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Infrastructure sector decarbonisation: Evaluating emissions and technological approaches

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With a focus on water and sanitation solutions in developing countries, Jacqueline has worked on various multilateral development bank projects, including landfill design, e-waste management solutions, and organic waste management technology. In addition, to her professional work, she is actively involved in industry development initiatives, such as serving on the FIDIC Africa committee for integrity, quality, risk andsStandards and being vice president of the Ghana consulting engineers future leaders group.

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Irene Yeboah is an Environmental and social safeguards and climate specialist at Constromart Africa in Accra, Ghana. She holds an MSc in urban management and development from Erasmus University and an integrated development studies from the University for Development Studies.

Irene is adept in climate change mitigation and adaptation, environmental and social impact assessment, and preparation of environmental and social management plans and implementation. She is a member of the Institute of Environmental Management and Assessment, International Association for Impact Assessment and International Water Association (IWA) working on multilateral development bank-funded projects as environment and social safeguards analyst and assistant urban planner on other projects. Her research focuses on embedding social sustainability in development projects to a sustainable society. She is passionate about sustainability and protecting the interest of people especially the vulnerable in making society a better place.

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Edward M. Melomey is an experienced civil engineer and project manager, steeped in construction and engineering leadership spanning two decades. He has led the implementation of several infrastructure projects as well as a bid of a local and international consortium to win the contract to provide consulting services for the first OPRC (World Bank funded performance-based contract) in Ghana.

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Introduction

The infrastructure sector plays a crucial role in the global economy, encompassing a wide array of activities from constructing buildings to maintaining critical structures. However, this sector is also a significant contributor to greenhouse gas emissions, particularly carbon dioxide (CO_2), due to its energy-intensive processes and materials[1]. As the urgency of addressing climate change becomes increasingly apparent, decarbonising the infrastructure sector is imperative. This article aims to examine the current emission levels in the infrastructure sector and explores various technological interventions aimed at reducing these emissions. The focus is on both construction and operational phases, highlighting innovations in materials, energy efficiency and renewable energy integration.

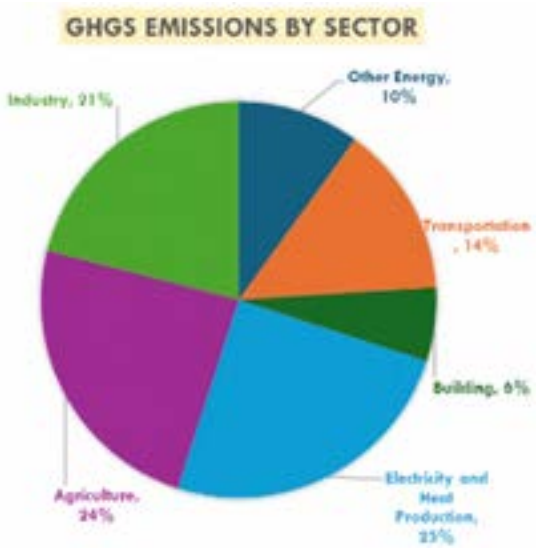

FIGURE 1: GHGS EMISSIONS BY SECTOR (SOURCE: IPCC 2014)

Current emission levels

The infrastructure sector's carbon footprint is vast, with construction activities alone accounting for approximately 10% of global CO_2 emissions[2]. Key sources of emissions include the production of cement and steel, both of which are essential materials in construction. Cement production, for instance, is responsible for about 8% of global CO_2 emissions[3]. The process of making cement involves the calcination of limestone (calcium carbonate), which releases large amounts of CO_2. Additionally, the energy-intensive nature of steel production, which often relies on coal as a primary energy source, significantly contributes to greenhouse gas emissions.

Moreover, operational energy use in buildings contributes significantly to overall emissions, with residential and commercial buildings accounting for nearly 30% of global energy[4]. This energy consumption is primarily driven by heating, cooling, lighting and the operation of various appliances and equipment. The inefficiency in building designs and the reliance on fossil fuel-based energy sources exacerbate the carbon footprint of the infrastructure sector.

Technological interventions

- **Sustainable materials:** One of the most promising strategies for reducing emissions in the infrastructure sector is the adoption of sustainable materials. Alternatives to traditional cement, such as geopolymer cement, offer substantial reductions in CO_2 emissions. Similarly, the use of recycled steel and other recycled materials can lower the carbon footprint of construction projects.
- **Energy efficiency:** Enhancing energy efficiency in both the construction and operational phases is crucial. Advanced building designs that incorporate passive solar heating, natural ventilation and high-performance insulation can significantly reduce energy demand. Additionally, the implementation of energy-efficient lighting, heating, ventilation and air conditioning systems can further decrease operational emissions.
- **Renewable energy integration:** Integrating renewable energy sources into infrastructure projects is another effective decarbonisation strategy. Solar panels, wind turbines and geothermal systems can provide clean energy for both construction processes and building operations. For instance, the use of solar photovoltaic panels on rooftops can generate electricity, reducing reliance on fossil fuels.

1. IPCC (2014). GHG Emissions by Gas and Sector
2. International Energy Agency (IEA). (2021). World Energy Outlook 2021.
3. United Nations Environment Programme (UNEP). (2020). Global Status Report for Buildings and Construction 2020
4. World Green Building Council. (2020). Bringing Embodied Carbon Upfront

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- **Digital technologies:** The adoption of digital technologies such as Building Information Modelling (BIM) and the internet of things (IoT) can optimise construction processes and building management. BIM enables precise planning and resource management, reducing waste and improving efficiency. IoT devices can monitor energy usage in real-time, allowing for more effective energy management and maintenance.
- **Carbon capture and storage (CCS):** While still in the early stages of development, CCS technologies hold potential for mitigating emissions from industrial processes. By capturing CO_2 emissions at their source and storing them underground, these technologies can significantly reduce the carbon footprint of cement and steel production.

Case studies

Several infrastructure projects around the world have successfully implemented decarbonisation strategies, demonstrating the potential for significant emission reductions. For example, the Bullitt Center in Seattle, USA, is renowned as the "greenest commercial building" in the world. Completed in 2013, the Bullitt Center showcases extensive use of sustainable materials, energy-efficient systems, and renewable energy sources. The building is designed to be energy-positive, generating more electricity than it consumes through its rooftop solar array[5]. Additionally, the Bullitt Center features advanced water management systems, including rainwater harvesting and greywater treatment, reducing its overall environmental footprint. Similarly, the City of Sydney's Green Infrastructure Master Plan is an ambitious initiative aimed at reducing the city's carbon emissions and enhancing urban resilience[6]. Key components of the plan include the implementation of green roofs and walls, which help to insulate buildings and reduce energy consumption. The plan also promotes the expansion of urban forests, which act as carbon sinks and improve air quality. Moreover, the City of Sydney is developing district energy systems that use renewable sources, such as solar and wind power, to provide heating and cooling to multiple buildings, thereby reducing reliance on fossil fuels.

Challenges and future directions

Despite the promising potential of these technological interventions, several challenges remain. High upfront costs, regulatory barriers as shown in figure 2 and a lack of awareness and expertise can hinder the widespread adoption of sustainable practices. However, ongoing research and development, coupled with supportive policies and incentives, can accelerate the transition towards a decarbonised infrastructure sector.

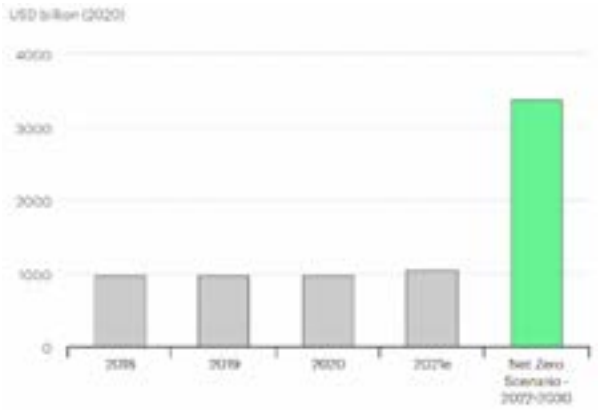

FIGURE 2: CLEAN ENERGY AND INFRASTRUCTURE INVESTMENT, 2018-2030 (SOURCE: IEA)

Conclusion

Decarbonising the infrastructure sector is not only crucial for mitigating the impacts of climate change, but also for creating a more sustainable future for generations to come. By continuously evaluating emissions and embracing technological advancements, we can make significant strides in reducing the sector's carbon footprint. Adoption of sustainable materials, energy-efficient practices, renewable energy sources, digital innovations and carbon capture and storage solutions will play a vital role in driving this transformation. As cities around the world expand, investing in sustainable infrastructure is paramount to ensuring a more resilient and environmentally friendly urban landscape. Let us all work together towards a greener future for our planet.

5. Bullitt Center. Date Assessed: 10/06/24. https://www.wbdg.org/additional-resources/case-studies/bullitt-center
6. City of Sydney. (2019). Green Infrastructure Master Plan. Date Assessed: 10/06/24. https://www.cityofsydney.nsw.gov.au/strategies-actions/green-infrastructure