented resources can be harvested whenever needed.

Advantages of rain water harvesting

(a) Promotes adequacy of underground water

(b) Mitigates the effect of drought

(c) Reduces soil erosion as surface run-off is reduced

(d) Decreases load on storm water disposal system

(e) Reduces flood hazards

(f) Improves ground water quality / decreases salinity (by dilution)

(g) Prevents ingress of sea water in subsurface aquifers in coastal areas

(h) Improves ground water table, thus saving energy (to lift water)

(i) The cost of recharging subsurface aquifer is lower than surface reservoirs

(j) The subsurface aquifer also serves as storage and distribution system

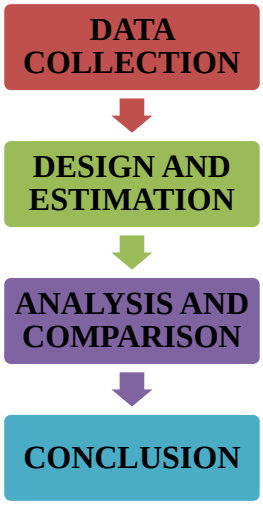
(k) No land is wasted for storage purpose and no population displacement is involved

(l) Storing water underground is environment friendly

2. METHODOLOGY

A comparative analysis between green building and conventional building is to be adopted for this study. The study is going to be carried out to an existing G+1 storey residential building. It is constructed as per the conventional ways using all old non-green materials. It does not use any energy efficient methods to improve its performance. The performance of this conventional building can be improved by using Green building technology. This analysis enabled to identify the relationship between sustainable features and its impact on initial cost as well as LCC. Comparison is done between the buildings is for total Energy cost required for the life of 25 years.

The following Flow chart shows the Planning schedule of work adopted for the Dissertation:



2.1 Data Collection

The primary data required for this study is collected directly from the owner of Conventional Building. The source of data collected is through questionnaire which is close - ended questionnaire and discussion with the owner. Some data is used in this study is of secondary nature. The secondary data is collected from sources such as web sites, journals and books, etc.

In developing countries like India energy is one of the main constrain, more than 40% of energy is consumed by buildings. Buildings, in general, are categories into residential, commercial and industrial buildings. In this residential buildings place a major role in consuming energy due to the ever growing population. So to save energy we should implement an efficient method. There are few building methods which can reduce energy consumption such as green buildings, passive buildings, ZEBs etc.

2.2 Design and Estimation

a) Energy Cost Estimation

In this, Total Energy costs required for 25 years are calculated for Conventional as well as Green building. In conventional building there is no any Energy efficient system installed. In other case, in Green building Solar Energy system is installed. So over all energy expenditure between both buildings is calculated as below.

Calculations for Conventional Building:-
Here for a residential Building let say 4 KW system required. 1 KW generates 4 units per day.
Hence for 4 KW= 4X4= 16 unit per day.
Electricity Cost for per day = 16 units X 10 Rs. Per unit

= 160 Rs. per Day.

Electricity Cost for a month will be = 30 X 160 = 4800 Rs. per Month.
Electricity Cost for a year will be = 12 X 4800 = 57600 Rs. per Year.
Hence, for the Life of 25 years Energy cost for conventional building will be,

= 25 X 57600 = 14,40,000 Rs./25 Years.

Calculations for Green Building:-
To install 4 KW solar system plant Initial cost will be,
For 1 KW approx. 75,000 Rs. Costs required.
Hence for 4 KW = 4X 75000 = Rs. 3,00,000 /-

From Government side there is subsidy for this. It is approx. 30 % of their benchmark cost, i.e. around Rs. 14,100 for 1 KW plant.
Hence for 4 KW = 4 X 14100 = Rs. 56,400 /- subsidy will be credited by Government in your account.
So, the amount will be now = 3,00,000-56,400

Rs. = 2,43,600 /-

2.3 Analysis and Comparison

From above calculations we got that, for Conventional building, monthly energy bill is around Rs. 4800/-. And annually it is Rs. 57600 /-

For the life of 25 years it goes around Rs. 14,40,000/- which is near almost the initial construction cost of building.

On other hand for Green building, initially only Rs. 3,00,000/- required for the installation of Solar system, from which around Rs. 56400 will be given by Government for subsidy on solar system. Following table shows the Return on Investment on Solar Energy System for 4 KW Plant installations,

Table No.1 Return on Investment (ROI)

Years ➔	1	2	3	4	5
Unit Generation with yield 1450 KWH/KWP /year	5800	5742	5700	5643	5587
Gross Unit Rate INR. 10.00	58000	57420	57000	56430	55870
Saving at the end of Year (INR)	58000	115420	172420	228850	284720

From the above Table, the **ROI is between 4 to 4.5 years**. That means within 4.5 years all invested money will be returned and there after **next 25-4.5= 21.5 years** the Electricity will be free of Cost.

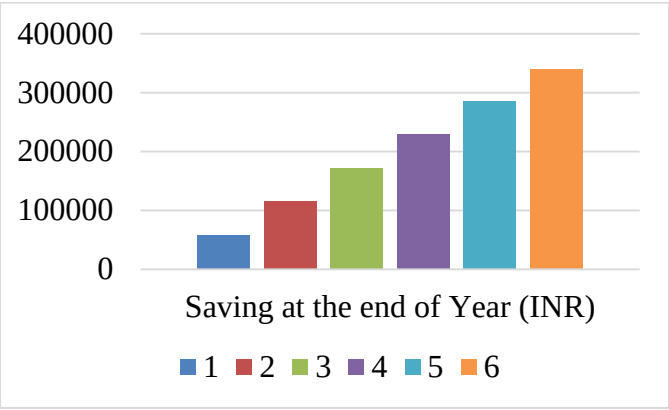


Chart No. 01 Return on Investment (ROI) on Energy cost For Green Building

b) Water saving Estimation

Estimation of Annual Rainwater Harvesting Potential

The annual rainfall(R) in Latur is approx. 725mm. Considering a roof top area (A) of 103.87 square meter and runoff coefficient (C) of 0.85, the rain water harvesting potential from roof top is,

= A x R x C

= 103.87 x 0.725 x 0.85

= 64.01 cum or 64010 liters.

Hence we can collect 64010 liters Rain water from Roof top annually.

Requirement of Water in Liters:-

Here for a family of having 5 members water requirement for 365 days is as given below-

Water required per person per day = 30 liters Approx.

So for 5 members = 5X30 = 150 Liters Approx. per day.

Hence for 365 days, required amount of water is,

= 365X5X30

= 54750 liters.

Comparison-

From above calculations we can compare that,

Water harvesting Potential (64010 liters) > Water requirement (54750 liters).

Hence we can save 64010-54750 = 9260 litres Rain-fall water and it can be drained for Recharging Ground Water Aquifers.

3. COST-BENEFIT ANALYSIS FOR GREEN BUILDING

By comparing Green building with Conventional building, Following table gives the cost-benefits of Green building as compare to conventional building:-

Table no. 2 Cost- Benefits of Green Building:-

2-12 %	Construction cost premium
25-30%	Savings in energy consumption

20-30%	Savings in water consumption
50%	Less wastage generation
35%	Reduced carbon emission
1.9-2%	Rental premium achieved in commercial buildings
30%	Reduction in building's operating expenses
40%	Increase in office space utilization

4. CONCLUSIONS

The outcomes of our study provide clear support of the affordability of Green building. From the LCCA of both the buildings, it is clear that the total cost needed for a Green building for 25 years is much less than that of a conventional building. In the case of overall maintenance cost and environmental impact, Green building is showing high performance compared to the conventional building. Hence this study proves that Green Building Technology can effectively adapt to all building sector to maintain the sustainability of the environment.

Green Building concept gives Tangible and non-tangible benefits from the stage of conceptualization of the project till the full useful life of the building, through initially in few projects the construction cost is higher than the base cost by approximately 16%, but this can be recovered within 2-3 years of lifecycle of the building by the way of saving in the operation of the green building. The main drawback of this technology is its high initial investment. To reduce the initial investment large scale constructions should start in the field of Green building, it can reduce the cost of energy efficient technologies. For that from government level awareness should be given to constructors about the benefits of Green Building Technology, which will help to attract more people to turn to sustainable technologies and can preserve our environment.

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