Green Retrofitting- An Energy Saving Alternative to Sustainable Future.

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ABSTRACT

Energy efficient construction methods and buildings are gaining peak with a great speed. Trending green building rating systems allow ease to design, construct, operate and monitor the new building construction. What is still lacking attention is the emissions and carbon footprint of the existing buildings. These buildings contribute to the increasing amounts of carbon emissions leading to temperature rise and climate change. To tackle this, it is very important to address the issue of emissions and the impact of the existing building on the environment. This is precisely where the Green retrofitting will act. Green retrofitting helps to modify the building interiors concerning Lighting systems, HVAC systems, attainment of thermal comfort, etc. to lead a positive impact on the environment. This chapter showcases green retrofitting, its benefits and challenges. Some real-life examples of retrofitting along with the statistical data on energy savings are mentioned. The chapter ends with a listing of several ways of retrofitting under multiple heads like Energy efficiency, HVAC systems, water efficiency, Indoor Air Quality etc.

Keywords – Existing Buildings; Green Retrofitting; Climate Change; Energy Efficiency; Carbon footprint

I. INTRODUCTION

According to United Nations Environment Programme's (UNEP) Global Status report for Buildings and Construction published in the year 2021, Energy use in the building and construction sector accounts for 36% of global energy consumption. 11% of carbon dioxide emissions come from the manufacturing of Cement, Steel, and Glass which are 3 major ingredients in building construction. With UN Sustainable Development Goals – Goal 11 on sustainable cities and communities it is projected to provide housing for all by the year 2030. This means doubling the construction activities to meet the basic housing needs. Any New building construction will lead to additions of CO_2 emissions eventually leading to an increase in earth temperatures and other climatic disasters. To meet the Net zero pledge by 2070 in India, it is now vital to start decarbonizing the building sector to carve our path towards Sustainability. Multiple strategies and new technologies are introduced to lower energy consumption and decrease the carbon emissions.

One of these strategies is the launch of Green Building Rating Systems. Green Building rating systems primarily focus on a sustainable way of new construction and making sure that the impact of this new construction is less negative on the environment. India has 3 major Green building rating systems namely IGBC (Indian Green Building Council), GRIHA (Green Rating for Integrated Habitat Assessment), and ASSOCHAM GEM. Though the credit system works differently for them, the intent of their criteria remains more or less the same. These rating systems thrive to incorporate sustainable practices in building design, construction and operation to ensure that future buildings are environmentally friendly. As per UNEP Global Status report for Buildings and Construction published in 2021, as compared to 2019, a rise of 13.9% in green building certification is seen in the year 2021. New policies are drafted to make green building a dominant technique in modern construction. However, these green building rating systems largely focus on new construction. But what needs to be understood is that the existing built constructions, especially non-residential, add to a large amount of energy consumption and CO_2 emissions. It is because the construction techniques, use of building materials, and approaches that took place a decade or two ago were not something we can now call a sustainable practice. Hence the operational emissions by these existing buildings are ruining the environment.

To get a greener and livable environment in the future, the existing building needs to be administered. Physical aspects of the existing buildings like configuration, orientation and location are difficult to modify. But what changes with time is the occupancy pattern, space utilization, codes and regulations and environmental standards. This is where Green Retrofitting the buildings will play a key role.

II. RETROFITTING

Any refurbishments, interventions or addition of new features in the existing building is called Retrofitting. It is the process of upgrading a building to enable it to respond positively to the environment. There are two types of Retrofitting:

1. Structural retrofitting is where the structural system of the building is improved by optimizing the strength of structural elements like columns and beams.
2. Green Retrofitting aims at reducing operational carbon emissions and their negative environmental impact. This is generally achieved by improving the efficiency of lighting, HVAC systems, windows, etc.

There stands a chance to differentiate between renovation and retrofitting. Renovation focuses on changing the appearance of the building externally or internally to enhance the aesthetics. On the contrary retrofitting improves the functionality of the building. But these both techniques are much more cost-effective than new construction. In new construction, the building is built from scratch which involves multiple consultants like Architects, Structural consultants, MEP consultants, Project Management consultants, and many more which can be a costly affair. UNEP states that the increase in construction and demolition activities will increase waste generation which will eventually destroy the natural and wildlife resources of over 70% of the land surface from now till 2032. This has raised an alarming situation on the amount of new construction and also about the operational emissions from the existing buildings out of which 90% are not built on sustainable parameters. Hence retrofitting these buildings makes much more sense.

Benefits of retrofitting:

1. Reduce negative environmental impact
2. Enhance building energy performance
3. Cost savings
4. Improved and healthier living
5. Increased Thermal comfort
6. Waste generation reduction

But as positive and easier as it may sound; retrofitting is challenging at times and has to cross over numerous barriers like:

1. Costing and Financing
2. Lack of knowledge of clients and service providers
3. No awareness of Green Building technologies and materials
4. Building code regulations
5. Lack of incentives

Yet once all in place, green retrofitting of existing buildings proves energy efficient and cost-effective compared to demolishing and building new. Green Retrofitting is an energy-saving alternative to reach our goal of Net Zero Emissions.

III. SOFTWARES TO SIMULATE RETROFITTING

With new technologies and smarter methods, experts around the world have developed Building Energy Modeling softwares. Building Energy Modeling Softwares (BEM) are energy analysis softwares that analyze an existing building as well as a new construction building for energy consumption to give a real-time output. These softwares are comprehensive, user-friendly, and time efficient. The application of BEM leverages its ability to answer questions related to Architectural Design, HVAC Design and operation, Building Performance, and Building Stock

analysis. These softwares are in demand to substantiate a new building design, retrofit design, code compliance, green building certification, real-time building control and operation, etc.
These softwares considers various input parameters like Building geometry and orientation, Project Location, Operation Schedule of lights, occupancy, plug loads, Construction Materials, HVAC systems and their materials, Lighting equipment, renewable energy systems and many more. Annual results are given by the softwares on an hourly basis. Hence through these softwares, it is possible to create an accurate building model which helps to predict the behavior of the project to thermal, visual and acoustic comfort.

Few softwares that are often used are:

1. EnergyPlus
2. OpenStudio
3. Autodesk Revit Insight plugin
4. Integrated Environmental Solution-IES VE
5. Design Builder
6. eQuest
7. Autodesk Revit Green Building Studio and Energy Analysis

IV. CASE STUDIES OF RETROFITTING

There have been examples from around the world where Architectural firms have changed the typology of an existing building and given an entirely new user and ambience to the place. MVRDV, a Netherlands-based architectural firm transformed a disused factory into a creative hub to accommodate offices. The rooftop bamboo landscape provides a leisure place with activities and amenities. To understand exactly what and how green retrofitting works and what is its contribution to saving the environment, let us look at a few examples.

1. <u>Paharpur Business Center, New Delhi</u> – India - A 25-year-old, 6-storey Building with a built area of 50,000 sq. ft. was retrofitted to achieve the lowest carbon footprint. This also helped to enhance the work environment for employees.
    a. 1200 plants were placed strategically to form an indoor jungle and help in purifying and cool the indoor air.
    b. Installation of advanced cooling towers.
    c. CFL Bulbs were replaced by LED.
    d. Rooftops Solar Panels.
    e. Motion and occupancy sensors in Lobby and washrooms.
    f. Procuring 5-star BEE-rated appliances.
    g. Heat reflecting cool tiles on the rooftop.
    h. Gray water recycling.
    i. Rainwater harvesting.

    These impactful energy-saving strategies helped to save more than 50% of the original energy consumption.

2. <u>Godrej Bhavan, Mumbai – India</u> – A 6-storey building built in 1972 underwent green energy saving retrofits in 2010 to reap savings of 12% in energy consumption.
    a. Upgradation of 35-year-old HVAC components.
    b. Creation of artificial floors to locate Air Handling Units (AHU).
    c. Installing a Building Energy Management System (BMS) to monitor energy use.
    d. Installed double-glazed clear glass for windows thus reducing the heat gain.
    e. Highly efficient lighting fixtures replaced conventional lighting fixtures.
    f. Addition of plantation around the building to control the ambient temperatures.

    These retrofits costing up to 54 lakhs Indian rupees were recovered within 5 years.

3. <u>Mahindra Towers, Mumbai – India</u> – Constructed in 1986 with a built-up area of 2,00,000 sq. ft. Mahindra towers received retrofitting with a focused aim of reducing lighting loads and improving the efficiency of cooling systems.
    a. Replacement of low efficient ceiling lights.

  b. Installing energy-efficient chillers.
  c. Insulation of AHU rooms.
  d. Replacing AHU motors with the high-efficiency motor.
  e. Conducting energy audit.

The retrofit methods cost up to 18.90 lakhs Indian Rupees which was impressively recovered within a year.

4. <u>One Prudential Plaza, Chicago- U.S.A.</u> – Formerly known as Prudential Building, One Prudential Plaza was the first significant skyscraper constructed in Chicago in 1955. This 41-storey building remained the tallest building in Chicago for 21 years.
    a. 1200 bays of single-paned windows replaced with high-energy performance glass.
    b. Windows with a higher thermal barrier were chosen.

   According to Environmental Protection Agency, 25% of the building's heating load and more than 50% of the building's cooling load can be reduced by using an efficient façade system. By changing the previous aluminum single pivot window to energy-efficient glass, this building achieved 16% of energy savings.

5. <u>Empire State Building, New York – U.S.A</u>. – this 2.8 million sq. ft. building incorporated various retrofitting changes in the year 2010 to achieve a 38% reduction in energy consumption.
    a. 6514 windows in the building were added with a pane of a coated film which significantly reduced the heat gain in summers.
    b. Chiller plants were rebuilt to match the ongoing efficiency and technology.
    c. Insulation was provided behind the radiators to avoid any heat loss.
    d. Upgrading of elevator systems to the regenerative braking system.
    e. Installation of the under-floor ventilation system to allow fresh air in.
    f. Individual temperature controls for the workplace were provided.

   All these upgrades have helped the owners to save more than $ 4 million every year.

6. <u>Harvard HouseZero, Harvard Center for Green Buildings and Cities Headquarters- U.S.A.</u> – This pre- 1940s headquarter building was completely transformed in an ambitious project to achieve a NetZero house. The focus was on harnessing natural ventilation, reducing energy use and gaining thermal comfort.
    a. Installation of Solar vent to instigate buoyancy drive natural ventilation.
    b. Triple glazed operable windows to enable natural ventilation and reduce solar heat gain.
    c. Optimized daylight across all the floor plate using enlarged windows and skylight.
    d. Improved insulation levels to ensure air-tightness.
    e. Rooftop Solar PV panels to supplement the energy requirements.

   The building demonstrated that the level of efficiency which was till now attained only in new construction can now also be achieved in existing buildings.

Other examples include Atlanta City Hall where the ordinary roof was transformed into a green roof. This 11-storey Neo-Gothic building built in 1930 now has a green roof with a cafeteria and a walkout patio to enhance the ambience and spirits of the users. Chicago City Hall also converted its roof to a roof garden in the year 2001 housing more than 100 species of plants. These green roofs are beneficial in terms of protecting the structural roof from damaging UV radiation and also act as roof insulation. Intangible benefits provide the user with a relaxing and calming place that can also be used to socialize.

V. WAYS OF RETROFITTING

Green retrofitting can be done in the following ways:

1. Lighting Systems
    a. Upgrading the lighting systems from CFL to LED and other efficient lights.
    b. Integrating motion sensors or occupancy sensors with the lighting systems.
    c. Installing task lighting for workplaces.
    d. Space utilization methods.

2. Energy efficiency
    a. Installing Solar Water Panels for hot water requirements and Solar PV panels on the rooftop for Electrical requirements.
    b. Integration of other Renewable energy systems.
    c. Using high-efficiency window glass. Select the window glass based on VLT (Visual Light Transmission), SHGC (Solar Heat Gain Co-efficient) and U-factor.
    d. Installing shading devices to avoid direct solar heat gain taking into consideration the amount of natural daylight required for the space.
    e. Daylight in the interiors can be boosted by light shelves and light-colored reflective surfaces.
    f. Green roof or vegetated roof to reduce the UHIE (Urban Heat Island Effect) and also to provide rooftop insulation against heat gains.
    g. Covering open pathways or parking lots on-site with vegetation cover or canopy.
    h. Smart metering in the building to monitor the electrical and water consumption.
    i. Use of BEE star-rated appliances (in India) during building operations.

3. HVAC Systems
    a. Replacing HVAC pumps and fans with higher Co-efficient of Performance.
    b. Insulating the joints to avoid any air leakages.
    c. Wall insulation to avoid heat gain.
    d. Continuous HVAC commissioning- to monitor the efficiency of the system.
    e. Enhancing Natural ventilation by increasing the window sizes keeping in mind the amount of solar heat gain.

4. Water Efficiency
    a. Use of low-flow water supply fixtures.
    b. Facility to harvest rainwater.
    c. Using water-efficient irrigation systems for landscaping.
    d. Treated water to be reused for chillers and cooling towers.

5. Waste Management
    a. Segregating the generated waste in wet waste and dry waste.
    b. Wet waste to be treated on-site in an organic waste composter. This helps to reduce the loads on Municipal waste management systems.
    c. In case of excessive wet waste generation, setting up a biogas plant will also be beneficial.

6. Indoor Air Quality
    a. Avoiding the Sick Building Syndrome by providing appropriate air changes required for a particular place.
    b. Incorporating interior vegetation to improve Indoor Air Quality and to cool the ambient temperature.
    c. Monitoring and cleaning of AC ducts.
    d. Use of paints that have low VOC (Volatile Organic Compound) value.

VI. CONCLUSION

This Chapter attempts to rationalize and strengthen the thoughts on green retrofitting of the existing buildings. It is a valuable step on our path toward NetZero. Though the intangible benefits of green retrofitting remain undocumented, the examples seen in this chapter demonstrate how small changes in the building's system and material can lead to a big positive impact on the environment. The initial investment in retrofitting may seem a large amount but the energy savings are around 20-40% of the previous energy consumption. These annual cost savings in energy consumption are economically viable for a developing country like us. Existing buildings can be taken up for stage-wise upgradation and the energy savings can be monitored. The decision on retrofitting will address climate change and carve a way for a sustainable future. We have to always remember that we have only one Earth and it is our shared responsibility to protect the planet.

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