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Design and Planning of Energy Efficient Building: A Critical Review

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ABSTRACT:
The need for energy efficient buildings has grown in response to growing concerns about the negative effects of buildings on the environment and the requirement to provide users with thermal, visual, auditory, spatial, and indoor environmental air quality comfort. To identify and categorise energy efficiency design, planning, and construction, this work used a review of papers published between 2007 and 2019. The data was gathered at random using the internet's Science Direct and Google Scholar search engines, and then analysed using theme textual analysis. The findings identified energy-efficient landscape designs, site selection, building orientation, building plan, and appropriate space organisation were among the strategies classified. Building envelope systems, building orientation, renewable energy integration, and day lighting design methods were also found to be the most widely used in buildings, according to the research. The review concludes by noting the important areas of attention in energy efficiency design methods for buildings, the amount to which research on the subject has developed, and future probable approaches on the matter.

KEY WORDS: Buildings, Energy Efficient Design strategies, Sustainability

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I. INTRODUCTION

The construction industry today is undergoing through green revolution (Gou, Prasad, & Lau, 2013). Since, global warming has become a very hot topic, and turning to more energy efficient design and construction is one of the best methods to prevent its negative impacts on the environment. We can greatly reduce the number of greenhouse gases discharged into the environment by reducing the number of natural resources, land, raw materials, and energy we use in and for building. The process of constructing a building that prioritises energy efficiency begins with knowing the proper design strategy, while also taking into account the surrounding climate and particular characteristics within the area. An energy-efficient construction provides acceptable living conditions within the home with the least amount of energy usage feasible, increasing resource efficiency. Measures to make a building more energy efficient span the whole lifecycle of the structure, from the construction phase to the operation and maintenance stages to the destruction phase. Buildings that are energy efficient are completely functioning and thermally comfortable for their residents. With the cost of energy rising and a potential energy crisis looming, the demand for energy-efficient building designs is becoming more critical. Buildings consume the second-highest amount of energy after industry, according to energy statistics data available for India from the Ministry of Statistics and Program Implementation in 2017. By providing an optimal mix of passive solar–design solutions, energy-efficient technology, and renewable resources, an energy-efficient building balances all aspects of energy use in a building. As a result, different countries have been developing building codes with focus on energy efficiency design solutions. Many of such codes have taken cognizance of the use of bioclimatic design concepts and principles and the incorporation of several energy efficiency saving measures with the overall target of making office buildings more energy efficient and at the same time promoting the comfort and health of users of such buildings

II. REVIEW OF AVAILABLE LITERATURES

According to Dewey, A. & Drahota, A. (2016). a systematic review of literature helps to identify, select and critically appraise research in order to answer clearly formulated question(s). For the researcher, a good understanding of the available literature is a must as it supplements and compliments the study. In this section, an attempt is made to review the literature available on Design and Planning of Energy Efficient Building with a view to exploring different views and perspectives taken by various thinkers and experts and are arranged chronologically under various themes.

Concept of Energy Efficiency

Energy efficiency is an important part of the global effort to reduce CO_2 emissions, with the goal of reducing primary energy use by 11 percent to 20 percent in the next ten years and 30 percent to 41 percent by 2050. According to these goals, **Chegut, A., Eichholtz, P., & Kok, N, (2019)** have explained that energy usage in buildings refers to the amount of energy used for heating, ventilation, and lighting.

Speer, B., Miller, M., Schaffer, W., Gueran, L., Reuter, A., Jang, B., & Widegren, K. ,(2015) defined energy efficiency as "the efficient use of energy to facilitate economic growth and social development while also promoting the health and well-being of occupants with little or no negative impact on the environment.

Kumbaroğlu, G., & Madlener, R. , (2012) added to the concept of Speer, B., Miller, M., Schaffer, W., Gueran, L., Reuter, A., Jang, B., & Widegren, K. by stating that as the global climate changes, countries are beginning to shift their ideas about energy use and how fossil-based energy harms the environment.

Li, J., & Colombier, M.(2009) suggests that the worldwide community has begun to insist on attempts to standardise solutions that make it essential for the built environment to be more energy efficient as a means of mitigating the consequences of global climate change. From the foregoing, it is clear that the authors agree that energy efficiency simply implies using the least amount of energy possible to obtain the best results. It is, to put it plainly, the removal of waste in the utilisation of energy by various writers.

Clark, W.W., Gibson, R., Barth, J. and Bonato, D. (2019) pointed out that because energy efficiency methods are incorporated into equipment and appliances, they result in long-term reductions in electricity consumption.

Tonn, B. & Carpenter, P. (2008) noted that various energy-efficient technologies have been invented, and several, such as refrigerators, clothes washers and dryers, hot water heaters, electronics, and lighting systems, can now be found in households all over the world.

Energy Efficient Building

Geissler, S., Österreicher, D., & Macharm, E. (2018) in their study revealed tha**t** the fast rise in temperature in metropolitan areas, as well as the increased risk of global warming and climate change, are among the reasons why energy efficient buildings are more important now than ever before.

Gosztonyi, S., Brychta, M., & Gruber, P. (2010) reported the Other adverse effects of climate change that have been recorded, including an increase in solar heat radiation that penetrates the inner area of buildings through holes in walls, roofs, and fabrics, causing overheating and discomfort.

According to Hong, **T., Taylor-Lange, S. C., D'Oca, S., Yan, D., & Corgnati, S. P. (2016)** buildings are the main perpetrators, accounting for one-third of greenhouse gas emissions and their detrimental impact on the environment. Buildings are said to account for one-third of global CO_2 emissions. Based on this idea, energy efficient buildings have been defined as structures that reduce energy use while also ensuring user comfort.

Szumilo, N., & Fuerst, F. (2017) elucidate in their study that to create energy efficient structures, super insulation of the building envelope systems, good controlled ventilation with heat recovery systems, and effective energy consumption system optimization are all required. Having effective energy efficient appliances and equipment systems, as well as the utilisation of natural resources such as renewable energy, and having very effective remotely controlled electrical appliance systems, are examples of these.

According to **Davenport, C. (2018)** the fundamental objective of establishing a building structure, is to provide a habitation or house for a man in order to protect him from the vagaries of the environment. This means that structures are designed and constructed with the primary goal of providing occupants with a level of comfort that allows them to perform efficiently.

El-Darwish, I., & Gomaa, M. (2017) in their study pointed out that Thermal and visual comfort are two of the many categories of comfort that building occupants are expected to enjoy. Due to which building professionals have recently become more aware of climate change and issues relating to energy use in buildings, as well as their ability to ensure that energy is used efficiently to provide occupants with acceptable levels of thermal and visual comfort.

Authors **Clifford, R., Mills, J., & Gratz, M. (2008)** and **Hong, T., Taylor-Lange, S. C., D'Oca, S., Yan, D., & Corgnati, S. P. (2016**) observed that Energy efficient buildings are first and foremost related with lower maintenance costs, a reduction in negative environmental effect, and a reduction in CO_2 emissions connected with building operations, all of which contribute to climate change. Second, by decreasing the consumption of natural resources such as energy, land, water, and depletable materials during their entire life cycle, they help to limit additional damage to the ecosystem. These could explain why the necessity for energy efficient buildings has been a topic of debate among authors from various research and academic backgrounds.

Energy Efficient Design Strategies

The research indicated that there are numerous technologies available that enable the construction of energy-efficient structures. Building energy efficiency design methods relate to the measures and features that are integrated during the design stage of a building to ensure that it uses less energy for lighting, heating, and ventilation. Building energy efficiency design solutions can be implemented from the start of a project or when upgrading older and existing structures.

Day, J. K., & Gunderson, D. E. (2015) in their literature noted that existing building rules and company policies that emphasise environmental protection have popularised energy efficient design solutions in structures in general and office buildings in particular.

Levine, M., D. Ürge-Vorsatz, K. Blok, L. Geng, D. Harvey, S. Lang, G. Levermore, A. Mongameli Mehlwana, S. Mirasgedis, A. Novikova, J. Rilling, H. & Yoshino (2007) found that there are numerous strategies for improving building energy efficiency, including but not limited to effective sustainable urban planning, optimised site planning and design, including natural ventilation and appropriate orientation; solar, geothermal, and other renewable energy integration, bioclimatic architectural design, and enhanced mechanical ventilation with optimised heat recovery system.

Gosztonyi, S., Brychta, M., & Gruber, P. (2010) suggested bioclimatic designs, mixed-mode (natural and mechanical) ventilation systems, and an optimal wall-to-wall ratio as solutions for reducing HVAC loads and making office buildings more energy efficient. On the one hand, **Hor, K., & Rahmat, M. K. (2018)** put forward that the energy demand in buildings are influenced by the facade features and design elements. **Raji, B., Tenpierik, M., & van den Dobbelsteen, A. (2017)** proposed a mix of strategies consisting building orientation, facade design treatment, strategic landscape, space planning, natural ventilation, natural lighting, and sun shading design.

Day, J. K., & Gunderson, D. E. (2015) found that lights, space heating, cooling, ventilation, and water heating account for the majority of energy utilised in buildings. Building energy consumption is influenced by a variety of elements, including climatic conditions, building design, building envelope, occupant behaviour, systems and controls, and maintenance, according to these writers.

Nwofe, P. A. (2014) stated that in order for a building to be energy efficient, it must follow a method that uses less energy for its functional requirements of cooling and lighting while ensuring comfort and the well-being of the structure's users. All of the aforementioned measures, in particular, can help to ensure that buildings use less energy while delivering considerably better thermal and visual comfort to inhabitants.

III. CONCLUSION

From the literature review, it is to be noted that the construction sector is one of the most important economic activities and yet there appears to be a dearth of purposeful effort in identifying and defining existing solutions applicable to various building typologies to serve as a reference for building designers and developers on the possibilities available. These have, among other things, muddled our awareness of the number of techniques available and the various groups into which they can be categorised; second, they have contributed to a lack of comprehension of the research trend on the issue. Because the industry is quickly expanding, environmental preservation provides a number of issues while also providing opportunity for diverse stakeholders. Most of green building studies focuses on environmental aspects of sustainability such as energy consumption, water efficiency and greenhouse gas emission together with the technical solutions, whereas the studies on social and economic aspects of sustainability are comparatively lean, despite a large number of literatures emphasizing their importance. The building and operation of a healthy, resource-efficient constructed environment based on ecological principles is known as sustainable construction. Resource efficiency, environmental protection, and waste minimization are all highlighted. One of the simplest, quickest, cheapest, and cleanest methods to address energy and environmental concerns is to improve energy efficiency. Buildings that use modest energy-saving techniques can save a significant amount of electricity. Appropriate knowledge and technology

are available to create energy efficient and green buildings, but overcoming behavioural, organisational, and financial barriers is required to achieve the desired results.

The construction industry must embrace environmentally friendly practises that will aid in the creation of new jobs, as well as offer exciting case studies from India and other parts of the world. This will also aid in the transition to more sustainable economies and societies, such as those based on renewable energy, waste reduction, and green construction. With the growing number of green projects, going green has a bright future.

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