Innovation in Design: A Study of Green Buildings

Kamayani Barshilia

Lady Irwin College, Delhi University

Abstract- Three-fourths of the world's energy is consumed in cities and more than half of it is consumed in buildings. The construction sector is one of the most traditional & cost oriented industries and it makes much sense to bring innovations that are environmentally and economically sustainable. Sustainability in the construction sector or in other words green buildings are mainly focused on the reduction of emissions, construction of energy efficient houses and maintaining thermal comfort of the occupants. However we can further innovate to excel in terms of zeroed environment impacts and resource optimization. To comprehend the innovations which have happened in green buildings, this study entitled "Innovations in Design- A Study of Green Buildings" was conducted. It focuses on technologies and strategies used and catalysts and hindrances faced while adopting Innovation category in green buildings certified under the prevalent green rating systems in India i.e. LEED and GRIHA. The study was done in five buildings, three of them were LEED certified and the rest two were GRIHA certified. After pooling the data for LEED certified buildings, it was found that LEED AP was involved throughout the design to certification process in all three buildings and a point is earned for the same. Initiatives were taken in terms of building materials and various points associated with it were earned such as minimizing embodied energy in construction, construction waste management, regional priority etc. Major efforts were also directed towards enhanced energy optimization of buildings through either passive design or exemplifying in use of energy efficient fixtures. Efforts were also made to influence lifestyles of people to ensure environment consciousness in society. On the other hand GRIHA rated buildings oriented their major efforts towards life cycle costing as to ensure minimum harm to environment throughout the operation cycle, resource recovery in order to use waste as a constructive resource. They ran camps for grassroots to make things better at elementary levels and then move upwards and also incorporated passive design features to ensure thermal comfort at minimum environmental and economic cost. Catalysts behind adopting innovation criteria were image and prestige, desire to earn more points, social responsibility. Impediments faced during implementation process were majorly concerned with difficulty in documentation process. It was also reported that there was less room for innovations as most of the environment benefiting indicators are addressed in the rating system. However the buildings overcame these challenges and implemented all the technologies and strategies effectively. The study also provides suggestions to overcome the limitations experienced while employing these technologies such as having open access to data regarding success stories of buildings already using those technologies, encouraging small and medium scale product innovators.

Index Terms- Green buildings, Green Rating Integrated Habitat Assessment (GRIHA), Innovation in design, Leadership in Energy and Environmental Design (LEED).

I. INTRODUCTION

"In a period of rapid change, the only ones who survive are those who innovate and create change"- Peter Drucker

According to IEA estimates, buildings are one of the most cost-effective sectors to reduce GHG emissions. Almost half of all energy generated across the world is used to cool, light, and ventilate buildings, and more than half of all resources are used in construction. By 2030, building-related greenhouse gas emissions are set to double: most of this will take place in emerging markets [1].

There is growing awareness among policymakers that innovative activity is the main driver of economic progress and well-being as well as a potential factor in meeting global challenges in domains such as the environment and health [2].

The term 'innovation' has its roots from the Latin word 'novus', which means 'new' and is derived into the verb 'in+novare' that covers the meaning 'to make new'. Therefore, in the broadest context, 'to innovate' is 'to begin or introduce (something new) for the first time', and 'innovation' has the meaning of 'the act of introducing something new' [3]. An innovation is a novel idea, process, product, technology or service which is better than and to some extent different from the existing ones. Innovation is about changing paradigms, creating new ideas, it's a process which inspires change and creates value [4].

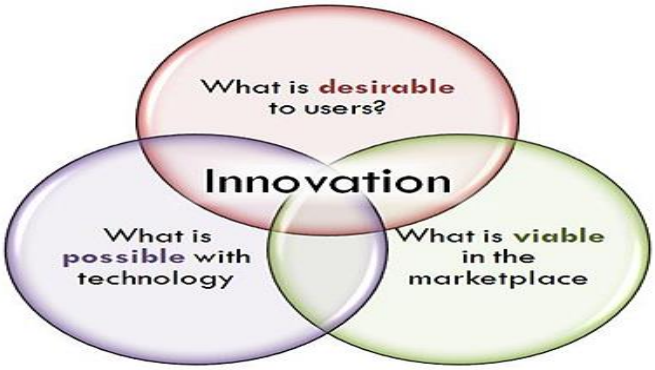

Figure 1.1: Mapping Innovation

There are many types of innovations and each one may be applicable to the building sector.

Innovations with varying scopes and impacts in the building sector have been, for example, the emergence of labels and standards for energy efficient houses and green commercial buildings, the business model of energy service companies

(ESCOs) or the concept of nationally appropriate mitigation actions (NAMAs). For achieving the goal of significantly reducing the carbon footprint of buildings until the mid of this century, innovation for more effective policies, better financing opportunities, and broader sectoral approaches as well as context-tailored approaches on the city, neighbourhood and building level are needed. Hence there is a need to share existing innovations and to trigger diffusion of successful approaches. At the same time, we also need to identify the need for innovations which have not been realized to lead the way for innovative policy and decision makers to come up with new solutions to make the global building sector more climate friendly [2].

Major innovations took place with the advent of green building concept.

To have Green Building Concept, we should look after the following [5] (Maralthamil, 2009):

1. Optimum use of Energy or power
2. Water conservation
3. Solid and Water Waste management, its treatment and reuse
4. Energy efficient transport systems
5. Efficient Building System Planning etc.

If all buildings in urban areas were made to adopt green Building concepts, India could save more than 8400 MW of power which is enough to light half of Delhi or 5.5 lakh homes a year according to estimates by TERI. A green building depletes very little of the natural resources during its construction and operation. The aim of a green building design is to minimize the demand on non-renewable resources and maximize the utilization efficiency of these resources when in use and utilization of renewable resources [6].

The first wave of green building technologies has led to efficiency gains and a veritable explosion of green design options for the owners of new and existing buildings. The second wave of innovations targeting the built environment is going a step further [7]:

1. to make buildings more intelligent from initial concept through design, construction, operation, retrofit and upgrade
2. to recognize the measures adopted, which contribute to the overall objective of designing and maintaining of green buildings and
3. those that are otherwise not covered in the green building rating system

A green building rating system is an evaluation tool that measures environmental performance of a building through its life cycle. Building rating systems are a popular tool to bring momentum in achieving energy efficiency and sustainability in buildings. In India, at present, there are predominantly two rating systems to certify buildings as green buildings, namely GRIHA and LEED. These rating systems have a predefined set of criteria and there are points for each one of these criterion. The buildings are required to fulfill the defined criteria and achieve a certain number of points to be certified.

GRIHA

GRIHA or Green Rating for Integrated Habitat Assessment is the National Rating System for India. The Energy and Research (TERI) conceived and developed the rating jointly with the Ministry of New and Renewable Energy, Government of India.
The different criteria are categorized as follows:

1. Sustainable site planning
2. Building planning and construction
3. Building operation and maintenance
4. **Innovation points**

Each Innovation Criterion will carry one point, subject to a maximum of four points.

LEED

Leadership in Energy and Environmental Design (LEED) was developed and piloted in the US in 1998 as a consensus-based building rating system based on the use of existing building technology. The rating system addresses specific environmental building related impacts using a whole building environmental performance approach [8].
The following are key components of the LEED system:

1. Sustainable Sites
2. Water Efficiency
3. Energy & Atmosphere
4. Materials & Resources
5. Indoor Environmental Quality
6. **Innovation in Design**
7. Regional Priority

Hence the study focused on the innovations made in green buildings.

II. METHODOLOGIES

The study was conducted in Delhi-National Capital Region as it in-houses large number of buildings registered/certified as green buildings. The millennium city has five platinum (highest) rated buildings certified by Leadership in Energy and Environmental Design, IGBC and also three GRIHA certified projects in this region.

Two sets of sample were identified for the study. These were Sample A which included LEED certified buildings and Sample B included GRIHA certified buildings. Different sample A and B were selected to understand the importance associated by both rating system with innovation as it is a non-mandatory yet prominent category under both the rating systems.

The unit of enquiry consisted of Architects, green building consultants and project managers of the buildings. This unit of enquiry was selected to gain a perspective on catalysts and hindrances encountered while scoring for this category and the benefits or gains involved with it. Information regarding ideas, technologies and strategies implemented to score points under this category was also collected from them. The project managers included were the managers involved in the process of carrying out an activity that leads to attempting or earning of an innovation point. The total sample size was 5 certified green buildings (3 LEED and 2 GRIHA certified). From each building architect, green building consultant and managers were

interviewed summing up the unit of enquiry to be 3-4 from each building and 18 for all the five buildings.

Following tools were used for data collection:

Case Study: Case study was made to sketch a profile of the building in terms of innovation points achieved by the building and the techniques and strategies implemented in order to gain them. Secondary Search was also conducted to draw information on innovation points/credits under different rating system from existing available data and to trace a list of green buildings that are to be taken as sample.

Structured Interview Schedule: An interview was conducted with the architects, managers, green building consultants to have face to face conversation with them in order to get a holistic picture of the process they had to undergo to achieve innovation points.

Structured Interview Schedules were designed for the study.

Interview schedule were prepared to profile LEED/GRIHA certified building in terms of "innovation in design" credits attained and technologies/strategies implemented to achieve these credits. Questions to elicit response on the catalysts and challenges encountered while adopting this category were included. Experts from the field were consulted for preparing the tool. It was divided into 2 parts; A &B. Section wise details of the tool are as follows:

1. Part A covered background information of the respondent in terms of year spent in organization, designation; questions regarding profile of building in terms of developer, architect, location, built up area etc.
2. Part B covered following questions:

- Regarding certification of the building, the rating it holds and the stage at which decision for certification was taken.
- Regarding innovation points earned and the decision maker for each innovation point.
- Concerning the process, technologies/strategies that were required to attempt those credits under innovation.
- Regarding challenges and catalysts related to the same credit.

III. FINDINGS

Case studies of LEED NC certified buildings

Building 1: The first building attempted fifty seven points under LEED-NC (V 2.1) out of a total of sixty nine possible points. They were able to earn all the attempted points except for one, successfully scored 56 points and were rewarded platinum rating under LEED-NC in the year 2009. They achieved all the five attempted points under innovation in design. The credits they have applied under this category are Rain water harvesting tank as rain water harvesting is executed in the building and rain water is collected for reuse and ground water recharge. The capacity of the storage tank is 650 kilolitres. Based on average rainfall, approximately 2,662,000 litres of rainwater are harvested on-site every year. Besides this light coloured open paver and shaded paved areas aid absorption of rain water decreasing the run-off; Comprehensive strategy and design to minimize embodied energy in construction of the building, a comprehensive strategy to avoid approximately 640 tonnes of CO2 emissions has been employed and excavated earth from the basement has been used for manufacturing compressed earth blocks on site, as substitute for burnt brick and concrete block and also locally available stones have been used for external cladding/ finishing and flooring, as a substitute for curtain glazing, metallic or ceramic cladding systems; thermal comfort through passive design as the building is designed to aid thermal comfort and reduce cooling loads inside the building through passive design techniques. The solar PV installation is also integrated into building design to provide thermal comfort passively and the geometry was worked out with the help of a solar chart and simulation software (Ecotect) to block the summer radiation without obstructing the view and allowing the winter sun to penetrate into the room; design strategy for influencing and educating lifestyle performances with respect to building materials as many groups keep visiting the building and thus it imparts education and influence lifestyles towards sustainable living and built environment. They also spread awareness through making the information available on their website; and lastly LEED Accredited Professional was hired by the building and scored a point for his/her involvement throughout the process of construction and certification.

Building 2: The second building is based on net zero building concept. The project achieved the LEED India NC (V. 1) Platinum rating achieving sixty four out of sixty nine possible points. For the category Innovation in Design, it applied for all five possible points and scored credits for LEED Accredited Professional as LEED AP was involved from planning stage till certification of the project; On-Site Renewable Energy as energy consumption for heating, cooling, ventilation and lighting is covered in full by renewable energy. A photovoltaic system on the roof generates some 88,884 kilowatt hours of renewable electricity each year while the annual consumption of the building is 78,910 kilowatt hours and also roof is covered with Kalzip panels (Stucco Embossed) which have very high Solar Reflectance i.e. almost 78.85%; Construction Waste Management as Various materials were identified during design phase that can be made of salvaged materials. Some of the reused materials in the project are Structural Steel (old steel beams were reused to make staircase), Mild steel, Ceramic Tiles (waste ceramic tiles from another project reused as flooring material for all porta cabins), Kota stone (reused as a flooring material and water proofing material in underground tanks), Fly ash bricks, Kerb Stones (painted ad reused on the periphery of the building for hard paved surface, GI framing (reused as framing structure for the rubber wood cladding in the reception area of the project) and Soiling Stones; Regional Material as the materials such as ready mix concrete, polyurethane insulation, cement, fly ash brick masonary, false ceiling gypsum were harvested, extracted and manufactured within 800 kms of the building's site; and Reduced Site Disturbance Development as it has proportioned the soft and hard paved area to be 1:1 i.e. half is the concretized paved area and half is the unpaved or area with grass.

Building 3: The building is LEED U.S.G.B.C. Platinum certified. It has earned 5/5 possible points under innovation in design category for passive architectural design as a prominent feature of the building is the top-lit atrium, which not only lights up the indoor spaces but provides a sense of grandeur to the office interior. The building is designed in a way that allows

sunlight to penetrate almost 85% of the interior spaces. The vertical stone louvers have been effectively used to soften the harsh sunlight entering the building, especially from the north-west and south-west directions; Rain water harvesting tank as the building has a rain water harvesting system and grey water is used for non-potable purposes like flushing and watering the gardens; Reused Material as During construction, 96.6% of the building waste was collected and diverted to authorized disposal agencies. To reuse resources, furniture from its old office was remodeled and used in the building and also 2.5% of the building material, like bamboo flooring, is from rapidly renewable resources, and 7.7% is reused or salvaged material; Energy efficiency (Exemplary Performance) as the building performed exceptionally under Energy and Atmosphere by exceeding the threshold requirement and using 60 % less energy than a conventional building owing to its day lit design and other passive architectural measures, energy efficient fixtures and efficient water cooled HVAC system and LEED Accredited Professional as LEED AP was hired for providing design guidelines for the building, documenting, scrutinizing the entire construction process and sending the documents to U.S.G.B.C. for acquiring the certification.

A. Case study of GRIHA certified buildings

Building 1: This has been designed as energy efficient building that complies with the ECBC (Energy Conservation Building Code) and has achieved 3-star GRIHA (Green Rating for Integrated Habitat Assessment) green rating certification. To earn bonus points, they have earned all possible points (4/4) by doing comprehensive lifecycle cost analysis of the project considering the cost arising from owning, operating, maintaining etc. This was considered important for project viability. They have scored another point for Integration of earth-air tunnel to reduce the annual building cooling/heating load as in the hospital, the Earth air tunnel (EAT) system is incorporated to provide pre-cooling of fresh air in Treated Fresh Air Units (TFAs) from 44 degree C to 28 degree C then cooling coils would further cool the air from 28 degree C to 14 degree C. Next point earned was Resource recovery from solid waste management and the process of biomethanation for treatment of food wastes generated from the canteen is applied. Setting up of a treatment plant for handling 300 kg of waste daily resulted in 18 m^3 of biogas and 30 kg of manure. Both biogas and manure are utilized within the campus. The payback period was one-and-a-half years. Fourth point earned was for passive architectural design strategies. Some of them adopted in the building were: building orientation designed to gain maximum benefits, self-shading building block, the spindle shaped design reduces air pressure on the building surface, the building blocks and their location create an air channel between blocks.

Building 2: The building covers an area of approximately 10 acres and is designed as an eco-friendly office complex, rated 3-star by GRIHA. It has large, contiguous, flexible & efficient floor plates and earthquake resistant structure.

It has earned 2/4 bonus points. To earn points under this stage, the management started a labour camp and scored a point for it. The camp included a creche as well as a hygiene and safety initiative for the labours. Arrangements were made with external agencies and internal audit was done time to time to ensure the effectiveness and the purpose followed strictly by the camp. Next point was earned for preservation of an old banyan tree as an approximately 100 year old banyan tree was prevented from cutting and was included into design of the building.

B. Catalysts and Hindrances

Catalyzing factors for LEED and GRIHA certified buildings

Catalysts/ Buildings	**1**	**2**	**3**	**4**	**5**
Easily achievable	✓				✓
Less cost intensive					
Positive outlook towards innovation	✓	✓	✓	✓	
Image and Prestige	✓	✓	✓	✓	✓
Self-satisfaction	✓	✓	✓	✓	✓
Good Payback	✓	✓	✓	✓	
Improved performance under other categories		✓	✓		
Desire to earn more points			✓		✓
To set an example	✓			✓	✓
Substantial environmental benefits				✓	

All the samples studied have one or the other source of motivation to facilitate the process of undergoing innovation category.

Hindrances faced by LEED and GRIHA buildings

Challenges/Buildings	**1**	**2**	**3**	**4**	**5**
Difficulty in documentation	✓	✓	✓	✓	✓
Not much scope left for innovation after complying with core categories	✓	✓	✓	✓	✓
Exemplary performance not easily achievable		✓	✓		
Unable to foresee any implied benefits at an early stage					✓

Hindrances refer to the challenges or obstacles faced by the samples while undergoing through the implementation of innovation category in their respective buildings.

C. Point of differences between LEED and GRIHA samples

Concept of Innovation: As seen in the case profile, most of the points earned by LEED buildings under 'Innovation in Design' category were architectural design or technology oriented such as passive techniques for thermal comfort, rain water harvesting tank, PV panels for onsite renewable energy etc. On the other hand in case of GRIHA certified buildings, most points were scored for idea or concept driven features such as running a labour camp, life cycle costing etc.

Catalysts: The urge to excel and set an example was found in all the GRIHA buildings and in only one-third of LEED buildings as the responses obtained expressed that buildings undergoing GRIHA certification focused more towards standing apart in the bunch of green buildings as Fortis itself was the first certified eco-friendly medical facility in India. All the LEED buildings also went for innovation in order to achieve improved performance under other core categories as LEED reference manual addresses innovation credits for exceeding thresholds of basic categories by further innovating in the architectural or operational style whereas all the GRIHA buildings were motivated by the desire to attaining substantial environmental benefits.

Hindrances: Majority (two-thirds) of the LEED buildings expressed that exceeding already highly set thresholds is a difficult part of the job and therefore exemplary performances are not easily achievable. Hence, found it difficult to score under path-1 of innovation in design whereas one-third of the GRIHA building could not foresee any implied environmental benefit of this category at design or construction stage and thus found difficulty in making up their mind to undergo this category. It's only during the operational phase that they realized the gains resulting from this category.

REFERENCES

[1] Infrawindow News Bureau. (2013, March 8). Demand for green building materials to grow 11% per annum. Eco Development. Retrieved January 14, 2013, from http://www.infrawindow.com/eco-development/demand-for-green-building-materials-to-grow-11-per-annum_444/

[2] Anand, S., Goswami, A. & Kolaskar, A. (2007). Innovation in India. National Knowledge Commission. Retrieved February 4, from http://www.knowledgecommission.gov.in/downloads/documents/NKC_Innovation.pdf

[3] Er, A. & Mutlu, B. (2003, April). Design innovation: Historical and theoretical perspectives on product innovation. Paper presented at The 5th European Academy of Design Conference, Barcelona. Retrieved March 2, 2013, from http://www.ub.edu/5ead/PDF/1/MutluEr.pdf

[4] Confederation of Indian Industries. (2013). Building business leadership.Retrieved March 2, from http://www.cii.in/Sectors.aspx?enc=prvePUj2bdMtgTmvPwvisYH+5EnGjyGXO9hLECvTuNu2U22GHqsoqBDRN1IJIGuz

[5] Malarthamil. (2009). The Concept of Green Buildings. Truthdive. Retrieved September 2, 2012, from http://truthdive.com/2009/06/05/the-concept-of green-buildings.html

[6] Gupta, Y.P. (2010). Need for developing green building concept in the country. NBM Media. Retrieved November 12, 2012, from http://www.nbmcw.com/articles/green-construction/15837-need-for-developing-green-building-concept-in-the-country.html

[7] Ministry of New and Renewable Energy & The Energy Resource Institute (2010). GRIHA Manual Volume. New Delhi, India: TERI Press.

[8] Indian Green Building Council. (2011). Green Building RatingSystem for New Construction & Major Renovation. LEED 2011 for India (97-98). Hyderabad, India: Anonymous.

AUTHORS

First Author – Kamayani Barshilia, Lady Irwin College, Delhi University, Email- kamayani.barshilia7891@gmail.com