International Journal of Innovative Research in Advanced Engineering (IJIRAE) ISSN: 2349-2163
Issue 5, Volume 2 (May 2015) www.ijirae.com

Reassessment of an energy efficient building using GRIHA methodology

Anshul Sheokand*
PG Scholar, Dept. of Civil Engg.
PEC University of Technology, Chandigarh

R.K Khitoliya
Professor, Dept. of Civil Engg.
PEC University of Technology

Jatinder Pal Singh
Dean (Academics)
Chandigarh College of Architecture

Abstract— In almost every country, a significant part of total greenhouse gas emissions come from buildings. According to World Watch Institute, about 40% of the energy use is dedicated to construction and operations of buildings. A green building depletes the natural resources to a minimum during its construction and operation. The aim of green building design is to minimize the demand on non renewable resources, maximize the utilization efficiency of these resources when in use, and maximize the reuse, recycling, and utilization of renewable resources. A green building rating system is an evaluation tool that measures environmental performance of a building through its life cycle. A comprehensive and suitable to Indian climate and buildings, National Rating System, called GRIHA (Green Rating for Integrated Habitat Assessment), was developed by MNRE based on the initial work carried out at The Energy and Resources Institute (TERI). The present paper is regarding the reassessment of evaluation tools of GRIHA methodology with the help of a case study. The HAREDA (Haryana Renewable Energy Development Agency) building which has been awarded five stars by ADaRSH (Association of Development and Research of Sustainable Habitats) has been selected for the case study. On the basis of TERI-GRIHA methodology, a reassessment has been conducted to found out if any misappropriation is present in the initial stage of assessment and also to countercheck the performance of existing unique features of the design in the operational stage. Also distinctions between pre-construction and post-construction criteria have been advocated.

Keywords- Sustainability; Green Buildings; Renewable; Rating system; Energy Efficient

I. INTRODUCTION

The concepts of sustainable construction and green building are the recent responses to address environmental problems and reduce the overall impacts of the building sector on the natural environment. In the last two decades, in both developing and developed countries, the attention on construction of green buildings and retrofitting of existing buildings by using low-carbon and green technologies has grown considerably. In India the two green rating systems being followed are: LEED India (Leadership in Energy and Environmental Design) -administered by the Indian Green building Council (IGBC) and GRIHA-Green Rating for Integrated Habitat Assessment developed by TERI (The Energy and Research Institute). TERI's green building rating system GRIHA has been developed as an instrumental tool to evaluate and rate the environmental performance of a building. GRIHA is a guiding and performance-oriented system where points are earned for meeting the design and performance intent of the criteria. Each criterion has a number of points assigned to it. It means that a project intending to meet the criterion would qualify for the points. GRIHA has a 100 point system consisting of some core points, which are mandatory to be met while the rest are optional points, which can be earned by complying with the commitment of the criterion for which the point is allocated. The innovation points are available over and above the 100 point system. This means that a project can hypothetically apply for a maximum of 104 points. But the final scoring shall be done out of 100 points. Different levels of certification (one star to five stars) are awarded based on the number of points earned. The minimum points required for certification is 50. Buildings scoring 50 to 60 points, 61 to 70 points, 71 to 80 points, and 81 to 90 points shall get one star, 'two stars', 'three stars' and 'four stars' respectively. A building scoring 91 to 100 points will get the maximum rating viz. five stars. There are in total of 34 criteria's in the GRIHA methodology.

II. THE CASE STUDY– HARYANA RENEWABLE DEVELOPMENT AGENCY (HAREDA) BUILDING, PANCHKULA, HARYANA, INDIA

The Renewable Energy Department, Haryana/HAREDA has constructed its office building in a plot of area 0.96 acres at institutional Plot No.1, Sector-17, Panchkula (Haryana). This building is one of its kind in the country in having energy autonomy by incorporating the latest and futuristic energy efficient concepts. It has been the first building in the Government sector to be constructed in Compliance with the Energy Conservation Building Codes (ECBC**).** Moreover, this building has been provided 5 star GRIHA rating (Provisional) by Association for Development and Research of Sustainable Habitats (ADaRSH) which is first of its kind in North India and first Govt. building in India.

This building has been constructed on the basis of solar passive design techniques having Building Integrated Photovoltaic (BIPV) system of 42.50 KW capacity, solar chimney, evaporative cooling, cavity walls, use of fly ash based bricks, water recycling and energy efficient lighting etc. The incorporation of these features has resulted in achieving an internal temperature of about 28^0 C without air conditioning.

The energy consumption in this building is estimated to be about 30 kWhr/m^2/year in comparison to the consumption of about 200 kWhr/m^2/year for other air conditioned buildings. No municipal water supply is required after the first monsoon with the 6.5 lacs litre underground tank that has been optimized for rainwater harvesting and consumption pattern of the building. Optimization of installed load has been about 55 kW only. This is one of its own kind of building with 25% reduced lighting energy need and Annual Energy Consumption at 3.48 units per sq, ft. against 18.5 units per sq. ft. of a conventional building. Also, evaporative cooling- fogging system (Mist Cooling) has been provided for cooling the non-AC areas of the building. The mist is created in the courtyard of the building with this mist cooling system and the pressure fans on the top of court yards makes squirrel effect in the area to cool the building. This cool air is sucked by solar chimneys. Due to this system the relative humidity ranges between 60%-75%.The very much emphasis with regard to plantation has been provided by planting herbal shrubs all across the building. Deciduous trees are planted on the West face of the building to allow winter heat gain while keeping the summer sun out. Evergreen bushes are planted on the North and East to cool the air as it enters the building. Evergreen high foliage planted in the berm along the main road to reduce the noise. All these features are evaluated with regard to the respective intent of the criteria's.

GRIHA evaluation report (2012) mentioned that Akshay Urja Bhawan/HAREDA was evaluated according to the benchmarks and guidelines of GRIHA Rating System. Final rating shall be awarded on compliance with the GRIHA criterion 32. The project has been awarded 90 points (87+3 bonus points) out of 96(92+4 bonus) applicable points by the evaluation committee of ADaRSH on providing necessary documentation and demonstrating compliance with mandatory criterion under GRIHA. Therefore, provisionally rated 5 star (97.83% (90/92 Points).

In India, sometimes buildings are overrated and correspondingly behave opposite to intended characteristics in the operational stage (CSE Report, 2012). Therefore, reassessment of HAREDA building is conducted as per the guidelines of GRIHA-TERI. (Figure 1 and 2 showing exterior and interior of building)

Figure 1-HAREDA Building

Figure 2- Interior Central Courtyard

III. RESULTS AND DISCUSSION

After adopting the methodology of GRIHA-TERI, the following results were observed for HAREDA building. Out of total 34 criteria only those criteria have been discussed which could be measured in the operational stage.

- **Criterion 1 –Sustainable site planning (1 point): Intent**-The intent of criterion 1 is to select an appropriate site such that the development of a project should not cause damage to the natural surroundings of the site. To attempt a GRIHA rating, the selected site must confirm to the development plan and the UDPFI (Urban Development Plans Formulation and Implementation) guidelines. To achieve one point in criterion 1, the selected site must be within ½ km radius of an existing transportation service.

  Results: The project is located in Sector 17, Panchkula, Haryana, India, which is a satellite town of Chandigarh. It is at a distance of 8 kms from the Chandigarh airport and lies in the Institutional zone of Panchkula. Necessary infrastructure and services like market place, ATM, banks, medical facilities and bus stand are located within 2 kms from site boundary. Therefore, locational characteristics are satisfying the intent of the criterion.

- **Criterion 4 – Design to include existing site feature (4 points): Intent:** To achieve points in criterion 4, the design of the building should complement the existing site conditions such that there is minimum disruption to natural site features. A detail site analysis is required to ensure sustainable site development.

Results: The design of the building should complement the existing site conditions such that there is minimum disruption to natural site features. The features justifying the awarded points are

a) North- South orientation of the building. Maximum openings have been designed along the North and South facade limiting windows on the East and West facade thus leading to minimum solar heat gain inside the building.

b) Vertical and horizontal shading devices have been used on all four facades to minimize direct solar heart gain and glare inside the building.

c) The building is planned around a central courtyard to channelize natural ventilation inside the building.

d) Thermal comfort is maintained inside the building during peak summer season by a unique process of misting. Misting is planned and designed in the courtyard. During hot summer days the cool water from misters is released in the courtyard and the hot air inside the building is channelized to the roof through solar chimneys thus maintaining comfortable thermal conditions inside the building.

e) Grass pavers have been used for paving around the building to reduce Urban Heat Island Effect (UHIE) and allow maximum percolation of water into the ground.

- **Criterion 5- Reduce hard paving on-site and /or provide shaded hard paved surfaces (2 points): Intent:** As a mandatory requirement of criterion 5, the total surface parking must not exceed as permitted by the local bye-laws. To achieve 2 points (optional) in criterion 5, net paved area of the site under parking, roads, paths or any other use should not exceed 25% of the site area or net imperviousness of site cannot exceed the imperviousness factor as prescribed by National Building Code and 50% of paved area must have pervious paving/open grid pavements/grass pavers; or shaded by vegetative roof/pergola; or topped with a material with solar reflectance of 0.5 or higher.

  Results: Parking has been provided in the basement and as well as on the surface. Also, few calculations have been done to check the fulfilment of this criterion. For this purpose data regarding the various parts of site area are mentioned below:

  Total site area is 3900 m^2, ground coverage is 1590 m^2, total paved area is 1040 m^2 out of which 520 m^2 is pervious paved area and 520 m^2 is impervious paved area.

  Calculations to support design commitment:

  $$\text{Net Paved area (\%)} = \frac{\text{Net impervious area on ground (m²)}}{\text{Total site area minus building footprint (m²)}} \times 100 = 520/(3900-1590) \times 100 = 22.5\%$$

  Therefore, total paved area on site is 22.5% which is as per the GRIHA requirement. Hence, awarded points are justified.

- **Criterion 14-Optimize energy performance of building within specified comforts limits (16 points): Intent:** The intent of the criterion is to optimize use of energy systems in buildings that maintain a specified indoor climate conducive to the functional requirements of the building. To achieve 16 points (8 mandatory and 8 optional) in criterion 14, the project must comply with all mandatory requirements of ECBC (Energy Conservation Building Code) 2007 of BEE(Bureau of Energy Efficiency), Government of India (mandatory 6 points) and must achieve the benchmarked EPI (Energy performance Index) as recommended by GRIHA (mandatory 2 points). In addition to the above, the project shall be awarded 2 – 8 points for every 10% reduction, to a maximum of 40% reduction, in EPI from the benchmarked value.

  Results: The project has demonstrated compliance with all mandatory requirement of ECBC (Energy Conservation Building Code) to get maximum attempted points. The analysis of features of building is conducted to contemplate their compliance with the mandatory requirement of criterion 14. The features incorporated are VRV air conditioning system has been installed; Equipment (Chiller & Compressor) efficiency meets ECBC requirements; Power transformers meet ECBC requirement and allow minimum losses.

  The GRIHA benchmarked EPI for the project is 63 kWh/m^2/year and the EPI of the building is 39 kWh/m^2/year, demonstrating 61 % reduction in energy consumption compared to benchmarked energy consumption. (Details in Table I)

Table I: Showing annual energy consumption of HAREDA building for last 1 year

Sr. No.	Duration 2 months	Total consumption from Grid(kWh)
1.	February,2014 to March, 2014	8263
2.	April,2014 to May, 2014	4954
3.	June,2014 to July, 2014	17682
4.	August,2014 to September,2014	20948
5.	October,2014 to November,2014	14600
6	December,2014 to January,2015	3788
Total		70235

EPI= Energy Consumption in kWh per year
Total Built-up area in m^2

= 70235/1590
= 44.17 kWh m^{-2} y^{-1}

EPI≈ 44 KWh m^{-2} y^{-1}

Therefore, EPI is under the permissible range up till now.

- **Criterion 17 – Use of low energy material in interiors (4 points): Intent:** The intent of criterion 17 is to use low-energy materials/finishes/products in interiors, which minimize the use of wood as a natural resource. To achieve 4 points in criterion 17, the project must demonstrate use of minimum 70% of total quantity of material as low-energy material in sub assembly/internal partitions/false ceilings/in-built furniture; flooring; and doors/windows frames.

  Results: The analysis shows that:

  a) More than 70% of the total quantity of material used for sub-assembly, internal portions, panelling, false ceiling and in-build furniture is low energy material. Green guard laminate and Armstrong mineral fibre ceiling tiles have been used.

  b) More than 70% of the total quantity if material used for flooring is low energy material. Moso Bamboo flooring, Kota stone and vitrified tiles and Thermatek heat resistant ceiling tiles have been used.

  c) 100 % of total quantity of material used for doors windows and frames is low energy material with recycled content. Ply & laminate flush doors have been used. Fenesta UPVC is used for window frames. Also, project officer has mentioned verbally that the scrap generated at the extrusion and fabrication of units is recycled. The material is 100% recyclable and has 10% pre-consumer recycled content.

  Therefore, materials used are complying with the intent of criterion. Hence points awarded are justified.

- **Criterion 18- Renewable energy utilization (5 points): Intent:** The intent of criterion 18 is to use renewable energy sources in building to reduce the use of conventional /fossil fuel based energy resources. To achieve points in criterion 18, the project must demonstrate installation of renewable energy system on site. The installed capacity of the system must be minimum 1% of the total connected load of internal artificial lighting and space conditioning. The project shall be awarded additional 1-4 points if the rated capacity of the proposed RE System meets annual energy requirements of equal to or more than 5%- 30% of internal lighting consumption.

  Results: The study found that the total connected load of artificial internal lighting and space conditioning the building is 88 kW. Installed capacity of the Renewable energy system installed on the site is 42.25 kWp which meets GRIHA requirement of minimum 1% capacity of connected load for internal artificial lighting and air conditioning. Total energy generated from solar PV is 83520kWh which is more than 30% of the internal artificial lighting requirement. Also, electricity from the solar plant has been supplied to the grid during the weekend days when office is closed.

But still maximum energy requirements during summer days will be fulfilled from the supply lines of state electricity board. Meanwhile, unnecessary usage of air conditioners has been prominent during some months of the year. Therefore, re-evaluation of awarded points must be conducted in the first audit report. Presently, allotted 5 points are not justified with the prescribed intent of criterion.

- **Criterion 19- Renewable energy based hot water system (3 points): Intent:** The intent of criterion 19 is to reduce dependency on conventional sources of energy to meet hot water demand of the site. To achieve 3 points in criterion 19, the project must demonstrate use of solar hot water heaters on site.

  Results: The Installed capacity of the solar hot water system is 7 KLPD. 100% of annual hot water demand is being met by solar power. Therefore, compliance is confirmed and signifying no change in the points awarded.

- **Criterion 21- Water recycle and reuse (including rainwater) (5 points): Intent:** The intent of criterion 21 is to utilize treated water and rainwater for various applications (including ground water recharge) to reduce the load on both the Municipal supplies as well as the sewerage system, and to improve the ground water table. To achieve points under criterion 21, the project must demonstrate use of treated waste water and /or rainwater to meet certain percentage of annual water demand. The project shall be awarded 1-3 points to demonstrate minimum 25%-75% annual water reuse. Additional 2 points shall be awarded to recharge surplus rainwater into aquifer.

  Results: As per GRIHA, since criterion 20 is non-applicable to the project, re-use of treated water and rain water to meet annual water demand is non-applicable to the project. However, as per the officials collected data the building demonstrated exemplary performance by meeting 66.83 % annual water demand by using 1117 KL of rainwater on the site and thus the project is being evaluated for the same. Total annual water demand on site is 1803 KL/year. Quantity of treated water and rain water collected from roof is 88 KL/year and 1117 KL/year respectively. Also the surplus rain water (from soft and paved surfaces) is recharged into the aquifer by appropriate filtrations technique. Hence points awarded are justified in relation to the intent of criterion.

- **Criterion 28 – Ensure water quality (2 points): Intent:** The intents of Criterion 28 is to ensure supply of good quality potable water for drinking/ washing purposes and the quality of treated waste water confirms to IS standards. To achieve 2 points in criterion 28, the project must comply with requirements of criterion 28.

  Results: (Shown in Table II)

Table II-Tests related to IS: 10500

Sr. No.	Parameters	Results	Desirable	Permissible
1.	pH value	7.2	6.5-8.5	No relaxation
2.	Turbidity(NTU)	00	Max 01	Max 5
3.	Total Hardness (as $CaCO_3$)-mg/l	156.8	Max 200	Max 600
4.	Chloride (as Cl^-)-mg/l	10.6	Max 250	Max 1000
5.	Total dissolved solids-mg/l	212	Max 500	Max 2000
6.	Nitrate-mg/l	2.1	Max 45	No relaxation
7.	Total alkalinity (as $CaCO_3$)-mg/l	120	Max 200	Max 600
8.	Total coliform per 100 ml	Not detectable	No relaxation	No relaxation

The project receives a water supply of 598 KL/year from Municipal Corporation. Water is purified by the water treatment plant and then by Reverse osmosis purifier installed in the building. Therefore, complying the intent of criterion.

- **Criterion 29-Acceptable outdoor and indoor noise levels (2 points): Intent:** The intent of the criterion is to enhance comfort by providing acceptable levels of outdoor and indoor noise levels. To achieve 2 points in criterion 29, outdoor noise level must confirm to acceptable limits set in Central Pollution Control Board – Environmental Standards and indoor noise level must confirm to acceptable limits set in National Building Code-2005.

  Results: The following measures have been adopted to control noise levels-

- High foliage trees planted along the boundary to reduce noise from the main road traffic.
- Sufficient distance of the main building block from the main road.
- Green belt along the built up area to improve its acoustical performance.

- Double glazed windows with UPVC (Unplasticized polyvinyl chloride) frame.
- Dow corning sealants used in south façade (side along the main road) of the building.
- Armstrong acoustic tile used in ceiling of conference room, meeting room, chairperson's room and training room.

Therefore, all these features are sufficient to comply with the intent of criteria. Hence points awarded are justified.

.

IV. CONCLUSIONS

Reassessing the building results into following conclusions:

GRIHA-TERI method lacks the distinction between pre and post-construction criteria's. While doing reassessment on the HAREDA building, problem regarding the choosing of a particular criterion for evaluation arises because of unrecognised post construction criteria's. However out of total 34 criteria only criterion- 14 (Optimise energy performance of building within specified comfort) and criterion-28(Ensure water quality) possesses the information in form of practical data which would be helpful in evaluation mechanism. These will account to only 16 points in total. Rest all the criteria's once evaluated during the provisional rating remained same. Therefore, in future stage during the operation of buildings the vitiated strength cannot be assessed. Non-compliance to the intent of criteria's hardly changes the provisional ratings. This might be among one of the problem with GRIHA method. Apart from this one criterion which should be added is regarding awareness of employees about green building concept and their compliance to the prescribed norms mentioned in criteria's. The current level of awareness about the unique features of case study building among its employees has been unsatisfactory.

References

[1] Balban, O., 2012, Climate change and cities: a review on the impacts and policy responses, *METU JFA 2012/1*, (29:1) 21-44.

[2] Baumert, K., Herzog, T. and Pershing, J., 2005, Navigating the numbers: Greenhouse gas data and international climate policy, *World Resources Institute, Washington, D.C.*

[3] Centre for Science and Environment, NGO, India, http://www.cseindia.org/content/green-building-rating-body-misleading-everyone-says-cse. [Accessed on 21st march 2015]

[4] Ding, G.K.C., 2008, Sustainable Construction – The Role of Environmental Assessment Tools, *Journal of Environmental Management*, 86(2008), 451-464

[5] Gill, S.E., Handley, J.F., Ennos, A.R. and Pauleit, S., 2007, Adapting Cities for Climate Change: The Role of the Green Infrastructure, *Built Environment*, 33(1): 115-133.

[6] Haryana Renewable Development Agency (HAREDA), http://hareda.gov.in/index.php?model=gallery&nid=21. [Accessed on 10th April 2015]

[7] TERI –GRIHA, Manual Volume 1, Introduction to National Rating System; Volume 2 Technical Manual for Trainers on Sustainable Site Planning, Health and Well-being during construction; Volume 3 Technical Manual for Trainers on Building and System Design Optimization, Renewable Energy Application; Volume 4 Water and Waste Management, Sustainable Building Materials, Health and Well-being of building Occupants, Building Operation and Maintenance; Volume 5 Technical Manual for Evaluators a guide for assessing GRIHA documentation, *Ministry of New and Renewable Energy, Second Reprint edition 2013,India.*

[8] TERI Griha, 2007, Rating System, http://www.teri.res.in/core /griha/ratingsystem.htm

