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Green Buildings in India - Rating Systems, Implementation and Cost Benefit Analysis - A Literature Review

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Abstract—*Sustainable development and construction is the need of the hour, and green buildings are a step in the right direction towards the conservation of energy, protection of the environment, and decreasing the life cycle costs incurred by built structures during maintenance. The buildings sector accounts for at least one-third of all energy related CO2 emissions worldwide, during the process of construction. Within the energy sector, buildings account for up to 40% of the total energy consumption in India. Moreover, according to U.S Energy Information Administration's International Energy Outlook 2017, the fastest growth in buildings energy consumption through 2040 will occur in India, more than twice the global increase. This is due to the fact that the construction industry contributes close to 19% of the nation's GDP (2011-2012) and this in turn will put enormous pressure on various resources such as energy, water, materials, causing a discernible impact on the environment. Hence Green Buildings are considered as the most viable solution to these interconnected problems, and this technical paper analyses the existing ratings systems LEED and GRIHA which promote energy efficient construction, the state of the art methodologies and practices adopted during the construction and operation of green buildings, explores existing case studies in the nation and further looks into the cost benefit analysis of such buildings through an elaborate literature review.*

Keywords: LEED, GRIHA, Green Buildings, Implementation, Cost-benefit analysis, Case studies

1. INTRODUCTION

Buildings account for 18% of global emissions today, or the equivalent of 9 billion tonnes of CO2 annually. If new technologies in construction are not adopted during this time of rapid growth, emissions could double by 2050, according to the United Nations Environment Program. The construction industry contributes around 11% of India's GDP and underpins the economic growth of the country. Given the size of the industry, environmentalists have turned their attention on the processes in this industry that contribute to the overall carbon footprint of the economy. The outcome is the energy efficient buildings that have popularly come to be known as Green Buildings.

Green building (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.

In India, the Green building industry started in 2001 and today there is roughly 20,000 sq. feet of green building space in the country (IGBC website). The decision to choose green construction is constrained by the extra cost of going green, i.e. the green premium. However, the life cycle cost of the building ultimately reduces in the long term. It is expected that stakeholders can expect a 14 percent savings in operational costs over five-year savings for new green buildings and 13 percent savings in operational costs over five years for green retrofit and renovation projects [1].

2. RATING SYSTEMS AND POLICIES

The Background paper for Sustainable Buildings and Construction for India: Policies, Practices and Performance [2] by UNEP and TERI states that: The country has a number of policy initiatives to mainstream energy efficiency and green buildings as control and regulatory instruments, including appliance standards, mandatory labeling and certification, energy efficiency obligations, and utility DSM(Demand side management) programs; economic and market-based instruments; fiscal instruments and incentives; support, information and voluntary action.

A few examples include: Energy Conservation Building Code 2007 where The Energy Conservation Act 2001 led to the formation of Bureau of Energy Efficiency (BEE) that formulated the Energy Conservation Building Code (ECBC); the Ministry of Environment and Forests (MoEF), Environmental Impact Assessment (EIA) and Clearance which is a mandatory certification requirement for construction projects having built up area above 20,000 sq.m and the Sustainable Habitat Mission under the National Action Plan

on Climate. Energy rating of appliances is also required and BEE has made star rating for energy efficiency mandatory for a host of electrical appliances from September 20, 2008.

With reference to the following literature, the analysis of the rating systems LEED and GRIHA has been carried out: GRIHA (Green Rating for Integrated Habitat Assessment) [3] a National rating system for Green Buildings by Ministry of New and Renewable Energy, Government of India, Comparative Study of LEED and GRIHA rating system [4] and Facilitating Green Building Adoption - An Optimization Based Decision Support Tool (IIM Bangalore) [5-1]. LEED India and GRIHA are the two rating systems which are accepted in India. The aim of LEED & GRIHA systems are similar. Both the systems use same approach to rate the performance of a structure and have created according grade levels for accreditation. However, the sustainability rating methodology varies considerably, from tool rating system one to another in terms of measurement of building performance, scope and environmental criteria within the infrastructure sector.

GRIHA: GRIHA is a national rating system for Green buildings in India. It was founded by TERI (The Energy and Resource Institute, New Delhi) and developed jointly by the Ministry of New and Renewable Energy, Government of India. GRIHA encourages the development of building designs, which aims to reduce conventional energy demand and further boost energy performance of the building within specified limits. The qualitative and quantitative assessment criteria of GRIHA, has the ability to 'rate' a building on the degree of its 'greenness'. A building is assessed on its predicted performance over its entire life cycle beginning from planning, to development, construction, operation and maintenance. This rating system, seeks to strike a balance between the established practices and emerging concepts, both at national and international level. On a broader scale, this system, along with the activities and processes that lead up to it, will benefit the community at large amount with the improvement in the environment by reducing GHG (greenhouse gas) emissions, improving energy security, and reducing the stress on natural resources. The rating applies to new building stock – commercial, institutional, and residential – of varied functions.

In GRIHA system points are earned for meeting the design and performance intent of the criteria and a project which falls within the criteria. GRIHA consists of 100-points, including some core points, which are mandatory, while the rest of them are optional. Based on the number of points earned, different levels of certification are provided (one star to five star). Atleast 50 points are required for certification. The various criterias fall under the categories of Pre-construction stage (intra- and inter-site issues like proximity to public transport, type of soil, kind of land, where the property is located, the flora and fauna on the land before construction activity starts, the natural landscape and land features), Building planning and construction stages include issues of resource conservation and reduction in resource demand, reuse and recovery of materials and resources, along with occupant health. Building operation and maintenance stage include issues of operation and maintenance of building systems and processes, monitoring and recording of energy consumption along with conservation of energy during the operation of a building.

LEED: The Leadership in Energy and Environmental Design (LEED) Green Building Rating System represents the U.S. Green Building Council's effort to provide a national standard for what constitutes a "green building." LEED-India programme has been adapted from United States Green Building Council's (USGBC) in 2007. An initiative undertaken by the Indian Green Building Council (IGBC) in India, it has set up the LEED 2011 for India Core Committee with the objective of the LEED rating system for the Indian context. LEED provides guidelines and specifications for building construction to achieve its sustainability goals and objectives. LEED is similar to checklist of credits that can be achieved 7 major categories including:

- Sustainable Sites
- Water Efficiency
- Energy & Atmosphere
- Materials & Resources
- Indoor Environmental Quality
- Innovation & Design Process
- Regional Priority

LEED evaluates a building for the amount of sustainability objectives it achieves and recognizes building at four certification level (Certified, Silver, Gold, Platinum) LEED is considered to be one of the most successful green building rating systems in the world because of its early market penetration and adoption by professionals. Since the CII-Godrej GBC achieved the prestigious LEED rating for its own centre at Hyderabad in 2003, the Green building movement has gained tremendous momentum. This rating system is based on accepted energy and environmental principles and is performance oriented, wherein credits are earned for satisfying criteria addressing specific environmental impacts inherent in the design and construction. On the basis of total credits earned, various levels of green building certification are awarded. The system is designed to be comprehensive in scope, yet simple in application. The exact credits in the LEED gives us guidelines for the design and construction of buildings of all sizes in both the public and private sectors. The aim of LEED India is to assist in the development of energy efficient, healthful, durable, affordable and environmentally sound commercial and institutional buildings.

3. EXISTING STATE OF THE ART METHODOLOGY AND THE IMPLEMENTATION OF GREEN BUILDING PROCESSES

The development of green building processes are divided across the planning, construction, operation and maintenance stages of the buildings. This section outlines the conceptual basis of green building processes and the various existing methods or innovations that can be implemented to develop energy efficient structures.

Role of Green Buildings in Sustainable Construction- Need, Challenges and Scope in the Indian Scenario by Devarshi Tathagat, Dr.Ramesh D. Dod [6-1] emphasizes the need of four 'R's which forms the basis for sustainable construction including Reduce: Lower quantity of building material, resources, and embodied energy. Reuse: Construction materials that are practical and structurally sound are reused. Recycle: Recycled materials are used, and home is designed for recyclables. Renewable: Energy from natural and renewable sources are emphasized upon. These four R's are the essence of green construction. Since the practices in green building are evolving there some methods in which they are derived:

Siting and design efficiency: Conceptually planning a building and designing it to meet its purpose and efficiency requirements is highly important, and optimization of processes to incorporate environmentally friendly building process should be undertaken here. Every design variable in the complex construction process must be addressed at this stage itself – any component or material to be used in construction should be carefully selected and designed to ensure long term environmental sustainability.

Energy efficiency: It is estimated that embodied energy which is the energy used during the construction processes may exceed the operational energy accrued by a building. Embodied energy may make up as much as 30% of the overall life cycle energy consumption. Material selection is essential here as materials like wood, lumber and recycled materials have a lower embodied energy than concrete or steel. To reduce operating energy use, air leakage through the building envelope must be reduced (the barrier between conditioned and unconditioned space). High-performance windows and extra insulation in walls, ceilings, and floors should be provided to reduce transfer of heat from outside and reduce the usage of heaters and coolers in cold and hot regions. Passive solar building design orients doors, windows, awnings and trees to shade windows and roofs during the summer and maximise gain of solar energy during cold seasons. Generation of renewable energy on the site for powering machinery and construction or to be installed to be operable during the life cycle of the building, through solar power, wind power, hydropower, or biomass can significantly reduce the environmental impact of the building.

Water efficiency: Water consumption must be reduced, water must be recycled and water quality must be maintained. To that end, construction contractors should increase their dependence on water that is collected, used, purified, and reused on-site. The protection and conservation of water throughout the life of a building can be done by installing site water catchment areas that store water for construction uses or landscaping and plumbing. Implementing this can reduces 15% to 20% of water requirement for construction of any multi-storeyed building as per surveyed result of EPA (Environmental Protection Agency). Dual plumbing recycles water in toilet flushing or by using water for other purposes. And ultra-low flush toilets and low flow fixtures can minimize waste water. Point of use water treatment and heating achieves efficient water use and good quality of water while reducing the amount of water in circulation. The use of non-sewage and greywater for on-site use such as site-irrigation will minimize demands on the local aquifer.

Life cycle assessment: A life cycle assessment (LCA) can address environmental and economic concerns by assessing a full range of impacts of the construction process: from extraction of raw materials through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling. Impacts taken into account include and are not limited to embodied energy, global warming potential, resource use, air pollution, water pollution, and waste. Although LCA is widely recognized as the best way to evaluate the environmental impacts of buildings (ISO 14040 provides a recognized LCA methodology), it is not yet a consistent requirement of green building rating systems and codes, which must be changed to encourage wide spread construction of green buildings.

Improving energy efficiency in buildings and Role of Green Buildings in Sustainable Construction- Need, Challenges and Scope in the Indian Scenario Devarshi Tathagat*, Dr.Ramesh D. Dod, [6-2] mentions that the following techniques can be used to improve green building construction: Structural or civil techniques: Insulated wall, Green cement, Fly ash bricks, transparent roof, green roof. Further conservation techniques include optimal use of natural light, replacing incandescent lamps by compact fluorescent lamps (CFL), replacement of conventional fluorescent lamp by energy efficient fluorescent lamp/LED. On site generation techniques can include establishment of solar lighting, solar wind hybrid, or solar paneling in car parks and roofs. Special systems/ techniques include grey water by evapotranspiration, porous pavement blocks and passive solar design.

During the maintenance and operation of structures, the following can be followed to improve energy efficiency: The most effective means to sustain, expand, and enhance the energy monitoring and targeting efforts in large public and commercial buildings is through the introduction of a system of methodology of bench marking and disclosure. Benchmarking methodology refers to methodology for

comparing a building's energy performance which needs to be clearly defined and simple to use through specially designed software. Schedule of reporting should be done where a date should be chosen as a deadline for the first submittal of benchmarking data and a schedule defined for future submissions. A Reporting system for how and where a building reports data should be clear, technically simple, and provide guidance for owners. A central database is preferred. Enforcement of the policy is essential to ensure participation. It can be done through penalties, incentives, or marketing triggers, such as proof of compliance at sale. Compliance support and outreach: Stakeholder outreach and education, trainings for skilled energy efficiency workers, and communication of these efforts can also be undertaken.

The following is a case study which examines the practices adopted in a green building constructed in India and examines the energy saved through the same:

ITC Grand Chola Hotel in Guindy, Chennai is one of the most massive commercial projects in India which has incorporated the green building construction techniques. The green cover which was already present in the site was preserved through sustainable planning in the initial stages. Excavation and construction was started only after preserving the top soil. ITC Grand Chola has reduced the consumption of water by 50.7% through low flow fixtures and 90% of the water in the complex is being recycled and reused. The GRIHA report on the ITC Grand Chola gives detailed information on the energy consumed in the building: 12,600 KWp Renewable energy was installed on the site, controlled centralized air conditioning system is used, occupancy sensors help to reduce the energy consumed, external shading and efficient glazing was provided to reduce solar heat gain. GRIHA rating system has provided 5 stars to this structure and this highlights the importance of green building practices across the nation, irrespective of the scale and commercial nature of the projects.

4. COST BENEFIT ANALYSIS

Green Buildings are financially beneficial in a way that conventional buildings are not. These benefits include energy and water savings, reduced waste, improved indoor environmental quality, greater employee comfort/productivity, reduced employee health costs and lower operations and maintenance costs. Cost-benefit analysis (CBA) is the examination of a decision in terms of its consequences or costs and benefits (Stephanie Riegg Cellini, James Edwin Kee (2010)). Various authors have undertaken the research to determine the benefit of green buildings in terms of economic investment and returns and have proven that life cycle costs, operation and maintenance costs of the structure reduce in the long term if green building design and methodology is incorporated, and workers' productivity and building value also increase due to the same.

Working Paper: 485, Facilitating Green Building Adoption - An Optimization Based Decision Support Tool by Debjyoti Roychuwdhury, Murthy, Jose PD [5-2] states that decision support tool indicates that we can get a one-star rating at a premium as low as 0.33% of the building cost, and a three-star rating can be achieved at ~ 2% and a five-star rating at 5.3% of the building cost. Moreover, the authors claim that at an additional investment for green features of around 3% of building cost (which implies a four-star GRIHA rating), there are considerable savings in water demand and energy demand (including renewable energy use) which reduces the life cycle cost of the building. The savings over the years can be brought forward to its present value by using a suitable discount rate and a factor representing the depreciation of performance.

The Massachusetts Technology Collaborative for the State of California Sustainable Building reported "The Costs and Financial Benefits of Green Buildings," [7-1] which provided an analysis of green building based on a review of LEED-certified buildings, and states that 2% nominal increase in green building design would save 20% of total construction throughout the life cycle of the building which is more than ten times the initial investment (The Business Case for Green Building, 2016). Operative costs are also reduced due to green building through reduced energy use, water use and lower maintenance cost of the building itself.

Chong, [8] in his studies mentioned that, evolving green buildings help their owners to earn higher rents, higher values and higher occupancy rates than non-green buildings. According to Kuiken [9] relaxed depreciation, higher rent, lower occupancy allowance all are price premium for green buildings. Green buildings sell at a higher price. McGraw Hill [10] measured the price premium for the sale of Energy Star ®-labeled buildings to be 12%. Another study estimated the premium on LEED-certified buildings at 31%. [11] Green buildings command higher rent premiums. By comparing rental agreements involving Energy Star buildings with non-Energy Star leases, researchers at Maastricht University [12] found that efficient buildings command 3.5% higher rents. Green buildings are found to more attractive to tenants. The same study found a 6% higher occupancy rate for Energy Star certified buildings

An early study by Greg Kats [7-2] with a sample of 33 green building projects suggested present value benefits of $37 to $55 U.S. dollars per square foot as a result of productivity gains from less sick time and greater worker productivity which were primarily from better ventilation, lighting and general environment. Green Buildings and Productivity by Miller et al. [13] also proved that natural light, good ventilation, the absence of organic compounds provides happier, healthier workers and leads to benefits in terms of recruitment, retention of employees, less sick time and greater productivity.

5. CONCLUSION

The building industry produces the second largest amount of demolition waste and greenhouse gases and causes large scale

destruction to the natural environment and necessitates sustainable development. The building industry also consumes a large amount of energy which must be reduced for a better environment. A green building uses less energy, water and other natural resources, creates less waste and greenhouse gases and is healthy for people living or working inside as compared to a regular structure. It also helps in creating buildings that optimize on the use of local materials, local ecology and most importantly they are built to reduce power, water and material requirements. These buildings are also built in notion of saving the environment for the future generation. This paper has analysed the previous literature relating to the construction of green buildings, the ratings system in place, the principles of sustainable construction methodology and existing techniques available to generate such structures, case studies analysing the positive impact of such developments and the cost-benefit analysis for the same. The importance of adopting this practice is highlighted, and more real estate stakeholders must subscribe to the same to ensure a greener nation in the future. For a fast developing country like India, which faces severe environmental destruction, construction of green buildings through sustainable development will be a true blessing.

REFERENCES

[1] Devine, Avis, "Why Energy-Effcient Commercial Real Estate Matters", Springer 2017.

[2] "The Background paper for Sustainable Buildings and Construction for India: Policies, Practices and Performance", UNEP and TERI.

[3] GRIHA, a National Rating System for Green Buildings by Ministry of New and Renewable Energy, Government of India - www.grihaindia.org

[4] Sande, Phadtare, "Comparative Study of LEED and GRIHA rating system", Journal of Information Knowledge And Research in Civil Engineering, Volume 3 Issue 2, November 14 - October 15

[5] Debjyoti, Roychowdhury, "Facilitating Green Building Adoption - An Optimization Based Decision Support Tool (IIM Bangalore)", March 2015

[6] Devarshi Tathagat, Dr.Ramesh D. Dod, "Role of Green Buildings in Sustainable Construction- Need, Challenges and Scope in the Indian Scenario", IOSR Journal of Mechanical and Civil Engineering, 2015

[7] Kats, Gregory, "Green Building Costs and Financial Benefits: A report for the Massachusetts Technology Collaborative", 2003

[8] Chong, J.," Demand for Green Buildings in Malaysia to Rise.", 2010

[9] Kuiken, H. J. (2009) Valuation of Sustainable Developed Real Estate: A Closer Look at Factors Used When Valuing Green Buildings. KTH Architecture and Built Environment, Stockholm. M.Sc Thesis

[10] Commercial & Institutional Green Building: Green Trends Driving Market Change, McGraw-Hill Construction and the USGBC, 2008.

[11] Fuerst, Franz and McAllister, Patrick “Green Noise or Green Value? Measuring the Price Effects of Environmental Certification in Commercial Buildings,” School of Real Estate and Planning, Henley Business School, April 25, 2009.

[12] Kok, Nils. Maestricht University, PRI Workshop, January 2009.

[13] Green Buildings and Productivity (August 19, 2009) by Norm G. Miller et al.