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Evaluation of Energy-Efficient Retrofit Potential for Hospitals in India

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Abstract

Energy efficiency and energy conservation play a key role in building a growing economy like India. India is continuously producing and using a large amount of energy 21% is attributed to the commercial sector. Hospitals in India's energy consumption growth rates are 12-15%, so this demand for energy consumption is only going to rise. Therefore, energy retrofitting is a pressing need of the hour. This paper aims to evaluate the various possible retrofitting options from an architectural point of view that can be applied to the building envelope. The insights to be used in the retrofitting model include wall insulation, roof insulation, and double-glazing windows. The energy consumption of the hospital is evaluated with the help of the Energy Performance Index (EPI) and then all potential options of retrofitting are considered. Then, the simulation model is built for the hospital chosen for the case study with all the measures that would bridge the gaps that are identified during the evaluation. Then, the energy usage is calculated for every retrofit measure applied. The chosen case study is the Trauma Centre, Jawaharlal Nehru Medical College, Aligarh. The finding shows that retrofitting will prove to be energy efficient.

Discipline: Architecture Science (Green & Healthcare Architecture), Energy Management; Sustainability; Hospital Management.

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1 Introduction

India is one of the largest growing economies in the world, consuming and building a huge amount of energy. Maintaining the economy in its best possible state has several angles to it. Energy conservation and energy efficiency are the prime factors that play a key role in building the economy. Accelerating the process of energy efficiency is the need of the hour. Currently, buildings consume about 35% of the total energy produced Around 9% of the total energy consumption is by the commercial sector (Evans, 2015). The Healthcare industry is the prime focus of energy consumption because they are operational throughout the day (Chakraborty, 2020).

In India, hospitals contribute 2-3% of total energy consumption, and the hospital building growth rate is 12-15% in the last decade (Teja, 2016). The World Health Organization (WHO) estimated that India needs 80,000 additional beds every year to meet the demands of India's population (Teja, 2016). In a growing economy like India, energy-efficient retrofitting of existing hospitals is required to improve its energy security and minimize greenhouse gases.

To address the cause of energy efficiency while maintaining the best possible living conditions for patients requires attention to the retrofitting of the envelope of the old buildings and not just on the designs of the new buildings (Dandia, 2021). For sustainability, destroying and rebuilding retrofitted hospitals is a challenging task.

Renovation, retrofit, and refurbishment are among the initiatives utilized to improve energy consumption performance in healthcare buildings. Retrofitting can result in improved energy consumption and reduced energy demand (Pan, 2007). Designing strategies for lessening the emission of greenhouse gases has been under focus by the government since the signing of the Kyoto Protocol (Communities, 2009). The best possible method to overcome this enormous emission of energy and meet the worldwide energy consumption demand is to come up with alternative renewable energy options (Reddy, 2021).

According to the Press Information Bureau (PIB) report of 2012, hospitals have a great potential for saving energy as most hospitals are built on the same base plan. Consequently, it is easier to develop a retrofitting plan that will be applied to several hospitals. Bringing this plan into action is challenging though and requires strategic excellence (Chakraborty, 2020). Using BIM or building simulation models are the most effective and relevant techniques to do the same.

2 Literature Review

India is one of the largest growing economies in the world, consuming and building a huge amount of energy. Maintaining the economy in its best possible state has several angles to it. Energy conservation and energy efficiency are the prime factors that play a key role in building the economy. Accelerating the process of energy efficiency is the need of the hour. One of the best options to address low building energy efficiency is the implementation of energy renovation strategies (Grillone, 2020).

Various case studies of energy audits in office building hospitals of India have indicated that energy saving potential of 20-50% in electricity end uses such as lighting, cooling, ventilation, etc. (USAID, 2009)

The best way is to renovate the building to reduce electricity consumption and therefore greenhouse gas emissions. (Monna, 2021). Retrofit measures lower the building's energy load by 39% (Alazazmeh, 2021). The energy consumed in buildings can be reduced by reducing energy loss, particularly through the building envelope. (Kamel, 2022)

Ardente et al. (2011) indicated that the most significant benefits of energy consumption assessment were the improvement of envelope thermal insulations, lighting, and glazing.

This study proceeds in the following manner: the selected buildings are first evaluated, compared with the standards, and reviewed for potential retrofitting options emphasizing the building envelope and then the reviewed options are implied on the selected building by building a potential model on the simulation software Rhino 7 with Climate Studio.

3 Method

3.1 Case Study

This research includes a careful analysis along with an investigation of the Trauma Centre at Jawaharlal Nehru Medical College, Aligarh. The Trauma Center building is located in Aligarh Muslim University, Aligarh, Uttar Pradesh. The total ground floor area is 2327 m^2 and the total Built area is around 6892 m^2. It is a three-storied building G+2.

The outer wall is 230 mm thick using clay brick and has both sides plaster, U-value is 2.13 W/m^2K, and the roof is a flat concrete slab with thick brick tilling over it (U-value is 2.07 W/m^2K). Windows are 6mm thick single glass and have an aluminum frame (U-value is 7.1 W/m^2K)

3.2 Energy Evaluation

Primarily, energy analysis is to be performed to get an idea of the total consumption of energy in the hospital. For, doing so, first of all, a simulation model using Rhino 7 and Climate Studio 1.9 is built with the present specifications of the building and it is then used to determine the Energy Performance Index (EPI) of the hospital.

The Energy Performance Index (EPI) is an excellent tool to track and compare the performance of energy consumption in buildings. EPI is tied to the size of the building because the energy used is calculated based on total floor space (Bakar, 2015). After this extensive data collection and detailed evaluation, using some technical input a base plan is prepared which is to be acted upon to bridge the gaps that were identified.

3.3 Retrofitting Options

Several retrofitting options for different features like the window roof and external wall of the building are identified. Potential options can be adding thermal insulation for external walls and roofs, for this, external thermal Insulation Composite Panel ETICS, U-value is .252 W/m^2K, is used. Replace all windows with double low E 3mm,13mm air gap windows, U-value is 1.53 W/m^2K, and add some extra projection to the windows. Simulation models are built using those inputs; they are then compared to make out the most viable one, which provides maximum energy efficiency.

4 Result and Discussion

4.1 Base case

A base model is prepared for simulation, and it has the following specification.

- The outer wall is 230 mm thick using clay brick and having both side plaster, U-value is 2.13 W/m^{2}K,
- The roof is flat concrete slab thick brick tilling over it (U-value is 2.07 W/m^{2}K).
- Windows are 6mm thick single glass and having aluminum frame (U-value is 7.1 W/m^{2}K)

As per Simulation result shown in Figure 1 EPI for base model is 289KWh/M^2/Yr

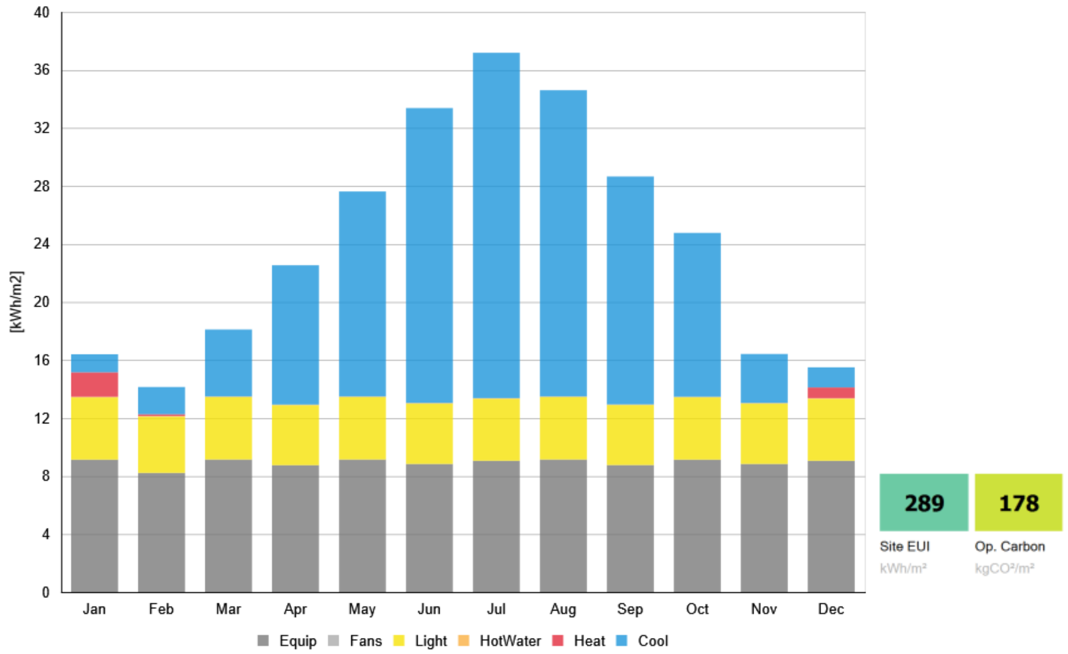

Figure 1: EPI for Existing Building

4.2 Roof Insulation

Polyurethane spray 30 mm-42 ± 2 kg/m^3 (U-value is 0.579 W/m^{2}K) is used. As per the simulation result in Figure 2, EPI for this case is 272KWh/M^2/Yr.

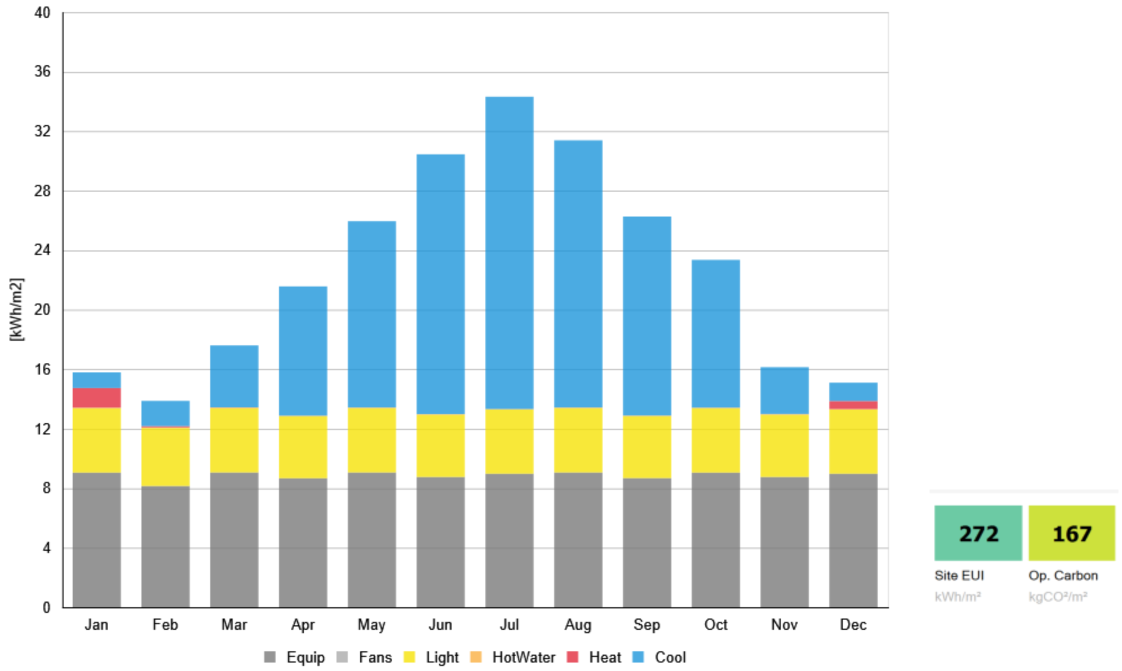

Figure 2: EPI for Existing Building with Roof Insulation

4.3 Replacing Windows

Double Glazing 13mm air Gap windows (U-value 0.579 W/m²K) are replaced with existing windows in the base model and As per the Simulation result in Figure 3, EPI for this case is 271KWh/M²/Yr.

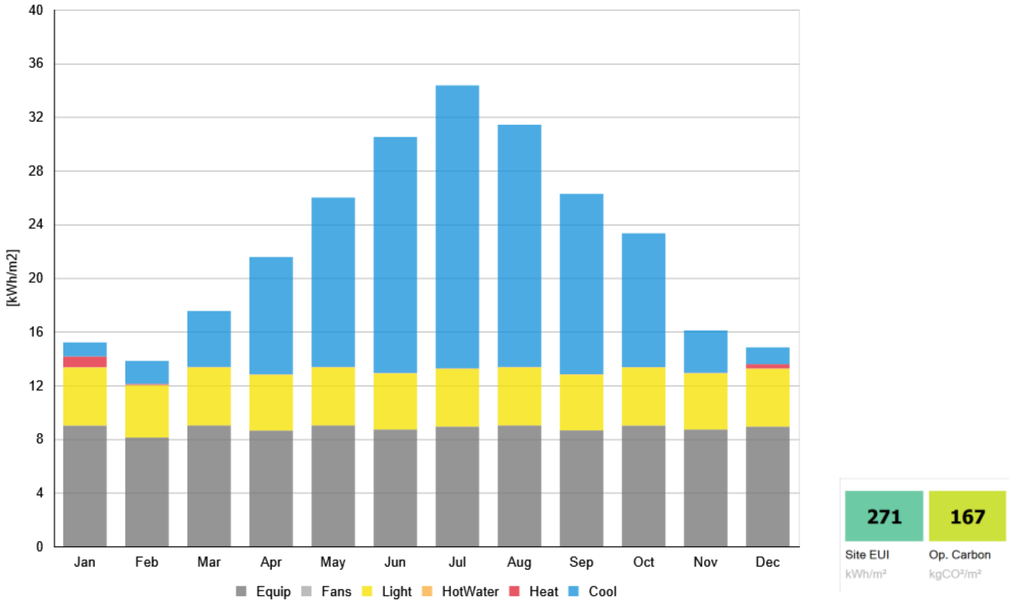

Figure 3: EPI for Existing Building with Roof Insulation + Replacing Windows

4.4 Insulation in the Outer Wall

External Thermal Insulation Composite System ETICS (U-value is 0.252 W/m²K) is use in the exterior wall from outside in the base model and As per Simulation result shown in Figure 4 EPI for this case is 215KWh/M²/Yr. After using all retrofitting fitting option discussed in this paper EPI saving is 74 KWh/M²/Yr.

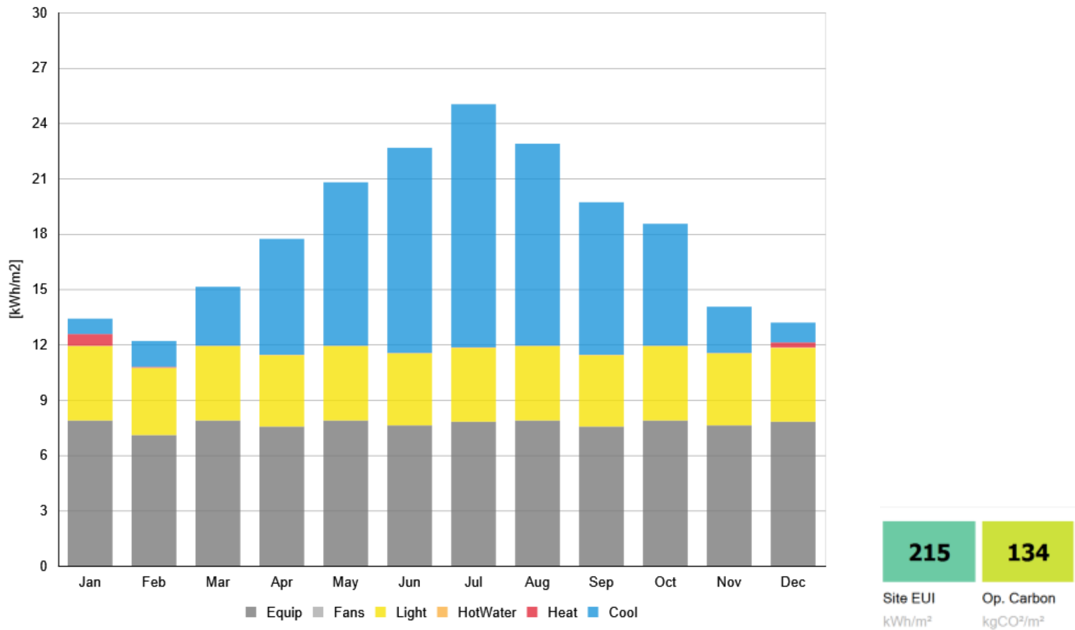

Figure 4: EPI for Existing Building with Roof Insulation +Replacing Windows + Outer Wall insulation

5 Conclusion

Wall insulation is most effective for energy conservation and replacing double-glazed Windows is not a good retrofitting option in this particular case because the Window Wall Ratio WWR is less than 25%. If the WWR is more than 50% then replacing Windows may be the better option. In the case of terracing insulation, energy conservation is seen but not effective when we compare it with the insulation in the outer wall. It is recommended in a future study that other retrofitting options are also evaluated.

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