Balancing Green Growth in the Construction Industry

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Abstract

This study examines green growth and clean development in Pakistan’s construction industry, aiming to mitigate substantial carbon emissions while maintaining economic growth. The construction sector, vital to the economy, also poses significant environmental challenges due to its high greenhouse gas (GHG) emissions, particularly CO₂ from fossil fuel combustion and methane from waste processes. This study explores international best practices such as China’s use of waste-derived fuels and Denmark’s biogas technology to highlight sustainable alternatives. It emphasizes the adoption of cleaner technologies and renewable energy to reduce emissions in the cement, steel, and brick kiln industries. The study recommends policy incentives, including tax credits and subsidies, to promote these sustainable practices. Implementing these strategies is crucial for Pakistan to achieve its economic goals and address environmental sustainability challenges. The document underscores the importance of transitioning to greener, energy-efficient technologies and offers practical solutions for long-term sustainable growth in the construction sector.

Keywords: Green growth, Clean development mechanisms, Carbon credits, Construction industry, GHG emissions
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INTRODUCTION

The construction and use of built environments account for approximately 39% of global greenhouse gas (GHG) emissions (Crawford 2022). Among these emissions, carbon dioxide ($\text{CO}_2$) is a major gas that is released during construction processes, energy combustion and industrial activities (International Energy Agency [IEA] 2022). The combustion of fossil fuels (such as coal, oil, and natural gas, for energy and heating purposes in buildings and construction sites) releases $\text{CO}_2$ into the atmosphere. From various sectors, the production of concrete and steel, which are essential materials in construction, are identified as the most significant contributors to CO2 emissions in the construction industry (Crawford 2022). The production of concrete is known for a substantial amount of $\text{CO}_2$ release due to the chemical reactions involved in cement production. Similarly, steel production involves high-temperature processes that emit $\text{CO}_2$ as a byproduct.

In Pakistan, construction industry has seen a rapid growth particularly in the 21st century due to the constantly increasing demand of the housing units. Steel and cement sectors contribute to 2.53 % of Pakistan’s GDP and 7.6% of the labour force (State Bank of Pakistan 2021). However, with this increasing demand, the resulting emissions (given high share of fossil fuels) from this sector are also increasing, leading to a need for scoping sustainable approaches that can lead to reduction in carbon footprints from the industry. Such efforts may include improving building energy performance, using more sustainable materials, adopting energy-efficient technologies, fuel substitution, and executing policies to promote energy security and sustainability (United Nations Environment Programme 2022).

To address the decarbonization challenge in the industrial sector, various mechanisms such as Clean Development Mechanism (CDM) and Article 6 of the Paris Agreement have been introduced for trading under the carbon markets. The CDM was a carbon offset scheme administered by the United Nations, established under Article 12 of Kyoto Protocol (United Nations Framework Convention for Climate Change [UNFCCC] 1997). It allows developed countries to invest in greenhouse gas (GHG) emissions reduction projects in developing countries to meet their own emission reduction targets. In return for their investments, the developed countries receive certified emission reductions (CERs), which represent a reduction of one ton of carbon dioxide ($\text{CO}_2$) or its equivalent. Carbon markets are trading systems where carbon credits are bought and sold as part of efforts to mitigate climate change. These markets facilitate the trade of carbon credits, which represent a certain amount of GHG emissions that an entity has reduced or prevented. Since the Paris Accord, the framework for carbon markets is governed under Paris Agreement with various countries already working around the Voluntary Carbon Markets (VCMs).
**Objectives:** This study aims to investigate the feasibility of GHG emission reductions from construction industry using CDM (previously governed mechanism) and carbon markets. Key objectives are:

- To examine the decarbonization drive through the integration of renewable energy sources and sustainable practices within the construction industry, particularly Cement, Steel and Bricks,
- To analyze the estimated emission reduction potential through the CDM projects of construction industry implemented in other countries,
- To Identify both direct and indirect social and economic benefits associated with the introduction of new processes, technologies and products and/or the effects of a project on other industries.

**METHODOLOGY**

The data used in this study is secondary in nature, therefore, the analysis is based on existing sources of information, including academic papers, reports, government publications, news articles, etc.

**3. LITERATURE REVIEW & CASE STUDIES**

Most of the studies conducted in China, Denmark, and Austria, focus the utilization of waste-derived fuels in the cement and building material industries, as well as the adoption of clean development mechanisms (CDMs) to enhance sustainability and reduce GHG emissions. Some studies underscore the importance of optimizing processes, harnessing waste heat, and integrating biogas plants within these sectors to promote environmental sustainability. They also provide a deeper insight into what can be done in Pakistan and its sustainable development policy. However, among various initiatives that addresses the decarbonization perspective, the use of Waste Heat Recovery (WHR) systems in Pakistan has been a success story, particularly in the cement industry. As of 2023, almost all major players have installed WHR systems leading to significant improvements in their energy efficiency portfolios. Similar trends have been observed globally.

Cement production has seen significant advancement in recent decades. Traditional kilns use fuels like coal, oil, petroleum coke, and natural gas. Owing to rising energy costs and environmental concerns, cement companies are increasingly exploring the replacement of conventional fuels with waste materials, such as waste oils, non-recycled plastics and paper, used tires, biomass wastes, and wastewater sludge. This paper discusses these alternatives, highlighting that the clinker firing process is well-suited for various alternative fuels (AF). The aim is to optimize process control and AF consumption while
maintaining clinker quality. With the global cement industry producing about 3.5 billion tons annually and consuming nearly 350 million tons of coal-equivalent fossil and AF, the potential for using AF is enormous. The study shows that many cement plants have partially replaced fossil fuels with AF, demonstrating that using waste as AF is both ecologically and economically beneficial (Chatziaragas et al. 2016). Lybæk (2014) presented a comprehensive analysis of Denmark’s biogas technology, emphasizing its role in energy distribution to combined heat and power plants or local networks. The historical and political context of biogas production, emphasizing its significance as a renewable energy source and waste processing technology. It also explores the utilization of organic materials to enhance gas yield and discusses the broader global and European implications of biogas production.

Further, Ellersdorfer and Weiβ (2012) quantified the synergy effects of integrating biogas plants with building materials industry facilities, such as cement works, in Austria. Their study focuses on energy and mass flow balances to assess the impact of combining these plants in terms of energy efficiency, investment and operating costs, GHG emissions reduction, and overall energy sustainability.

4. DISCUSSION AND ANALYSIS

Now, with a substantial understanding of CDM, the carbon market, and its key players, it is possible to examine various industries. While successful solutions have already been implemented in the construction sector, including cement, steel, and brick kiln industries, a more impactful approach to addressing climate change is necessary.

4.1 Cement Industry

The cement industry contributes to about 8% of CO₂ emissions worldwide. The direct CO₂ emissions intensity of cement production has remained relatively stable over recent years (International Energy Agency 2023). A rough estimate shows that around 0.8 to 1.0 kg of CO₂ is emitted per kg of cement produced. While cement’s CO₂ emissions are relatively lower than other industries, its substantial volume makes it a concern for climate change mitigation.

The cement sector showed positive trading with a notable increase of cement by July 2023. During the fiscal year 2022-23, total cement dispatches (domestic and exports) were
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44.57m tons (Global Cement 2024).

Keeping in view of the above facts, the construction industry emits significant amounts of carbon dioxide (CO₂) and methane (CH₄) as greenhouse gasses. CO₂ is released primarily from energy combustion and industrial processes, while methane emissions may arise from various construction activities. Addressing these emissions and curtailing the use of oil is crucial in achieving global climate goals and ensuring a sustainable future for the construction industry. The way forward is to identify and develop a process under the umbrella of Clean Development Mechanisms (CDMs) and Carbon Credits System for the long-term achievement of the Sustainable Development Goals of the country.

The adoption of CDM initiatives have significantly enhanced sustainability in Chinese cement enterprises. The heat recovery projects help reduce the GHG emissions from the global cement industry adopts multiple practices and technologies that can help achieve the goal of sustainable development. This is what required in Pakistan. One such interesting example is the Hunan Zhuzhou Sinoma Cement Project by China.

In Hunan Province of China, the Hunan Zhuzhou Sinoma Cement 9MW Waste Heat Recovery Project is a noteworthy initiative that aims at enhancing the sustainability of cement production in the region (United Nations Framework Convention on Climate Change, 2012) This project on the one hand addresses the multi-stage process of cement production, striving to minimize its environmental impact, on the other it contributes to the reduction of GHG emissions, aligning with international efforts to combat climate change. It further makes a localized yet significant contribution to the broader global climate agenda. Lastly, it generates numerous employment opportunities for the residents. This workforce participation provides economic benefits to the region, supporting livelihoods (UNFCCC 2012).

The cement production process involves several stages, beginning with the preparation of raw materials like limestone and clay, which are crushed, mixed, and homogenized. These are combined with additives such as silica sand and iron ore, then ground into a fine powder. The mixture undergoes calcination, forming clinker in a suspension pre-heater stack and rotary kiln. The clinker is rapidly cooled with air quenching coolers and stored in silos for further processing. The primary environmental benefit of the Hunan Zhuzhou Sinoma Cement 9MW Waste Heat Recovery Project lies in its potential to reduce greenhouse gas emissions by an estimated 44,260 tons of CO2e annually during the crediting period (United Nations Framework Convention on Climate Change, 2012). This reduction is achieved by the utilization of waste heat, which improves energy efficiency and minimizes additional emissions associated with energy production. This initiative contributes to the broader sustainability goals of the cement sector in Hunan Province.
Additionally, this project serves to demonstrate energy-efficient technology and improved energy efficiency within the cement production facility. It is noteworthy for its contribution to reducing operational costs and conserving resources. Furthermore, the project enhances power supply diversity in Hunan Province, reducing dependency on fossil fuel-based power generation. This aligns with China’s strategy to transition towards a more sustainable and low-carbon energy mix. (United Nations Framework Convention on Climate Change, 2012)

Pakistan has a major chance to adopt practices from projects such as the Hunan Zhuzhou Sinoma to make sure its own cement production processes can be more sustainable. There is no need to find these practices from scratch. Pakistan can provide the same benefits they provide to the people of Hunan province.

4.2 Steel Industry

Pakistan, with an output of 6 million metric tons in 2022, is ranked the 27th largest steel producer globally. The sector, dominated by 20 major players holding 80% of the market share, is crucial to industrial growth, contributing over 5% to the country’s GDP and providing over 200,000 jobs with an annual production capacity exceeding 5 million tons. As per Mckinsey, Steel production emits approximately 1.85 to 1.89 tons of CO₂ per ton of steel (Policy Circle, 2024) The steel industry significantly contributes to global CO₂ emissions, accounting for around 5% of emissions in the EU and 7% worldwide (World Steel Association 2021).

Efforts are being made to decarbonize the steel industry and reduce its carbon footprint. Energy consumption in most of the integrated steel plants in India is generally high at 7000–7500 KWH (6–6.5 Giga Calorie) per ton of crude steel as compared to 4.5–5.0 in steel plants abroad. For Pakistan, a very interesting CDM project worth taking inspiration from is the Songshan Steel Project between Denmark and China. The Songshan Making project, a collaborative effort between Denmark and China, represents a significant stride in the realm of steel production with a keen focus on sustainability and emissions reduction. Comprising two plants designed to utilize gas derived from coke as a key feedstock, this
initiative leverages innovative technologies to mitigate environmental impact and generate clean energy (Songshun Steel, 2013).

At the core of the Songshan Making project is a Waste Heat Recovery Boiler and an integrated power generation system, designed to capture and utilize waste heat, thereby enhancing the energy efficiency of steel production. Denmark benefits from emission reduction units through this innovative approach, highlighting the project’s commitment to environmental stewardship.

Adjacent to the existing sintering complex, a new power plant will feature the Waste Heat Recovery Boiler, a steam turbine, and a generator. Sintering, a key preliminary phase in steel manufacturing, involves compacting and forming a solid mass through pressure or heat, releasing substantial quantities of steam.

The Songshan Making project is notable for its ability to significantly reduce GHG emissions, preventing nearly 100,000 tons of CO₂ emissions annually. This is achieved through the efficient capture and utilization of waste heat, turning it into a valuable resource (Danish Energy Agency 2013). Furthermore, the project incorporates a significant power generation component, boasting a megawatt (MW) power generator with the capability to produce an impressive 140,417 megawatt-hours (MWh) of electricity. This substantial power output not only supports the energy demands of the steel production process but also contributes clean electricity to the grid, thereby promoting sustainable energy practices.

In conclusion, the Songshan Making project exemplifies the fusion of advanced technology, environmental consciousness, and sustainable energy production in the steel manufacturing sector. By utilizing waste heat to generate electricity and significantly reducing CO₂ emissions, this collaborative endeavour between Denmark and China sets a noteworthy precedent for environmentally responsible industrial practices while fostering clean energy generation. For Pakistan, it provides a technological solution to our current steel practices’ carbon emissions.

4.3 The Brick Klin Industry

Around 1,500 billion bricks are produced every year, out of which 1300 billion are produced by Asia. Of those, China produces one (1) billion bricks. Asia produces 90% of the global produce, major brick producers are China, India, Pakistan, Vietnam, Bangladesh and India. 10 million workers are employed in this sector alone. (Climate and Clean Air Coalition [CCAC] 2022). The worldwide fired clay-brick production contributes 0.48 kg CO₂ eq per kg, or 1.1 Gt CO₂ eq, total emissions, each year (Karen Scrivener and Hisham 2022). The total
annual emissions estimated as 23,300 tons of particulate matter PM2.5, 15,500 tons of SO2, 302,000 tons of CO, 6,000 tons of black carbon, and 1.8 million tons of CO2. (Book chapter 2012-Bangladesh). Brick kilns burn 0.375 Million tons of coal per year, globally. In the case of Pakistan, Brick kilns are one of the major contributors to GHG emissions. The country has around 20,000 brick kilns, employing approximately 1.3 million people and producing 82.5 billion of bricks annually, having an average weight of 1.9 - 2 kg per brick (Quéré et al., 2018). It is responsible for 1.5% of Pakistan’s GDP. The estimated coal consumption for firing bricks is 13 million tons. Besides, 30-40% of the other fuel is used that includes rice husk, cotton stalk, saw dust, biomass residue and bagasse. The brick kiln industry in Pakistan has historically faced challenges related to carbon emissions. Traditional kilns often rely on inefficient firing techniques, such as burning coal or wood, which release greenhouse gases and particulate matter into the atmosphere. This has led to concerns about air pollution and environmental degradation. (International Centre for Integrated Mountain Development, 2018)

The brick kiln industry is labor-intensive and has provided employment opportunities to a sizable number of people, particularly in rural areas of Pakistan. Workers are engaged in various stages of brick production, including clay preparation, molding, stacking, and firing. The employment figures can vary depending on the size and capacity of the kilns and seasonal demand.

In recent years, the Pakistan government and environmental organizations have introduced regulations and initiatives aimed at reducing emissions and promoting cleaner technologies in the brick kiln industry. Efforts have been made to encourage kiln owners to transition to cleaner and more energy-efficient technologies, such as zig-zag kilns and hybrid Hoffman kilns.

To reduce reliance on bricks, the government and private sector should promote alternative building materials like concrete blocks, fly ash bricks, and compressed earth blocks, which are more environmentally sustainable and can be produced using cleaner technologies (Ali, 2022).

Additionally, the new brick kilns in Bangladesh, a Danish Energy Agency project, serve as a model for sustainable innovation in brick manufacturing. This initiative addresses the environmental and social challenges of conventional brick kilns, marking a transformative shift in the industry (Danish Energy Agency 2013). The Brick Kiln Production project aims...
to replace polluting brick kilns with advanced technology, reducing coal consumption by nearly 50% and saving around 100,000 tons of CO2 annually. It integrates Hybrid Hoffman Kiln technology from China, improving air quality and promoting sustainable development. The project’s success in Bangladesh may lead to broader adoption in Pakistan and beyond, offering a pathway to a cleaner, more sustainable future for global brick manufacturing.

Looking ahead, the Brick Kiln Production project offers compelling prospects. Initially implemented in 20 brickworks in Bangladesh, the technology introduced by this project holds promise for broader adoption [Danish Energy Agency, 2013, 63]. Its successful integration may serve as a catalyst for establishing new brickworks in Pakistan and potentially extending the technology’s reach to other regions and countries facing similar challenges in the brick manufacturing sector. In the years to come, the experience garnered from this project may well emerge as a competitive advantage for the Pakistan brick industry, fostering sustainable growth and environmental stewardship.

5. POLICY RECOMMENDATIONS

To successfully implement carbon markets and CDM projects in Pakistan, it is crucial to gather specific data of the construction industry, including emissions per metric ton and production rates. GHG mitigation strategies, economic prosperity and social affluence should also be considered within the CDM framework. It is essential to build capacity, establish emission reduction policies, facilitate adoption, and optimize programming for effective application. Executing carbon markets for Pakistan involves various strategies to effectively manage carbon emissions and promote sustainability:

1. **Sustainable Carbon Credit Trading/ Pricing Mechanisms:** Carbon credits incentivize industrialists to reduce emissions. An entity under the umbrella of State Bank of Pakistan may be established. A stepwise implementation mechanism and clear communication of the benefits could be opted for the inclusion of all the stakeholders, such as the construction industry regulators and patrons.

2. **Capacity Building:** For successful carbon market implementation, capacity-building efforts must be initiated. This could include educating stakeholders about the benefits and mechanics of national and international carbon markets.

3. **Emission Reduction Policies:** Policies like carbon quotas and market mechanisms are key strategies to achieve emission reduction targets. Crystal clear polices must be communicated to all shareholders and benefactors.

4. **Climate Resilience and Carbon Trading Projects:** Optimal programming models considering costs of emission reduction, supervision, and other factors to design effective implementation strategies. Projects to enhance climate resilience and carbon trading should be launched in collaboration with other industries with other countries.
5. **Innovative Approaches:** It includes innovative ways of exploring fundraising markets other than the traditional Carbon Markets. For example, Denmark has explored fundraising through the European Union Innovation Fund as an alternative to the EU’s carbon market.

6. **Carbon Trading within Country:** Pakistan through the introduction of a carbon trading mechanism within its own country can ripe the benefits of emission reduction by one party and supported by another party. Its implementation involves creating a market-based system to regulate and incentivize the reduction of GHG emissions through the establishment of policy framework, emissions inventory, cap and trade system, system of offsets and credits and the establishment of market infrastructure of the market players.

7. **Green Tax Reform:** Tax reforms and cap and trade mechanisms could be introduced, which will raise carbon tax to reduce emissions and promote sustainability. For example, as done in Denmark.

Overall, these projects and strategies offer a pathway for Pakistan to reduce GHG emissions, promote sustainable development, and contribute to global efforts to combat climate change. Embracing these initiatives will be crucial for a greener and more sustainable future for Pakistan’s construction industry as well as the nation.

**6. CONCLUSION**

The study presents a comprehensive analysis of the potential for greenhouse gas (GHG) emission reductions within Pakistan’s construction industry, focusing on the cement, steel, and brick sectors. It explores the feasibility of leveraging CDM projects and carbon markets to achieve these reductions. While the study demonstrates several strengths, such as its extensive review of global best practices and its detailed assessment of the environmental impact of the construction industry, it also faces certain limitations.

One major advantage of the study is its evidence-based approach that has been drawn from international case studies. For instance, the analysis of the Hunan Zhuzhou Sinoma Cement Project in China and the Songshan Steel Project between Denmark and China highlights how waste heat recovery and innovative technologies can significantly reduce emissions while improving energy efficiency and providing economic benefits to local communities. These examples provide valuable insights that can guide Pakistan’s efforts to decarbonize its construction industry.

On the contrary, the study has certain limitations. The reliance on secondary data sources may affect the precision of the findings, as it limits the ability to account for local variations in industrial processes and economic conditions. Additionally, while the study identifies
potential environmental benefits, it does not extensively address the economic and social implications of transitioning to these new technologies for all stakeholders involved, particularly small and medium-sized enterprises (SMEs) in Pakistan. However, further research is needed to gather primary data and conduct detailed cost-benefit analyses tailored to Pakistan’s specific context.
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