

Cost Effectiveness of Energy Green Buildings

Karrar Raof Kareem^{a*} and R.K. Pandey^b

^aMinistry of Electricity – Republic of Iraq, General Directorate of Electricity, Alfurat Middle Region, Al Najaf Power Plant.

^bDepartment of Civil Engineering, SHIATS (Formerly AAI-DU), Allahabad- 211007, U.P., India

Accepted 20 October 2013, Available online 25 October 2013, **Vol.3, No.4 (October 2013)**

Abstract

Sustainable construction is the need of the hour to mitigate the adverse environmental impacts of the construction industry. While at the macro level initiatives like the Kyoto Protocol and EIA are being taken, at the building level the same is being propagated is Green buildings. Green buildings promote ecologically sensitive construction bringing environmental benefits, health benefits, energy and water savings to its owners, occupants and society. However, they are not looked as successful enough profit making ventures. This research looks at the cost effectiveness of Green buildings by classifying benefits into direct savings and indirect savings category. Three case studies of platinum rated Green buildings are analysed for the same with life cycle costing procedures. Finally a model building base case is created on the computer, simulated before and after applying energy conservation measures incrementally and then checked for cost effectiveness and sorted in order of profitability.

Keywords: Sustainable construction, Kyoto Protocol, Cost effectiveness

1. General Introduction

Construction is the wheel of the growth of civilizations. In a rapidly growing world there is an ever more increasing demand of houses, offices, shopping spaces, industries, educational institutions, and hospitals. Today we have become more efficient in harnessing resources and use them for the present day needs. But in the frenetic pace of creating bigger, higher, mightier at a fast pace we have somewhere ignored what are its impacts on the world around us like the global climate change.

Climate change is one of the most important global environmental challenges facing humanity with implications for food production, natural ecosystems, freshwater supply, health, etc. According to the latest scientific assessment the earth's climate system has demonstrably changed on both global and regional scales since the preindustrial era. Further evidence shows that most of the warming (of 0.1 C per decade) observed over the last 50 years, is attributable to human activities (Sathayel Shukla et al, 2006). The Intergovernmental Panel on Climate Change (IPCC) projects that the global mean temperature may increase between 1.4 and 5.8 degrees Celsius (C) by 2100. This unprecedented increase is expected to have severe impacts on the global hydrological system, ecosystems, sea level, crop production and related processes.

The climate change issue is part of the larger challenge of sustainable development.

The construction industry is responsible for roughly 40 percent of all resource consumption and 40 percent of all (including greenhouse gas emissions). Construction activities, whether through the manufacturing of materials or through the operational activities of actual construction, also lead to a number of other environmental problems.

All this brings us to the evermore need for adopting Sustainable Construction practices today.

2. Sustainable Construction

Sustainable construction is the responsible stewardship of our natural, human and financial resources through a practical and balanced approach (<http://www.afcee.brooks.af.mil/green/brochure/brochure.pdf>.) Sustainability is the need of the hour in construction to offset the adverse environmental and climate impacts globally. They are an investment into to the future generations to come. This means having the most minimal impact on the environment, utilizations of ditz resources in a sustainable manner and minimization of waste.

It calls for integrating environmentally responsible practices into the construction process from the very beginning till its delivery and maintaining these practices over its entire lifecycle. Through conservation, improved maintainability, recycling, reduction and reuse of waste we can meet their own. In this sense Sustainable construction is part of sustainable development which aims to 'creating a healthy built environment using resource efficient, ecologically based principles'.

*Corresponding author: **Karrar Raof Kareem**

There are steps that are being taken towards Sustainability all around-from Sustainable Development principles at a larger scale, environmental policies, research and studies to the construction of Energy efficient green buildings address at the scale of the individual development level the same issues that are causing concern at the global level.

3. Aim of the Study

This study aims to answer the following question: Does it make financial and economic sense to build a green building? How can Green buildings be made to stand in commercial competitiveness to the kind of construction that is prevalent today?

This project aims to analysis the gaps and investigate into the possibility of reduction between the two competing issues of environmental degradation and economic viability through the study of building projects and see if it possible to successfully achieve a healthy and balanced mix of the two.

Generally Green buildings are seen to cost more to build than conventional buildings, and hence less profitable. However, they also offer significant cost savings over time. This study will look into the cost effectiveness of such Energy Efficient 'Green' buildings vis a vis the more prevalent 'conventional' buildings. This is with the aim to see what would make Sustainable development viable, and in fact attractive in the present scenario. The objective would be to check if sustainable practices adopted can give better performance and better economic efficiency.

This will be done through the economic analysis of

- Cost distributions for typical office buildings
- Cost distribution of a 'Green building'
- Case study of Green buildings
- Case study of a Model building

The economic analysis will compare results for various scenarios and try to come up with conclusions as to the cost effectiveness of green buildings. It will also try to determine the relative effectiveness of measures through simulation studies.

This approach to construction economics through the environmental perspective is at the core of this research project.

4. Literature Study Review

A literature survey was carried out of the existing body of knowledge in the form of books, papers and articles. On the agenda of global climatic change and sustainability there were a number of papers available which cited interdisciplinary researches in the fields of economics, sociology and environment to measure the impacts of the construction industry. Notable amongst these was Climate change, sustainable development and India: Global and national concerns which stated that 'the most effective way to address climate change is to adopt a sustainable development pathway by shifting to environmentally sustainable technologies and promotion of energy efficiency, renewable energy, forest conservation,

reforestation, water conservation, etc. There were references to works being carried out in this direction and efforts to bring sustainability as a guiding factor for future development, mainly in Agenda 21 for Sustainable construction in developing countries (4 Chrisna du Plaassis, 2006) and The LSE SusCon Project: Sustainable Construction: The Social Science research agenda (<http://www.usaid.gov/ourwork/economicgrowthandtrade/energy/publications/successstories/indiagreenbizctr.pdf>).

The charter of the Kyoto Protocol available at United Nations Information Service (<http://www.unis.unvienna.org/unis/index.html>) stated the carbon trading measured being adopted between nations as a measure to reduce emissions. Similarly, Environmental Impact Assessment and its need were established through the resource of the website of – COE of the Madras School of Economics (www.coe.mse.ac.in) which is doing a lot of research in this area. The Ministry of Environment and Forest (MoEF) website (<http://www.envfor.nic.in/welcome.html>) had resources on the procedures for EIA, its need and its principles.

5. Sustainability and Sustainable Construction

5.1 Sustainability

Sustainability- is responsible stewardship of our natural, human and financial resources through a practical and balanced approach. Sustainability integrates environmentally responsible practices into the process of facility delivery from the very beginning. Through conservation, improved maintainability, recycling, reduction and reuse of waste we can meet today's needs without compromising on the ability of the future generations to meet their own.

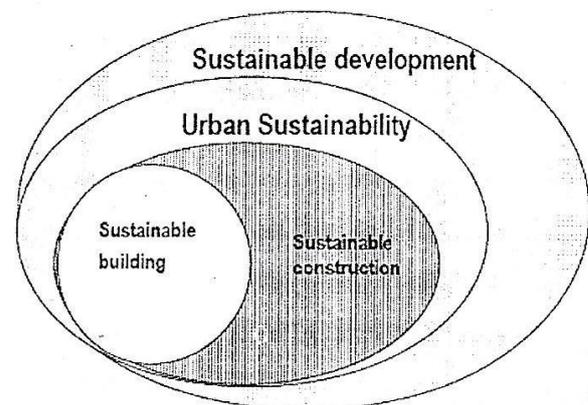


Fig 1 Sustainable building and development

Sustainable construction is part of sustainable development which aims to 'creating a healthy built environment using resource efficient, ecologically based principles'.

5.2 Macro Scale Measures

5.2.1 Kyoto Protocol

The Kyoto Protocol which came into force in 16 Feb 2005, offers incentives that governments, businesses and consumers can use to build a climate-friendly economy and promote sustainable development

It has reasserted the importance of stabilizing greenhouse gas concentrations in the atmosphere and adhering to sustainable development principles. The Protocol has laid out guidelines and rules regarding the extent to which a participating industrialized country should reduce its emissions of six greenhouse gases-carbon dioxide, methane, nitrous oxide, chlorofluorocarbon, hydro fluorocarbons and per fluorocarbons. It requires listed industrialized countries to reduce their greenhouse gas emissions by a weighted average of 5.2%, based on the 1990 greenhouse gas emissions(http://www.unis.unvienna.org/unis/_____index.html)The reduction is to be achieved by the end of the five-year period, 2008 to 2012. The Kyoto Protocol does not require the developing countries to reduce their greenhouse gas emissions.

This implies that

- Thirty industrialized countries will be legally bound to meet quantitative targets for reducing or limiting their greenhouse gas emissions.
- More importantly it brings into effect a mechanism to make the international carbon trading market a legal and practical reality. The Protocol’s “emissions trading” regime enables industrialized countries to buy and sell emissions credits amongst themselves; this market-based approach will improve the efficiency and cost- effectiveness of emissions cuts.

5.2.2 Environmental Impact Assessment (EIA)

Environmental impact assessment (EIA) is a tool that seeks to ensure sustainable development through the evaluation of those impacts arising from a major activity (policy, plan, program, or project) that are likely to have significant environmental effects. It is anticipatory, participatory, and systematic in nature and relies on multidisciplinary input.

Today, the EIA has become a requirement in more than 100 countries. In many European countries, it came into vogue with the introduction of the concept of sustainable development after the World Commission of Environment in 1987. In India, though EIA came into existence around 1978-79, it was made mandatory only in 1994 (www.coe.mse.ac.in)

EIA takes a comprehensive look at the environmental impact and involves many parties, grouped by their role definition within the process. They are

1. Project Proponent
2. Environment Consultant
3. State Pollution Control Board (PCB)/ Pollution Control Committee (PCC)
4. Public Law
5. Impact Assessment Agency (IAA)

The extent to which the assessment is done shows the holistic nature of the process involving a number of disciplines addressing all the various aspects of the

environment and sustainability. The Assessment committee consists of consists of people from the following disciplines to look at

1. Eco-system Management
2. Air/Water Pollution Control
3. Water Resource Management
4. Flora/Fauna conservation and management
5. Land Use Planning
6. Social Sciences/Rehabilitation
7. Project Appraisal
8. Ecology
9. Environmental Health
10. Subject Area Specialists
11. Representatives of NGOs/persons concerned with environmental issues.

5.3 Buildings-Green Rating Systems

Rating systems work with the premise that what can be measured can be improved. It has a qualitative and quantitative assessment criteria, that enables to “rate” a building on the degree of its “greenness”. Greenness here stands for the sustainability quotient of a building, of the features of a particular development that strive to make the building more sustainable. It stands for an Environment friendly, ecologically sensitive, Resources conserving and energy efficient (water of energy), Waste minimizing approach.

The acronym “Green building” has come to mean a Sustainable development in this context.

A rating system brings in a measurement criterion for rating the qualitative and quantities aspects of a wide variety of building developments across the same level. It does it by evaluation of the building with reference to a performance model that it has development.

6. Analysing the Cost Effectiveness

6.1 Costs And Financial Benefits Of A Green Building

The types of Cost associated with the ownership of a building are

1. Capital Expenditure Costs
2. Running Cost
3. Operation and Maintenance Cost

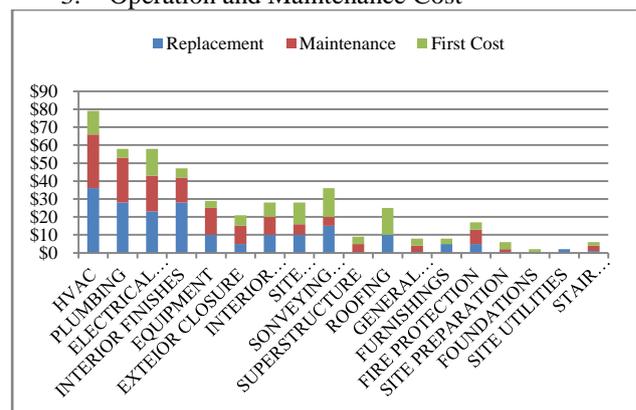


Fig 2 Total life cycle cost of components

6.2 Classification of Benefits

Of the benefits that are to be gained from a green building, some elements are relatively easy to quantify, such as energy and water savings, as well as those that are less easily quantified, such as positive environmental impact or the improvement in productivity (see Appendix 1) due to better indoor environment.

The following charts tell the distribution of Incremental Costs associated with green building can be seen in the fulfilling requirements for green certification of the rating systems-namely LEED and GRIHA.

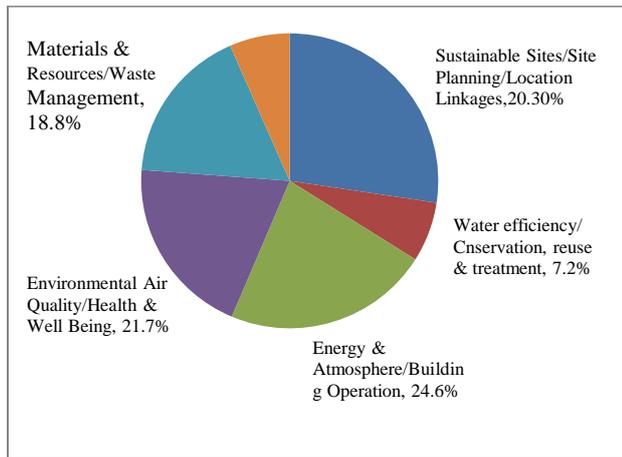


Fig 3 Point wise breakup of LEED criteria

6.3 Sensitivity Analysis

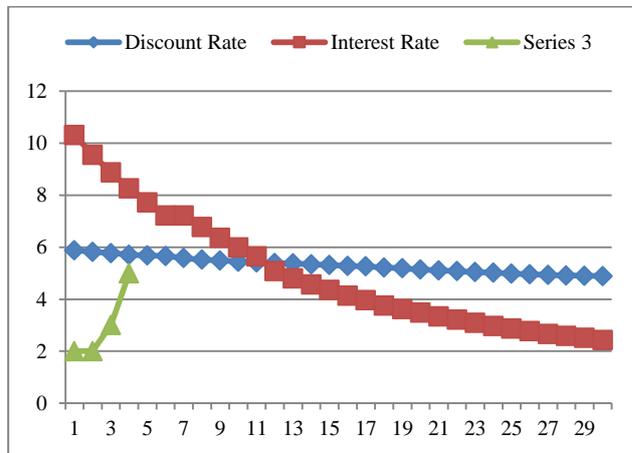
A sensitivity analysis of one of the options was performed to evaluate the effect of changes in the critical input parameters from the base case assumptions. These sensitivity with respect to the unit energy cost components viz. discount rate, inflation rate, energy inflation rate and general inflation rate. It tells the effect of how the Savings to Investment ratio changes as the rates get varied. The example taken for economic analysis has 3 cases for comparison-each with different capital costs, running costs and maintenance costs.

From the analysis we see that

1. Time period of study has a significant bearing on the choice of alternative. Shorter study periods tend to favour lower first costs over higher ones, and savings have lesser impacts unless they are tremendous.
2. Return on investment in terms of percentage can be used to compare two or more alternatives, but it is not an absolute measure of the savings potential. Low Cost ECMs with low savings can prove to be less beneficial than the absolute savings in a higher cost investment even if the ROI is better in the first case.
3. Savings to Investment ratio is an important measure and depicts the true potential of a measure. However the decision may still be influenced by the term of study as the higher SIR alternative might not be able to catch up before the study term expires.
4. Payback-Simple payback gives first quick results for

5. comparison. A truer and lifecycle costed measure however is the discounted payback.

Finally a cost effective decision must be made carefully selecting the various rates and study periods. The results may be analysis for the better payback but also for the savings potential SIR.



7. Building Model

A building model now needs to be creating a building for cost effectiveness with various measures. What has become apparent by now is that first costs should not be the driving principle to determine profitability, and that a number of Green measures do in fact result in buildings that are a better investment decision.

It would also be valid to know which measures have the highest contribution. We now need to test the cost effectiveness measure wise since apparently all the green measures would not be equally cost effective – some would be giving more attractive returns than the other

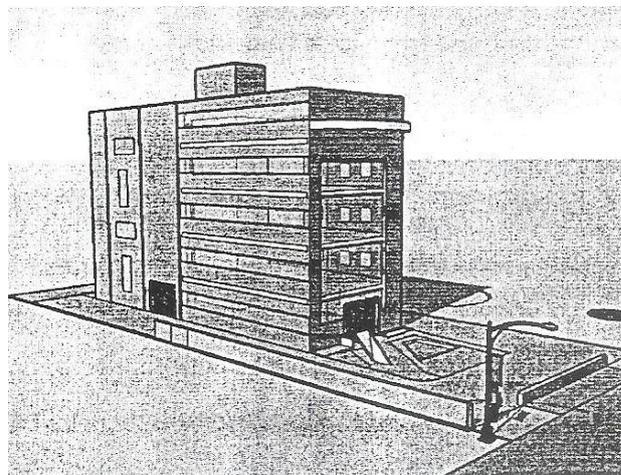


Fig 4 Model building: North view

A model building of 1000 sqm has been taken. It would assume the kind of straightforward structure and aesthetics that is quite prevalent in office building being created nowadays. The 1000 sqm are divided on 5 floors of 200 sqm each and it has one basement below.

7.1 Simulation

Simulation of the building was done using eQuest software. Developed by a team of developers in the United States, it is freely available on the internet to download and use. The parameters of the buildings can be defined in this – length, breadth, no of floors, shape of the building. It takes vertical staking arrangements as one floor over the other. Zones on each floor can be defined and accorded properties of air conditioning.

A screenshot of the building model as developed in the software is shown below.

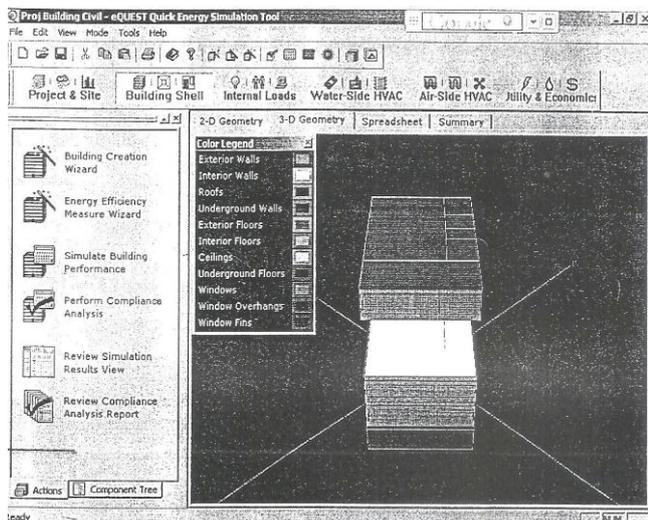


Fig 5 Model building 3d view in eQuest software

In the base case scenario that is generated the building is taken to be facing North East-South West oriented. The external wall area is taken as 50% glazed.

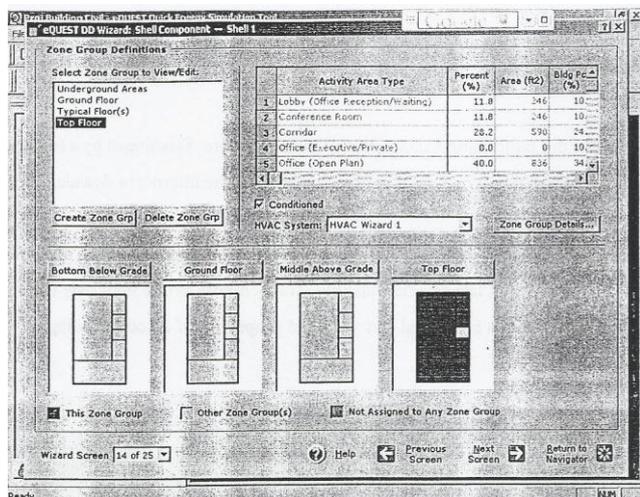


Fig 6 Model building description in eQuest software

Screen shot above showing the zoning of areas
Screen shot showing the building parameters that can be defined

Conclusions

From the study of cost effectiveness of Green Buildings we can conclude that Green Buildings are cost effective depending on the kinds of measures that are taken. To spend on any environmental and health benefits measures might be good to garner must aim for a certain profit in view of deciding which measures to adopt. Even if the highest Green certification is not sought after, owners should be certain that their buildings can still be made environment friendly AND cost effective by adopting the whole life costing approach.

Green rating systems, on their part, should include in the certification process a cost component for the measures and its alternatives. By bringing in Life cycle costing and establishing that profitability can be had to greater extent with Green measures a greater number of people will tend to join this movement.

On the other hand, there might be the apprehension that environmental and health beneficial measures will be pushed behind. In such a case linking of measures- the environment friendly approach to the profitable ones can be done to take advantage of both. Buildings having adopted a number of environment friendly measures can also be certified and given incentives/tax breaks by the government to further promote the overall sustainability index.

By promoting energy efficiency and cycle costing into the mainstream procedure of design and development there should be an all-round benefit.

- Profit to the owner
- More buildings turning Green and energy efficient
- Greater benefit to the environment and improved sustainability of construction

References

I Sathayel. Shukla and Ravindranath (Feb 2006), Climate Change, Sustainable Development And India: Global And National Concerns, Current science, vol. 90, no. 3, 10.
 Brochure from an Overview of the USAF Environmentally Responsible Facilities Guide: <http://www.afcee.brooks.af.mil/green/brochure/brochure.pdf>.
 Chrna du Plaessis Agnda 21 For Sustainable Construction In Developing Counties; A discussion document Published by the CSIR Building and Construction Technology Press Release: ENV/DV/897;12 May 2006 Global Climate Change Poses Greatest challenge <http://www.unis.unvienna.org/unis/index.html>
 Center of Excellence; Madras School of Environment www.coe.mse.ac.in
 Sun-Sook Kima, In-Ho Yangb, et al. (2005), Development of a housing performance evaluation model for multi-family residential buildings in Korea Building an Environment 40, 1103-1116 doi:10.1016/j.buildenv.2004.09.014
 Mili Majumdar & Pradeep Kumar; Green building rating recognizing energy efficient buildings and beyond; TERI press
 Gregory H.Kats; Green Building Costs and Financial Benefits; www.masstech.org
 Xenergy Inc and SERA Architect; Green building: Applying

the LEEDS ratings system; Portland Energy Office, Oregon
Guidelines For Life Cycle Cost Analysis; Stanform
University Land and Building; October 200
S Srinivas, Senior Counsellor, CII- Godrej GBC, Green
Buildings in India: Lessons Learnt
<http://www.igbc.in/igbc/article.jsp>
Nanditta Chibber; Newsarticle Wipro and the green
Buildings; www.rediff.com
Yyonee Rydn and Paula Vandergert. The LSE SusCon
Project:SustainableConstruction: The Social Science
research agenda
Article on CII-GBC building at
<http://www.usaid.gov/ourwork/economicgrowthandtrade/energy/publications/successstories/indiagreenbizctr.pdf>.
Article on ITC building at <http://www.rkaindia.com/-projectarchitects>

Author's Details



Mr.Karrar Raof Kareem Kamoona Born in Najaf in January 1981, he received his B.sc. university of Kufa -Civil Engineering , since 2005 he has been with Ministry of Electricity – Republic of Iraq, General directorate of electricity, Alfurat middle region, Al Najaf power plant. M.Tech (Civil Eng.), Construction and Management, Civil Engineer at Republic of Iraq, Ministry of Electricity, Iraq.



Mr. Prof. R.K. Pandey, Assistant Professor, Department of Civil Engineering, SHIATS (Formerly AAI-DU), Allahabad- 211007, U.P., India