

# Integrating Low-Carbon And Sustainable Materials In Archiving Net-Zero Carbon Building Design

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## Abstract

*Buildings account for a huge share of global greenhouse gas emissions, with construction materials being a major contributor. This research explores the role of low-carbon and eco-friendly materials in achieving net-zero emissions while maintaining safety, durability, and cost-effectiveness. It highlights the need to balance material innovation, long-term sustainability, and compliance with building regulations. The study identifies opportunities and challenges in adopting sustainable materials, providing valuable insights for architects, engineers, and policymakers to advance sustainable construction and support global decarbonization efforts.*

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## I. Introduction

The construction industry accounts for a significant share of global carbon emissions, contributing approximately 37% of total greenhouse gas emissions annually (IEA, 2022). This impact is largely driven by the use of carbon-intensive materials like cement, and steel, as well as the energy demands of buildings throughout their lifecycle. As global efforts to mitigate climate change keep rising, achieving net-zero carbon (NZC) in building design has become a critical goal for architects, engineers, and policymakers.

This project investigates the role of low-carbon and sustainable materials in achieving NZC building designs, emphasising their application in aquatic centres. These materials, such as cross-laminated timber (CLT), geopolymer concrete, and recycled aggregates, offer significant reductions in embodied carbon without compromising structural integrity or functionality.

By focusing on the integration of these materials and technologies, this study aims to address key challenges, including high initial costs, resource availability, and technical feasibility, while identifying opportunities for long-term savings and lifecycle sustainability. This technical project is aligned with the 6050 EXQ Design Project and aspires to create a sustainable aquatic facility that aligns with global Net Zero Carbon (NZC) targets while enhancing community and functional value.

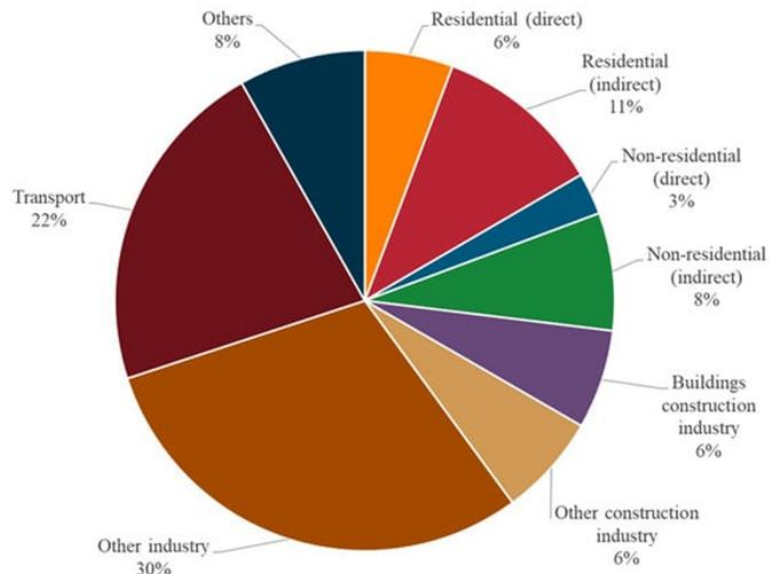
## II. List Of Abbreviations

Abbreviation	Meaning
CO <sub>2</sub>	Carbon dioxide
NZC	Net Zero Carbon
BIM	Building Information Modelling
CLT	Cross Laminated Timber

## III. Literature Review

### Low-Carbon Materials and Their Role in Net-Zero Carbon Building Design

Low-carbon materials such as bamboo, geopolymer concrete, and recycled or repurposed materials are increasingly recognized as sustainable alternatives to traditional carbon-intensive materials like steel and Portland cement. These materials offer substantial environmental benefits, with lower carbon footprints and greater potential for recycling and reuse, contributing significantly to the reduction of both embodied and operational carbon emissions.



**Figure1.** Global energy and process emissions from buildings, including embodied emissions from new construction. From IEA (2022)

Brownell (2020) emphasizes that biobased materials, including Hempcrete and Cross-Laminated Timber (CLT), play a key role in achieving Net Zero Carbon (NZC) building design. These materials are valuable not only for their ability to reduce carbon emissions but also for maintaining the necessary strength and durability in construction, often replacing more carbon-heavy alternatives like steel and concrete. CLT, for instance, is a low carbon alternative to steel as it sequesters carbon during its growth and use, providing a carbon-negative option (Brownell, 2020).

In addition to material choices, operational carbon emissions can be significantly reduced through the use of high-performance insulation, reflective roofing, and photovoltaic-integrated materials. These strategies not only improve a building's energy efficiency but also help support passive cooling, natural ventilation, and the generation of renewable energy on-site. The combined effect of these strategies enhances the overall sustainability of a building, aligning it with NZC goals (Liang et al., 2012).

#### **Economic and Technical Considerations of Net Zero Carbon Buildings**

Despite the clear environmental advantages, the widespread adoption of low-carbon materials is often hindered by economic and technical challenges. The primary barrier is typically the higher upfront cost of these materials, influenced by factors like transportation costs and material availability. However, research by Siegner and Searcy (2021) highlights that while the initial investment is higher, the long-term benefits outweigh the costs. These benefits include energy savings, waste reduction, and lower maintenance costs over the building's lifespan, which significantly reduce the total cost of ownership. Moreover, sustainable building certifications and financial incentives, such as tax credits for energy-efficient designs and green building certifications, can help alleviate the initial financial burden and encourage the adoption of low-carbon materials (Siegner & Searcy, 2021).

The transition to net-zero carbon buildings, therefore, requires a careful balance between short-term costs and long-term savings. As the market for low-carbon materials grows, economies of scale and innovation will likely reduce costs, making these materials more accessible and economically viable for a broader range of construction projects.

### **IV. Case Study**

#### **London Aquatics Centre – Integrating Low-Carbon and Sustainable Materials in Net-Zero Building Design**

London Aquatic Centre is a building that is into practical application of sustainable materials and energy-efficient designs in a commercial building. This building demonstrates how innovative architectural solutions can reduce carbon emissions while maintaining functionality and structural integrity.

The London Aquatics Centre embodies several sustainable design principles that align closely with the aspirations for creating a sustainable aquatic centre as part of the Design Project 6050 EXQ.

The facility integrates low-carbon materials, such as Timber, recycled concrete aggregates and fly ash, replacing traditional cement to significantly reduce embodied carbon emissions (MPA The Concrete Centre 2012). The London Aquatics Centre features an advanced water management system that combines water recycling for

pool filtration with rainwater harvesting, significantly reducing the reliance on potable water. Additionally, the facility is connected to the Queen Elizabeth Olympic Park's district heating and power network, which lowers operational carbon emissions (Construction21, 2012).



Figure 2. Perspective view of the London Aquatic Centre, showing its timber ceiling structure. From Zaha Hadid Architects (2011)

The centre's adaptability demonstrates a sustainable lifecycle approach, as its post-Olympics reconfiguration supports both community and competitive use, minimizing waste and prolonging its operational lifespan. These design strategies serve as inspiration for my project, providing a roadmap for achieving a green, sustainable aquatic space that fosters environmental stewardship and resource efficiency while catering to the needs of its users.

## **V. Project Proposal**

### **Aim and Objectives**

This report aims to investigate the integration of low-carbon and sustainable materials into modern buildings to achieve net-zero carbon targets while maintaining structural strength, cost efficiency, and compliance with modern building standards. It aims to investigate the application of these materials in building design, to reduce environmental impact while ensuring functionality and structural standards.

### **Justification**

As the construction industry seeks to reduce CO<sub>2</sub> emissions globally, sustainable materials play a critical role by lowering embodied and operational carbon, promoting resource efficiency, and aligning with net-zero targets. This report is essential for advancing sustainable building practices, addressing construction challenges, and contributing to global efforts to combat climate change.

## **VI. Methodology**

The methodology for this project uses a desktop-based approach focused on integrating low-carbon and sustainable materials in net-zero carbon aquatic building designs. It involves an extensive review of academic literature, case studies, and industry reports to explore the environmental, technical, and financial aspects of using sustainable materials. By analysing existing research and practical examples, this methodology aims to create a comprehensive understanding of how sustainable materials contribute to achieving NZC goals in aquatic facilities while addressing the challenges and opportunities they present.

Based on Brownell's (2020) approach, integrating low-carbon materials like Cross Laminated Timber, hempcrete, and recycled material, employing passive design strategies such as natural ventilation and optimised daylighting, and incorporating renewable energy systems like photovoltaic panels and district heating, while utilizing BIM tools and simulations to ensure Net Zero Carbon compliance before construction.

A detailed analysis of the London Aquatics Centre serves as a core case study, highlighting practical applications of recycled materials, energy-efficient technologies, and adaptive design strategies to lower carbon emissions without compromising on the building's usability, durability, or architectural significance.

**Predicted Outcomes**

This project aims to deliver an in-depth report on the integration of low-carbon and sustainable materials in achieving net-zero carbon (NZC) building designs. It explores how various materials can be effectively used to reduce both embodied and operational carbon in buildings, focusing on the practical application of these materials in real-world scenarios. The report offers comprehensive insights into how to balance environmental benefits with cost-effectiveness and functionality, providing architectural technologists, engineers, and other stakeholders with actionable guidance for designing and constructing buildings that meet Net Zero Carbon goals while looking at financial, technical, and logistical challenges.

**Resources Required**

<b>ICT Devices</b>	This includes using laptops, desktops, and mobile phones as essential tools for conducting research for this project report. These devices were employed to gather information from various online sources, enabling efficient access to academic articles, databases, industry reports, and other digital resources.
<b>Web-based resources</b>	Coventry Locate was primarily used to access most of the books and articles about this technical report, supplemented by additional research from Google Scholar, JSTOR, PubMed and ScienceDirect.
<b>Software</b>	Microsoft Word, Google Chrome, and Grammarly were utilised throughout the research and writing process to compile, edit, and format the report effectively.
<b>Workspace</b>	Coventry University library and my personal workspace
<b>Time Management Tools</b>	Microsoft project, calendar and reminders were used to track progress and meet the deadline.

**References**

- [1]. Brownell, B. E. (Ed.). (2020). *Examining The Environmental Impacts Of Materials And Buildings*. IGI Global.
- [2]. Construction21. (2012). London Aquatics Centre: Sustainability. <https://www.construction21.org/Data/Sources/Users/12/03-Feb-2014/london-aquatics-centresustainability.pdf>
- [3]. IEA. (2022). *Technology And Innovation Pathways For Zero-Carbon-Ready Buildings By 2030*. <https://www.iea.org/reports/technology-and-innovation-pathways-for-zero-carbon-ready-buildings-by-2030>.
- [4]. Liang, Y., Pan, Y., Yuan, X., Yang, Y., Fu, L., Li, J., ... & Kosonen, R. (2022). *Assessment Of Operational Carbon Emission Reduction Of Energy Conservation Measures For Commercial Buildings: Model Development*. *Energy And Buildings*. <https://doi.org/10.1016/j.enbuild.2022.112189>
- [5]. MPA The Concrete Centre. (2012). *Aquatics Centre, London*. <https://www.concretecentre.com/case-studies/aquatics-centre-london.aspx>
- [6]. Siegner, M., & Searcy, C. (2021). *If Companies Want Net-Zero Carbon Offices, They Need To Focus On Building Materials*. *The Conversation*.
- [7]. Zaha Hadid Architect (2011). *London Aquatic Centre*. <https://www.zaha-hadid.com/architecture/london-aquatics-centre/>