https://doi.org/10.36375/prepare_u.iiche.a396

Carbon Footprint Reduction from Construction Industry: A Review

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Abstract

The building sector is one of the largest contributors to greenhouse gas emission in urban areas. Quantitative assessment of the carbon footprint of urban buildings is needed for advance research and policy debates on building carbon emission reduction and sustainable architectural planning. Businesses are now attempting to reduce their negative effects on the environment by incorporating environmental considerations into their supply chain processes. The review emphasizes the significance of optimizing construction processes to minimize energy consumption and waste generation. The use of low-carbon materials such as recycled and locally sourced materials, as well as the implementation of energy-efficient designs, can significantly reduce carbon emissions. Additionally, the incorporation of renewable energy sources, such as solar and wind power, can further minimize the environmental impact. With a variety of problems faced by designers and planners, the practices taken to reduce carbon footprints are very diverse. As global concerns about environmental sustainability grow, there is an urgent need to reduce the carbon footprint associated with construction activities. This review explores various strategies and technologies that have been employed to mitigate carbon emissions throughout the construction lifecycle. By adopting sustainable practices and technologies, the construction industries can play a vital role in carbon footprint reduction.

Keywords: Greenhouse gases; Carbon footprint; Construction Lifecycle; Supply Chain Operations; Low-carbon materials.

1. Introduction

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The global construction sector plays a pivotal role in shaping society's infrastructure and buildings but is accompanied by a significant environmental impact, consuming substantial amounts of non-renewable energy and contributing to elevated carbon dioxide (CO_2) emissions [1]. Increased greenhouse gas emissions in the industrial age, caused primarily by human activities, pose a serious threat to the global environment Due to the use of fossil fuels and desertification increased, these emissions, especially carbon dioxide (CO_2), contribute to climate change. As CO_2 levels rise, broader environmental risks, agricultural instability, and potential public health challenges intensify [2]. The relentless growth in worldwide average atmospheric temperature, attributed to human-driven emissions of heat-trapping greenhouse gases, has resulted inside the pervasive phenomenon of global warming. Urbanization, a key contributor to this anthropogenic affect, has appreciably propelled CO_2 emissions inside the constructing quarter. As a vital aspect of economic and social improvement, the constructing region, spanning creation to operation, has emerged as a major environmental problem, accounting for a tremendous component of global CO_2 emissions [3]. This paper gives an assessment of the challenges, environmental affects, and mitigation strategies critical for curbing CO_2 emissions inside the dynamic realm of urban improvement and construction.

2. Literature Review

Globally, construction and building operations contribute significantly to environmental issues, responsible for 33% of greenhouse gas (GHG) emissions and 40% of global energy consumption. The increasing urban population is expected to fuel future construction, intensifying GHG emissions. Policies like building codes can effectively reduce emissions, but criticisms include complexity and lack of flexibility. Alternatively, a carbon tax, with lower administrative costs, appeals to stakeholders for its simplicity. However, setting an appropriate tax rate is challenging, and public opposition may hinder its effectiveness [4]. The sustainable advancement of the building sector faces a critical challenge with the substantial carbon dioxide (CO_2) emissions from non-sustainable energy sources during planning, construction, and operations. The reliance on fossil fuels, constituting 40% of global greenhouse gas emissions in

construction, overshadows the 6% contribution from renewable energy sources. Efforts to reduce the CO_2 footprint in high-density urban areas remain insufficient. Indirect CO_2 emissions from electricity use dominate, accounting for 85% globally, while direct emissions constitute 14%. Meeting the 2030 Climate and Energy Framework goals necessitates addressing low productivity and efficiency through detailed evaluations of construction and operation processes across the building's life cycle [3]. This escalating emission of greenhouse gases, particularly carbon dioxide (CO_2), surpasses agreed-upon safe levels, posing severe threats such as disruptive weather disasters, agricultural instability, and public health challenges. The concept of a carbon footprint, originating in the 1990s, measures the cumulative greenhouse gas emissions, expressed in tons of CO_2 equivalents per year, produced by individuals, companies, or activities. Greenhouse gases, encompassing various compounds, including CO_2 and methane, stem from diverse processes like fossil fuel combustion, manufacturing, land-use practices, and transportation, with associated pollutants impacting living organisms [5].

3. Carbon Emissions in Construction Industry

The global construction sector contributes 5.5% of total CO_2 emissions, with 99.5% of its direct energy use derived from fossil fuels, mainly for on-site construction operations. Improving energy efficiency and optimizing construction machine operations offer significant potential for reducing direct carbon emissions. Indirect carbon emissions, dominated by non-renewable energy resources (85%) and non-energy use (14%), highlight the importance of addressing materials in the construction sector. Imported inputs, especially from higher carbon-intensity countries, contribute to carbon embodied in domestic construction. Strategies to mitigate carbon emissions include enhancing energy efficiency, adopting a renewable energy mix, and encouraging innovation, particularly in emerging economies like China, which plays a crucial role in the global construction sector's carbon mitigation efforts. Cement production, a major source of non-energy use CO_2 emissions, requires strategies like energy saving, carbon separation, and carbon capture and storage for decarbonization. Policy development is essential to overcome barriers

and challenges, especially economic factors and legislation, in implementing carbon capture and storage solutions [1]. Despite proposed innovative methods for mitigating carbon footprints, especially in dense urban areas, the issue persists. A critical factor is the direct correlation between non-sustainable energy use and environmental impact, with construction activities emitting CO_2 both directly and indirectly. Addressing this challenge involves meticulous evaluation and optimization of construction and operation processes throughout a building's life cycle, aiming to enhance productivity and efficiency while aligning with global sustainability targets [3]. Managing carbon emissions is crucial across various stages of a building's life cycle. The product stage involves upstream emissions from raw material extraction, manufacturing, and transportation. Building lifespan significantly impacts embodied emissions, with longer lifespans correlating to lower emissions. Material nature, such as cement and steel, plays a pivotal role, with virtual and physical carbon considerations. The choice of energy in manufacturing also influences embodied emissions. Construction stages involve emissions from material transportation and on-site activities, with fossil fuel use being a primary contributor. The operational phase contributes the majority of CO_2 emissions, influenced by factors like energy source and user behavior. Additionally, end-use and demolition phases have minimal green-house gas contributions, with recycling presenting a potential for further emission reduction [6].

4. Technological Innovations and Sustainable Practices

Carbon footprint management is a critical process aimed at mitigating the environmental impact of human activities, particularly in the construction industry. Many countries have implemented strategic policies to reduce carbon emissions and energy consumption. Green building practices, such as sustainable construction and the use of eco-friendly materials, are key strategies for achieving emission reduction targets. Various rating systems, like LEED and BREEAM, play a crucial role in setting standards and promoting sustainable building efficiencies globally. The construction sector's significant contribution to greenhouse gas emissions underscores the need for innovative solutions. Utilizing low-carbon cement, recyclable materials, and

implementing efficient waste management practices are highlighted as effective strategies. Furthermore, reducing transportation-related emissions, optimizing energy usage, and incorporating green land conservation practices contribute to a more sustainable construction industry. Despite efforts in developed countries, there's a slower adoption of green building concepts in developing nations, emphasizing the importance of global collaboration in advancing technological innovations and sustainable practices for a greener future [5]. Technological innovation plays an important role in reducing the environmental impact of the construction industry on the environment in pursuit of sustainable construction practices One prominent approach is to incorporate or replace traditional clinker materials for cement production, reducing energy consumption and CO_2 emissions, and new clinker chemistry offers an environmentally friendly alternative than conventional Portland cement. By incorporating additives such as fly ash and silica fume, lightweight concrete not only improves the quality of buildings but also contributes to a significant reduction in CO_2 emissions Furthermore, materials a reused-materials, such as recycled asphalt pavement and recycled concrete aggregates promote sustainable development in construction. The adoption of energy-efficient technologies, like fluidized bed kilns and oxy-fuel technologies, demonstrates a commitment to lowering energy consumption and emissions in cement production. Moreover, innovations in building materials, such as magnesium oxide as an alternative to calcium-based binders in clay bricks, contribute to lower carbon footprints. The focus extends beyond the construction phase, emphasizing the importance of efficient building operations through energy-efficient HVAC systems, water-saving technologies, and renewable energy integration. The construction project aims to create a resilient and environmentally friendly built environment while recognizing these sustainable practices and technological advancements [4].

5. Conclusion

In conclusion, this review paper explores the critical concept of reducing carbon footprints within the construction industry. It gives a brief evaluation of various strategies for promoting sustainable improvement. The construction sector, acknowledged for its great

contribution to worldwide carbon emissions, is at a crossroads that demands transformative measures. The paper highlights key techniques which include the use of green materials, modern construction techniques, and the inclusion of renewable energy sources as possible pathways to scale down carbon footprints. Additionally, it underscores the significance of adopting life cycle tests to gauge the general environmental effects. The review emphasizes the need for collaborative efforts among policymakers, industry professionals, and stakeholders to strengthen sustainable practices. The potential blessings amplify past environmental conservation, encompassing economic viability, public health, and societal well-being. Embracing sustainable practices is portrayed not simply as an ethical preference however as a crucial step toward carbon footprint reduction and environmentally responsible future within the ever-evolving creation landscape.

Acknowledgments

The author would like to acknowledge the help and support of Department of Chemical Engineering of Calcutta Institute of Technology. I have not used any financial support from anywhere although I am thankful to our Respected Director Academics for his constant encouragements throughout the project.

Statements & Declarations

Funding

"The author declares that no funds, grants, or other support were received during the preparation of this manuscript."

Competing Interests

"The author has no relevant financial or non-financial interests to disclose."

Author Contributions

"All authors contributed to perform the literature survey and to find the appropriate research gap for the present review study and literature survey was performed by [Sohel Baidya]. The first draft of the manuscript was written by [Sohel Baidya] and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript."

References

1. Huang, L., Krigsvoll, G., Johansen F., Liu, Y., Zhang, X., (2017). Carbon emission of global construction sector. *Renewable and Sustainable Energy Reviews (2017).* http://dx.doi.org/10.1016/j.rser.2017.06.001.

2. Labaran, YH., Mathur, VS., Farouq, MM., (2021). The carbon footprint of construction industry: A review of direct and indirect emission. *Journal of Sustainable Construction Materials and Technologies. 6. 101-115.* http://dx.doi.org/10.29187/jscmt.2021.66.
3. Ahmed, Ali, K., Ahmad, MI., Yusup, Y., (2020). Issues, Impacts, and Mitigations of Carbon Dioxide Emissions in the Building Sector. *Sustainability, 12, 7427.* https://doi.org/10.3390/su12187427.
4. Sizirici, B., Fseha, Y., Cho, C.-S., Yildiz, I., Byon, Y.-J., (2021). A Review of Carbon Footprint Reduction in Construction Industry, from Design to Operation. *Materials, 14, 6094.* https://doi.org/10.3390/ma14206094.
5. Labaran, YH., Mathur, VS., Muhammad, SU., Musa, AA., (2022). Carbon footprint management: A review of construction industry. *Cleaner Engineering and Technology, Volume 9, 100531, ISSN 2666-7908.* https://doi.org/10.1016/j.clet.2022.100531.
6. Fenner, AE., Kibert, CJ., Woo, J., Morque, S., Razkenari, M., Hakim, H., Lu, X., (2018). The carbon footprint of buildings: A review of methodologies and applications. *Renewable and Sustainable Energy Reviews, Volume 94, Pages 1142-1152, ISSN 1364-0321.* https://doi.org/10.1016/j.rser.2018.07.012.