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*Review*

# Literature review on environmental aspects of ESG performance in Vietnam's cement industry

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**Abstract:** This article examined the pivotal role of environmental factors within the environmental, social, and governance (ESG) framework in shaping the development of Vietnam's cement industry. It highlights how sustainability drivers influence environmental management practices and overall sectoral performance. Rising cement demand, evolving regulations, and the growing emphasis on sustainable construction have propelled the prioritization of environmental sustainability, facilitated by the adoption of robust environmental management systems (EMS). This environmental focus has resulted in tangible improvements in community health, employee well-being, stakeholder relations, regulatory compliance, and investor confidence, ultimately driving innovation, operational efficiency, and cost reduction. This industry-wide shift aligns with consumer preferences for eco-friendly construction materials and fosters a culture of sustainability across Vietnam's cement sector. Notably, the industry has made significant progress in embracing cleaner production technologies, waste utilization, and green financing to drive its environmental sustainability agenda, underscoring the increasing prominence of ESG considerations. While the importance of ESG factors is widely recognized, a research gap persists in quantifying the specific contributions of the ESG pillars to overall ESG performance in the cement industry.

**Keywords:** cement industry; environmental management systems; ESG; sustainability; Vietnam

## 1. Introduction

Concrete, as the dominant construction material, is indispensable to Vietnam's modern infrastructure development, from highways and buildings to dams and utility networks. This ubiquity stems from its durability, resistance to fire and water, and cost-effective production. Despite these competitive advantages, cement manufacturing is classified as a high-energy-intensive industry, characterized by substantial fuel and electricity consumption throughout production, resulting in major greenhouse gas (GHG) emissions. The process involves fusing limestone and clay at temperatures up to 1450 °C [1]. This reaction generates large amounts of $CO_2$, accounting for about 90% of total emissions from cement production [2] (Figure 1).

As shown in Figure 1, process-related emissions from clinker calcination account for the majority (~ 60%) of cement's $CO_2$ emissions, while fossil-fuel combustion contributes the remaining ~ 40%. This highlights that effective decarbonization strategies must address material substitution, which reduce process emissions, and energy transition, which cuts combustion-related emissions, rather than focusing on a single source.

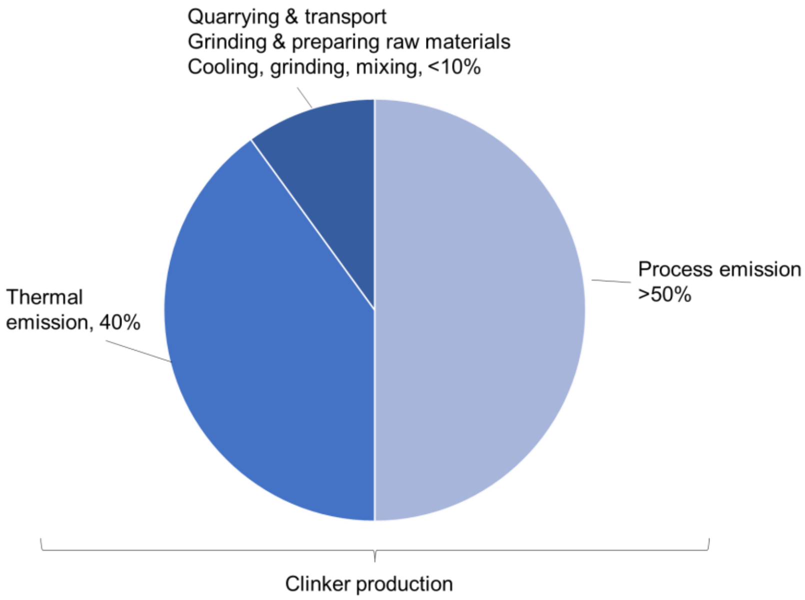



**Figure 1.** Clinker production accounts for the majority of $CO_2$ emissions in the cement production process [3].

The rapid increase in cement production over recent decades is a primary factor contributing to the industry's high emissions. Globally, the cement sector emitted 1.58 Gt $CO_2$ in 2023 [4]. Among hard-to-abate industries, it has the highest $CO_2$ intensity at 6.9 kg per dollar, much higher than iron and steel (1.4 kg) or oil and gas (0.8 kg) [3,5]. Five countries, namely China (57%), India, Vietnam, the United States, and Indonesia, account for nearly three-quarters of global cement production [3]. This dominance is driven by rapid urbanization and industrialization in Asia and Sub-Saharan Africa [6–8].

In response to intensifying concerns over climate change and the obligation to meet the Paris Agreement targets, the cement industry faces mounting pressure to decarbonize. Investors increasingly seek ESG information, focusing on climate-related risks and management practices. Research indicates that a company's commitment to green strategies, organizational culture, identification, and environmental values can effectively foster green innovation [9,10]. Among the three ESG pillars, the *environmental* component (the *E*) exerts the strongest influence on corporate decision-making. This is particularly evident in construction materials such as cement, where firms prioritize environmental performance in corporate strategies [11]. The E pillar focuses on a company's environmental impact, encompassing efforts to reduce carbon footprint, manage natural resources responsibly, and minimize environmental harm through initiatives related to sustainability, clean energy, and waste reduction [12]. Reinforcing the *environment* pillar also strengthens the *social* and *governance* dimensions [13].

Vietnam's cement industry is expanding rapidly, driven by population growth, economic development, and accelerating urbanization. This growth, however, comes at a cost: the sector is a major source of pollutant emissions, contributing significantly to environmental degradation. While some companies have adopted cleaner production technologies, these efforts remain fragmented, and the sector faces an urgent need for a comprehensive environmental management system (EMS) to balance growth with sustainability, as discussed in Sections 4 and 5.

To establish a foundation for this study, we conducted a narrative literature review. A systematic review was not feasible due to the limited number of ESG-related studies specific to Vietnam's cement sector. We searched Scopus, ScienceDirect, and Google Scholar for publications from 2010 to 2024 using Boolean combinations of "cement", "Vietnam", "ESG", "sustainability", and "environmental management". The inclusion criteria required peer-reviewed journal articles and authoritative research reports that directly address ESG or environmental management practices in the cement and construction sectors, whereas unrelated studies were excluded. In total, 79 publications met the inclusion criteria and were synthesized to provide the evidence base for this review. Our screening prioritized studies that link environmental actions to social and governance outcomes within the cement and construction context; stand-alone social or governance topics lacking environmental linkage were excluded from the scope.

However, the existing evidence base remains uneven. Some studies report positive relationships between environmental initiatives and employee or community outcomes [14,15], whereas others find weak or indirect effects. Moreover, community acceptance varies across contexts and may shift over time [16]. Beyond these results, two gaps stand out for the cement sector: (i) a shortage of sector-specific analyses on E–S–G interconnections, particularly in Vietnam, where recent research continues to prioritize environmental and technical practices while neglecting social and governance dimensions [17]; and (ii) a bias toward corporate-level data, with limited evidence at the employee or micro-social level, as noted by Barbosa et al. [18]. These patterns motivate our environment-centered synthesis, which traces how environmental practices influence social and governance performance in Vietnam's cement industry.

Addressing these gaps, the paper offers an environment-centric review that maps how environmental practices in Vietnam's cement industry reduce emissions while enhancing social outcomes, governance quality, and long-term competitiveness.

## 2. Dynamics of Vietnam's cement industry

Vietnam has emerged as the world's largest cement exporter, generating export revenues of USD 1.8 billion in 2022 and USD 1.6 billion in 2023, surpassing other major exporters such as Türkiye, Canada, and Germany [18] (Figure 2). In the domestic market, the cement industry has shown equally dynamic and increasingly sustainable trends. According to statistics from Finn group, domestic cement sales fluctuated slightly but overall remained stable around 62–66 million tons over the five-year period (Figure 3) [19]. Although domestic and export sales are expected to stabilize as the market matures, partly due to China's zero-COVID policy and changing trade dynamics [19,20], Vietnam's cement market remains highly promising.

Domestically, Vietnam's rapidly expanding economy, driven by urbanization and infrastructure development, has sustained strong cement demand, with domestic sales accounting for the majority of total industry volume between 2018 and 2022 [19]. The expansion of Vietnam's cement industry is inextricably linked to the country's modernization and ongoing urbanization. The construction sector and Vietnam's economic growth show a strong positive correlation [19], indicating that as the economy expands, the construction sector, which is heavily reliant on cement, also grows. In recent years, Vietnam has made significant strides in developing its urban infrastructure, particularly in major cities such as Hanoi and Ho Chi Minh City. Studies predict that Vietnam's strong urbanization trend will continue, with the urbanization rate expected to keep rising over the next several years [21] (Figure 4). The growing demand for cement in Vietnam has been driven by the government's ambitious initiatives to modernize national infrastructure and expand its urban areas [19].

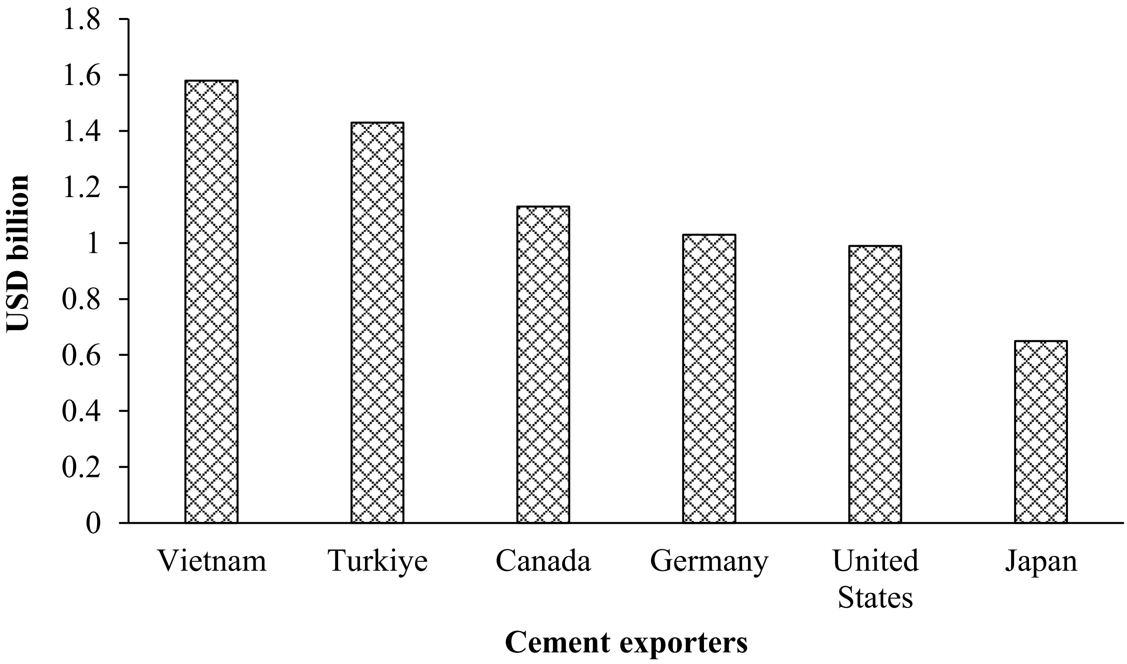



**Figure 2.** World's largest cement exporters in 2023. Vietnam leads with US$1.58 billion, followed by Türkiye and Canada [18].

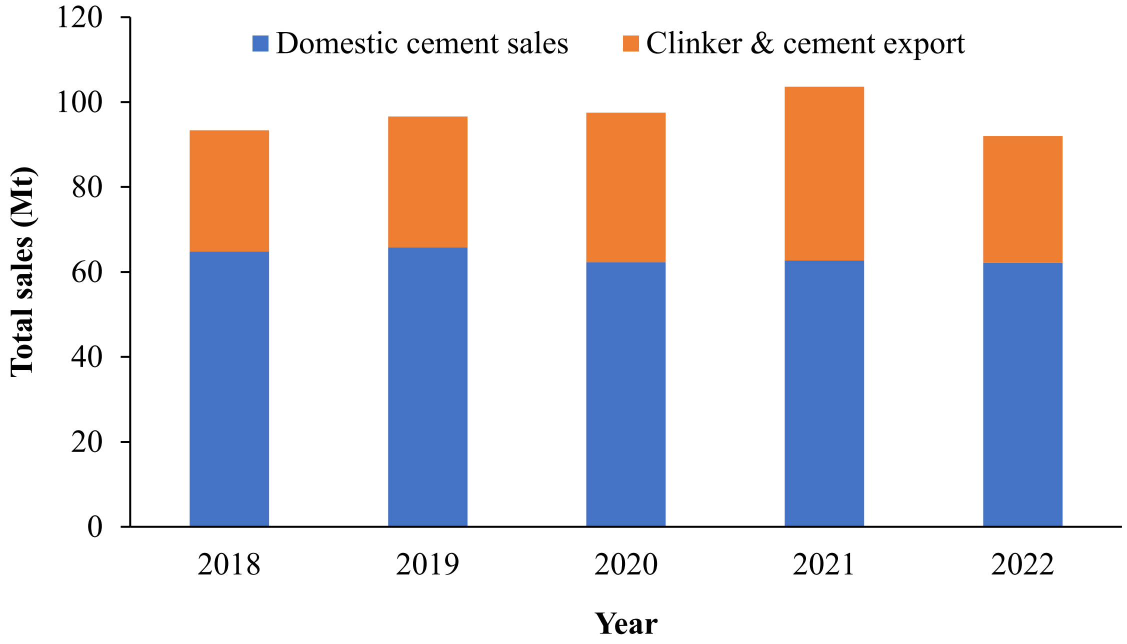



**Figure 3.** Vietnam cement domestic and export sales from 2018 to 2022 (Mt) [19].

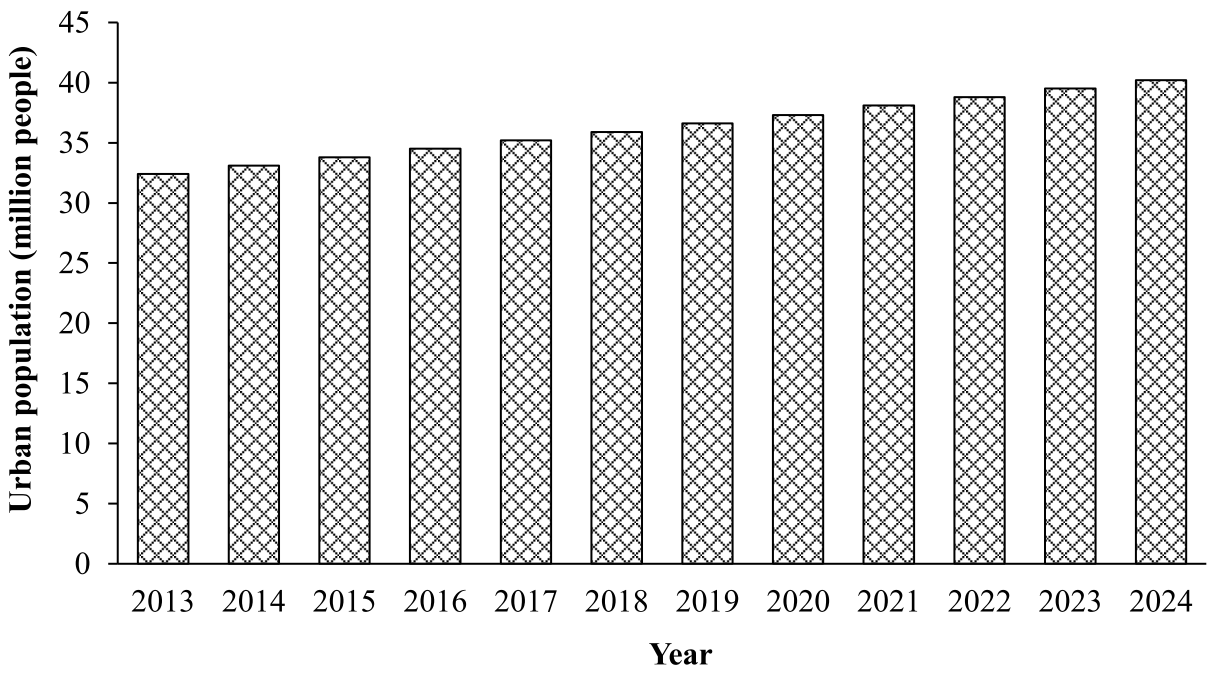



**Figure 4.** Urbanization trends in Vietnam (2013–2024), measured as the share of the population living in urban areas (million people) [22].

Meanwhile, global inflation, pandemics, the Russia–Ukraine conflict, and climate change are among the high-risk events that have disrupted the global economy in recent years. From broad agreement to precise laws, the goals and expectations for sustainable development have evolved. Companies are now required to disclose internal operational decisions based on their ESG performance, which has become a key evaluation metric for many organizations. Whereas in the past, companies emphasized earnings-per-share financial performance, ESG is now used to assess a company's overall performance in corporate governance, social responsibility, and environmental stewardship [23]. ESG has thus become a crucial metric for assessing an organization's sustainable growth. ESG disclosure also ensures that businesses meet investor expectations. Previously, investors evaluated the value of investments primarily based on financial data. In contrast, investors' interest in ESG data and its implications for businesses, particularly regarding climate change impacts and risk management, has grown markedly in recent years. The importance of corporate sustainability disclosure has increased dramatically in response to growing investor demand. Furthermore, precise and effective communication tailored to different stakeholders and topics is essential [24,25].

Vietnam's rapid economic progress, driven by urbanization and industrialization, has come with a substantial environmental cost. The nation's GDP per capita has grown by an average of 5% annually over the past three decades, while its greenhouse gas emissions have risen by roughly 6% per year [26]. Cement is estimated to contribute around 33% of Vietnam's annual GHG emissions [27]. In response, Vietnam has demonstrated a strong commitment to climate action. The nation pledged to achieve net-zero emissions by 2050 at COP26 and, in November 2022, submitted its updated Nationally Determined Contribution (NDC) at COP27. Compared with the business-as-usual scenario, Vietnam's unconditional contribution rose from 9% to 15.8%, and its conditional contribution increased from 27% to 43.5% in the updated NDC (Table 1), reflecting more ambitious emission-reduction targets [26]. Furthermore, the National Climate Change Strategy, released in July 2022, outlines sector-specific reduction targets and priority sectors through 2050, serving as a key framework for Vietnam's climate policy. Notably, by drastically lowering its greenhouse gas emissions, the cement sector is expected to play a crucial role in helping Vietnam meet its NDC commitment [28].

**Table 1.** Emission-reduction targets in Vietnam's NDC 2020 and NDC 2022 (adapted from [29]).

| Sector | Unconditional contribution | | | | Conditional contribution | | | |
|---|---|---|---|---|---|---|---|---|
| | NDC 2020 | | NDC 2022 | | NDC 2020 | | NDC 2022 | |
| | % | Mt $CO_2$e | % | Mt $CO_2$e | % | Mt $CO_2$e | % | Mt $CO_2$e |
| Energy | 5.5 | 51.5 | 7.0 | 64.8 | 16.7 | 155.8 | 24.4 | 227.0 |
| Agriculture | 0.7 | 6.8 | 1.3 | 12.4 | 3.5 | 32.6 | 5.5 | 50.9 |
| LULUCF* | 1.0 | 9.3 | 3.5 | 32.5 | 2.3 | 21.2 | 5.0 | 46.6 |
| Waste | 1.0 | 9.1 | 1.0 | 8.7 | 3.6 | 33.1 | 3.2 | 29.4 |
| IP** | 0.8 | 7.2 | 3.0 | 27.9 | 0.9 | 8.0 | 5.4 | 49.8 |
| Total | 9.0 | 83.9 | 15.8 | 6.3 | 27.0 | 250.8 | 43.5 | 403.7 |

*LULUCF: Land use, land-use change, and forestry.

**IP: Industrial process, includes construction materials, chemical industry, and HFCs consumption.

Under these circumstances, as the global focus on ESG intensifies, many Vietnamese cement producers have adopted energy-efficiency and decarbonization technologies to optimize production costs and meet ESG requirements in export markets, given the current global market volatility [21,24]. These efforts have strengthened the competitiveness of domestic cement manufacturers, particularly amid challenging market conditions.

## 3. Environmental impact of the cement industry

Despite its undeniable role in supporting economic development and GDP growth, cement manufacturing is among the most energy and emission-intensive industries worldwide. Globally, cumulative carbon uptake from cement over the past 96 years accounts for approximately 78.1% of the global total [4].

Life-cycle analyses consistently show that the manufacturing stage is the dominant contributor to total $CO_2$ emissions in cement production [30] (Table 2). Specifically, more than 80% of emissions during the cement production life cycle are associated with the kiln and preheater/precalciner stages. Moreover, cement production requires large quantities of raw materials, energy, and fuels derived from natural resources [31]. As a result, this production cycle generates various pollutants, byproducts, and wastes.

These environmental impacts can be categorized into two main sources [4,30,31], as follows: (1) Non-combustion emissions: Approximately 60% of the direct emissions do not arise from fuel combustion but from the chemical reactions during the clinker calcination process, where limestone is heated in the kiln. The decomposition of calcium carbonate ($CaCO_3$) into calcium oxide (CaO) and $CO_2$ is a crucial step in cement production, releasing $CO_2$ as a byproduct. (2) Fuel combustion emissions: The remaining $CO_2$ emissions are primarily produced by burning fossil fuels, biomass, or alternative fossil and mixed wastes to reach the high temperatures (around 1450 °C) required for clinker production [32]. The combustion of these fuels in kilns, as well as electricity usage, contributes to the remaining emissions [33,34].

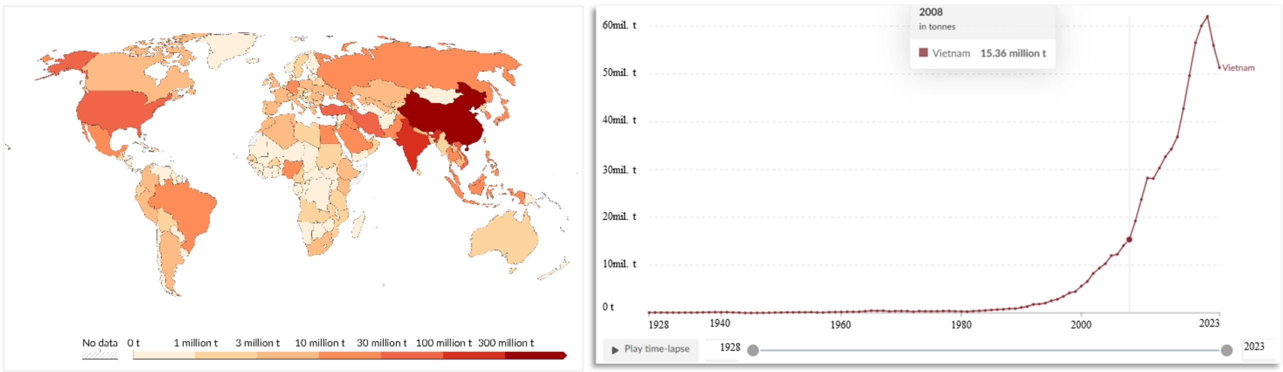
**Table 2.** Energy use and $CO_2$ emission points across the cement manufacturing process*. (Author's elaboration based on IEA, 2021 [35] and numeric values compiled from [30])

| | Quarry | Crusher | Transport | Raw mill | Preheater/precalciner and kiln | | Cooler | Cement mill | Logistics |
|---|---|---|---|---|---|---|---|---|---|
| Energy, MJ/t-clinker | 40 | 5 | 40 | 100 | 3150 | | 160 | 285 | 115 |
| $CO_2$, kg/t-clinker | 3 | 1 | 7 | 17 | 479 | 319 | 28 | 49 | 22 |

*Energy and $CO_2$ intensities are indicative and reported per t-clinker; actual values vary with technology, fuels, and plant efficiency.

Furthermore, cement production requires the extraction of raw materials such as limestone, which can result in habitat destruction and landscape degradation. Cement manufacturing processes also generate air pollutants, including particulate matter, sulfur dioxide, and nitrogen oxides, which degrade air quality and may cause respiratory and other health problems [36]. Dust emission from cement production can adversely affect both human health and the surrounding environment. Additionally, the industry's high-water consumption, waste generation, and potential soil contamination all contribute to its substantial environmental footprint.

In Vietnam, the cement industry has expanded significantly over the past two decades, reaching approximately 120 million tons of annual capacity and positioning the country among the world's top five producers [19,37]. However, this growth has been accompanied by rising GHG emissions, high electricity demand, and increasing solid and hazardous waste generation. Figure 5 illustrates both global and Vietnam-specific $CO_2$ emission trends, showing that Vietnam has sequestered 19.91 $MtCO_2$, ranking just behind Indonesia, Thailand, the Philippines, and Laos, which have sequestered 17.54, 9.34, 7.68, and 5.68 Mt $CO_2$, respectively. This trend is particularly evident in 2024, when the leading countries for carbon uptake from cement are concentrated in Asia, driven by the region's high demand for infrastructure development.




a) b)

**Figure 5.** Spatial distributions and trend of cement-related $CO_2$ emissions: (a) global distribution, 2023; (b) Vietnam time series, 1928–2023 [38].

While Vietnam's total $CO_2$ emissions from cement have continued to increase alongside production growth, the emission intensity per ton of cement output has remained relatively stable in recent years. As illustrated in Figure 6, the direct $CO_2$ intensity has remained around 0.6 $tCO_2$ per ton of cement since 2018, reflecting incremental efficiency improvements but no substantial decarbonization progress. However, to align with the Net-Zero Emissions 2030 pathway, the intensity must decline to approximately 0.45 $tCO_2$ per ton of cement, equivalent to a 25% reduction from current levels [39].

Bridging this gap requires coordinated actions across both major emission sources:

(i) Process emissions from clinker calcination, which can be reduced through lower clinker factors (greater use of supplementary cementitious materials such as slag, fly ash, and calcined clay/$LC^3$), alternative binders, and early deployment of carbon capture, utilization, and storage (CCUS) at high-clinker plants;

(ii) Combustion-related emissions, which can be mitigated through increased substitution of alternative fuels, efficiency upgrades in kilns and grinding systems (including waste heat recovery and modern preheater/precalciner retrofits), and greater use of clean electricity.

Demand-side measures, including product standards, environmental product declaration (EPD)-based procurement, and green building codes, are also critical for accelerating the market uptake of low-carbon cements [30,40,41].

Taken together, these trends indicate that Vietnam's cement sector has reached a plateau in emission intensity but not yet in total emissions, underscoring the need for stronger technological innovation, policy support, and investment to guide the industry toward a sustainable trajectory.

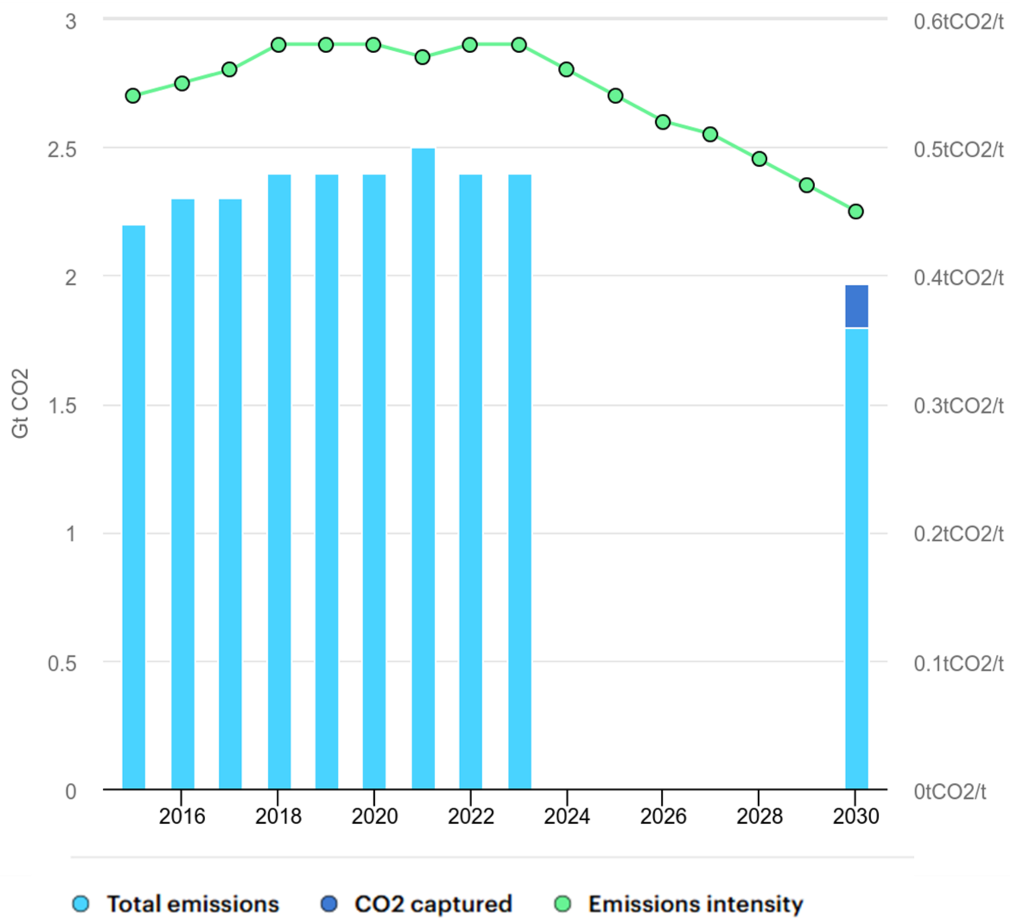



**Figure 6.** Direct $CO_2$ emissions intensity of cement production from 2016 to 2030 ($tCO_2$ per ton of cement) [39].

## 4. Cleaner production initiatives

Many leading companies in Vietnam's cement industry have begun implementing various cleaner production initiatives aimed at mitigating their environmental impact. These initiatives encompass a range of strategies focused on improving energy efficiency, utilizing alternative fuels, reducing emissions, and advancing sustainable resource management.

Several cement plants in Vietnam have explored using alternative fuels such as biomass, industrial waste, and municipal solid waste to replace conventional fossil fuels like coal [19,27]. According to recent reports, 11 cement plants have successfully integrated alternative fuels, replacing approximately 30% of their coal consumption [42]. In parallel, domestic cement manufacturers are increasingly adopting waste heat recovery (WHR) systems to capture excess heat from kiln operations and convert it into steam or electricity. The strong financial and operational efficiency, along with the ease of adoption of WHR systems, has made them one of the most practical and rapidly expanding decarbonization technologies in the cement industry [33,43]. As of April 2023, 24 out of 66 private cement manufacturers had installed WHR systems with a total capacity of 46.9 MW, while substantial potential remains for additional installations among other manufacturers [19].

Meanwhile, in order to improve both plant efficiency and waste management, co-processing in the cement industry has emerged as a technological initiative employed by several leading cement producers in Vietnam. NSEE Vietnam (Siam City Cement), VICEM's But Son Cement, and Quang Ninh Construction & Cement Co.'s Lam Thach Cement Plant are among the pioneers in co-processing [19]. Currently, INSEE is the only cement manufacturer in Vietnam with a full co-processing license, allowing it to handle all types of waste, including hazardous waste. In 2023, approximately 14 million tons of waste were converted into energy and raw materials through INSEE's Ecocycle program, avoiding an estimated 15 million tons of GHG emissions [44]. Table 3 shows the co-processing capacities and coal substitution rates of leading cement producers in Vietnam.

**Table 3.** Co-processing capacity and substitution rates of leading cement producers in Vietnam [19].

| Company | Co-processing capacity (tpd) | Coal substitution rate* |
|---|---|---|
| INSEE | 5000 | 27 |
| VICEM But Son cement | 4000 | 20 |
| Lam Thach Plant | 1500 | 20 |
| VICEM Ha Tien cement | 4000 | 5 |
| VICEM Ha Long cement | 5500 | 3 |

*Refers to the percentage of coal replaced by alternative sources through co-processing

However, co-processing also presents potential environmental challenges. The combustion of municipal or industrial wastes can generate additional pollutants such as nitrogen oxides ($NO_x$), sulfur oxides ($SO_x$), heavy metals, and persistent organic pollutants (e.g., PCDD/Fs), if feedstock sorting and emission control systems are inadequate [45]. Many cement producers are adopting advanced emission-control technologies to capture and treat pollutants generated during the production process [46]. Furthermore, emerging manufacturing approaches offer both operational advantages and viable pathways for mitigating environmental impacts [39,40,47]. To maintain long-term value, Vietnam's cement producers should adopt a comprehensive approach that includes a well-developed EMS and fully integrates ESG principles into their core business strategies. Such holistic integration is crucial for achieving sustainable success across the industry.

## 5. The importance of strong environmental management systems in Vietnam's cement industry

An EMS is a structured framework that enables organizations to manage, monitor, and continually improve their environmental performance. A robust EMS typically comprises an environmental policy, impact assessments, measurable objectives, management programs, continuous monitoring, and regular audits to ensure compliance and ongoing improvement [48,49]. In the cement industry, implementing an EMS supports sustainable practices and enhances overall performance, particularly across three key dimensions: regulatory frameworks, market competitiveness, and operational efficiency [31,49].

### *5.1. Regulatory frameworks and ESG*

Regulatory frameworks are key determinants shaping the ESG factors within an EMS. These frameworks strongly influence how organizations operate, promoting social and governance aspects alongside environmental considerations [50,51]. For instance, in Vietnam, firms operating in environmentally sensitive or high-polluting sectors are required to submit environmental impact assessment reports to the Ministry of Natural Resources and Environment or relevant local environmental authorities [52]. Additionally, the Vietnamese government has demonstrated a strong commitment to promoting green building development and energy efficiency through financial incentives and green building codes [53,54]. This commitment is reflected in several national strategies and initiatives, underscoring the importance of sustainability in the country's overall development agenda [55]. The Environmental Protection Law in Vietnam is pivotal in establishing the country's environmental governance framework. It strengthens penalties for pollution, establishes incentive mechanisms for environmental protection, and mandates public oversight. Moreover, ISO 14001 certification requirements are also integrated [52].

The influence of this law on corporate ESG performance is evident in several ways. From an environmental perspective, stricter penalties for violations, such as exceeding emission limits or engaging in illegal waste disposal, raise the cost of non-compliance and enhance environmental awareness among firms, particularly those that have historically relied on pollution-intensive growth models [56]. From a governance perspective, the law's incentive mechanisms, such as tax credits and subsidies, encourage corporate investment in cleaner production technologies and the adoption of comprehensive EMSs. Meanwhile, the law's emphasis on public supervision and mandatory disclosure strengthens social accountability by empowering community oversight. This enhanced transparency has prompted cement companies to respond more proactively to stakeholder environmental concerns, thereby improving their social responsibility performance and contributing to broader sustainable development goals [56,57].

At the international level, climate policies have already influenced $CO_2$ outcomes in the cement sector. Cross-country analyses show that nations with binding Kyoto Protocol targets experienced statistically significant declines in cement manufacturing and cement-related $CO_2$ emissions compared with non-binding peers, suggesting policy-driven technological and process adjustments [58]. Under the EU Emissions Trading System, ex-post evaluations report emission reductions in covered sectors without significant aggregate output losses, while cement-specific studies examine competitiveness and potential carbon-leakage effects under free allocation and trading rules [59,60]. In parallel, the UNFCCC Clean Development Mechanism introduced standardized methodologies, including AM0024 for WHR and ACM0005 for increased blended-cement and SCM use, which enabled project-based emission reductions in developing economies [61].

Building on these regulatory signals and international experiences, market forces and shifting customer preferences now shape how Vietnamese cement producers operationalize their ESG commitments. This is further elaborated in Section 5.2.

### *5.2. Market competition and shifting consumer awareness*

In an era increasingly defined by ESG considerations, it is imperative for the cement industry to enhance its corporate reputation through process innovation and contributions to environmental sustainability. In recent years, the global landscape has been shaped by significant challenges, including climate change, pandemics, geopolitical conflicts, and economic instability. As a result, demands and expectations for sustainable development have evolved from broad consensus to concrete regulatory requirements. Corporate ESG performance has become a fundamental evaluation metric, requiring firms to disclose internal operational decisions and their commitments to ESG practices [62,63].

Consequently, public awareness of environmental issues has risen notably, accompanied by a growing consumer preference for eco-friendly materials [64]. This shift has become one of the strongest drivers motivating Vietnamese cement producers to adopt ESG-oriented strategies, particularly on the environmental dimension, which is the most visible and widely promoted. Vietnamese consumers are becoming increasingly conscious of environmental issues and are adjusting their purchasing behaviors accordingly. They actively seek products and services from socially responsible companies while avoiding those perceived as environmentally or socially harmful [65]. This shift in consumer awareness has led to a growing preference for eco-friendly materials. A recent survey found that over 70% of Vietnamese consumers are willing to pay more for sustainable, environmentally friendly products [66], while 65% actively seek and purchase from companies with strong environmental and social responsibility practices [65]. Furthermore, a government study revealed that over 80% of Vietnamese homebuyers and developers now consider environmental certifications and sustainable features as important purchasing factors, up from just 45% a decade ago [67]. This changing consumer sentiment has prompted many Vietnamese cement producers to invest in green technologies and adopt more sustainable practices to meet the rising demand for eco-friendly building materials.

The growing demand for environmentally friendly construction projects has further accelerated the integration of sustainability in Vietnam's cement sector. The construction industry plays a crucial role in the economy, but it also contributes significantly to global environmental pollution, resource consumption, and carbon emissions [68]. In response, Vietnam has implemented the National Strategy for Green Growth and the National Plan for Efficient Energy Use and Savings to promote green buildings and energy efficiency [68,69]. Currently, four prominent green building certification systems are used in Vietnam: LEED, LOTUS, EDGE, and Green Mark [70]. Other systems, such as WELL, Fitwel, and EarthCheck, have far fewer certified projects. Among these certification types, LEED is the most prevalent, with LEED-certified projects accounting for over 52% of all projects under the four main certification systems in Vietnam (Figure 7) [71]. As of September 2022, a total of 258 projects in Vietnam had achieved green building certification under these four systems, with industrial projects accounting for 37.2% of the total [71].

Gradually, the growing consumer awareness and strong demand for green building certifications in Vietnam's construction industry have significantly influenced the ESG priorities of the nation's cement producers, with the environmental dimension playing the dominant role.

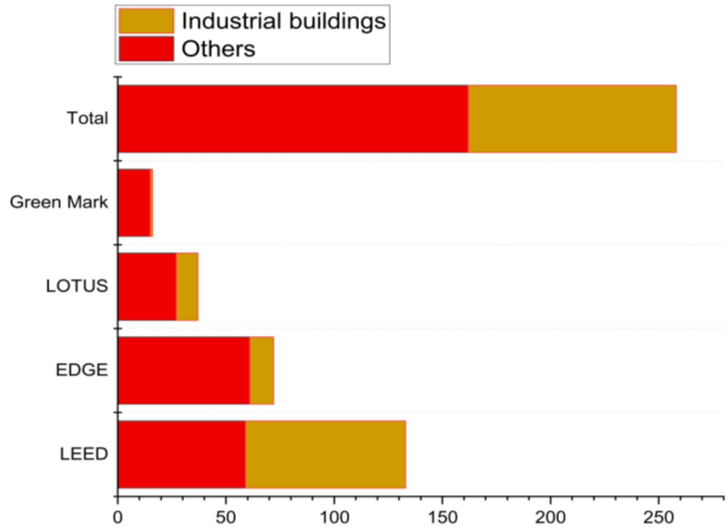



**Figure 7.** Statistics on the number of green industrial projects in Vietnam (as of September 2022) [71].

### *5.3. Operational benefits and organizational culture*

A comprehensive EMS delivers multiple operational benefits, aligning with consumer expectations while simultaneously transforming organizational culture. By integrating environmental factors into strategic planning and operational decision-making, cement plants can proactively identify opportunities to minimize environmental impacts and maximize resource efficiency. An EMS enables cement plants to systematically monitor environmental performance, track progress toward established targets, and identify areas for continuous improvement. Furthermore, the implementation of an EMS has led to significant improvements in environmental performance, as evidenced by Vietnamese cement plants that have adopted ISO 14001 certification [49].

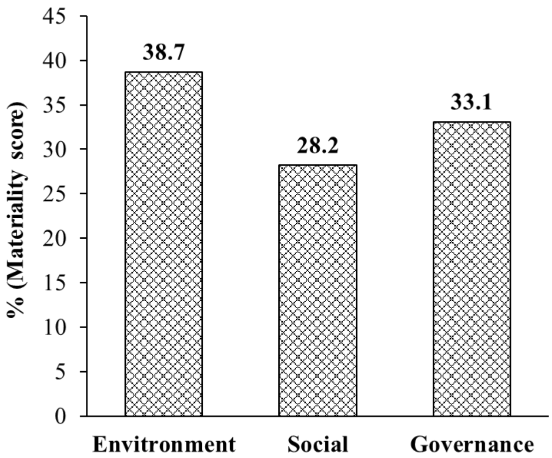
Given the cement industry's substantial GHG emissions, there is a growing need to strengthen environmental sustainability through cleaner production, which presenting vast opportunities for improvement. According to a report by the International Finance Corporation (IFC), a member of the World Bank Group, cement producers that implement robust environmental, social, and governance practices can achieve significant operational and financial benefits. The IFC's research indicates that cement companies with strong ESG management systems achieve 15–20% reduction in energy consumption, 10–15% decrease in waste generation, and 5–10% improvement in overall production efficiency [3].

Additionally, adopting ESG practices positively influences a cement producer's organizational culture. These companies have reported a 20–30% increase in customer satisfaction and 10–15% improvement in employee retention rates [3]. Peer-reviewed research supports this finding: a 2024 analysis found that companies embracing ESG principles exhibit higher total factor productivity, partly because they improve workforce efficiency and reduce operational waste [72]. In other words, engaging in responsible practices helps eliminate inefficiencies, enabling employees to become more productive with the same resources.

## 6. The role of *environmental* in driving ESG performance in cement production

Building on the aforementioned drivers, the *environmental* pillar represents one of the most material dimensions for Vietnam's cement industry. This section synthesizes the mechanisms through which environmental practices influence social and governance performance in cement production, drawing upon both firm-level and sectoral evidence.

According to MSCI's materiality report, in the construction materials industry, the environmental pillar has the highest materiality score and the strongest impact on corporate decision-making. Specifically, carbon emissions have been identified as the top priority for most businesses in this sector (Figure 8) [11].

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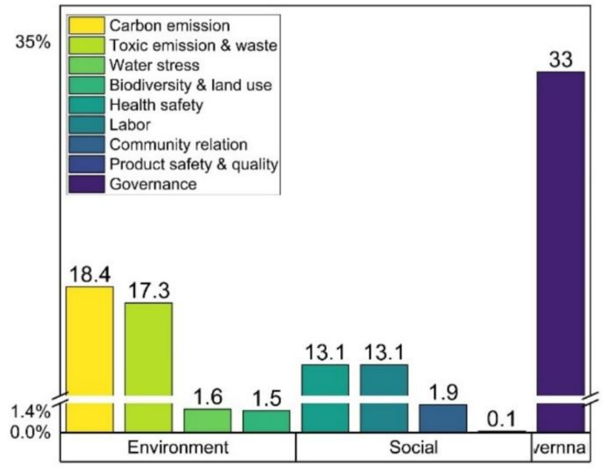


b)

**Figure 8.** Materiality scores of ESG pillars in the construction materials sector: (a) pillar-level scores (environment, social, governance); (b) topic-level materiality contributions by pillar [11].

Numerous studies have demonstrated strong interconnections between the *environmental* pillar and the *social* and *governance* dimensions across operations, regulatory frameworks, financing mechanisms, and societal outcomes. Sun et al., using PLS-SEM and ANN models on a dataset of 457 manufacturing firms, confirmed that energy efficiency, a key driver of the environmental pillar, positively influences all ESG dimensions. Firms with mature EMSs not only fulfill environmental responsibilities but also build stronger stakeholder trust, leading to improved community relations, employee well-being, and broader social benefits [73]. Baran et al. similarly emphasized that sustainable practices enhance social performance, while an IFC (2020) survey reported that cement companies with strong ESG management achieved 20–30% higher customer satisfaction and 10–15% greater employee retention [74]. Collectively, this evidence suggests that integrating environmental and social performance offers firms a competitive advantage, as stakeholders increasingly reward environmental responsibility and social accountability [75]. Voluntary environmental initiatives further reinforce corporate performance [76,77] while strengthening long-term commitments to environmental protection [78].

Strengthening the environmental pillar also drives climate-related initiatives addressing emissions reduction, resource efficiency, waste management, and renewable energy adoption, in alignment with regulations, industry standards, and stakeholder expectations. Firms adopting low-carbon strategies or energy optimization typically establish stronger governance frameworks to track performance, thereby improving efficiency and fostering accountability and transparency. These dynamics are consistent with the findings of Kwilinski, Lyulyov, and Pimonenko, who identified a mutually reinforcing relationship between sustainable practices and governance quality [79]. At the same time, external drivers such as environmental regulations and carbon pricing further influence corporate financial decisions and sustainability goals [73]. Ultimately, a well-implemented EMS not only embeds sustainable practices but also ensures compliance, mitigates risks, and attracts responsible investors, thereby strengthening governance and enhancing transparency [13,75].

In Vietnam's cement industry, the environmental pillar often takes precedence, driven by rising consumer demand for sustainable construction and increasingly stringent regulatory scrutiny. A notable strategy has been the adoption of EPDs, which provide third-party verified data on life-cycle environmental impacts, including resource use, energy consumption, and carbon footprint [72]. For many Vietnamese cement manufacturers, EPDs enhance product credibility, attract sustainability-conscious customers, and strengthen brand image. For example, Vicem Ha Long leveraged EPD certification to expand its share of green building projects, achieving a 25% revenue increase from this segment [20].

By prioritizing the environmental pillar, cement producers can catalyze positive transformations across the social and governance dimensions, fostering a more sustainable and responsible industry. This integrated approach not only improves environmental performance but also cultivates a culture of sustainability that permeates organizations, ultimately reinforcing all three ESG pillars.

## 7. Conclusion

This review examined how the environmental pillar shapes ESG performance in Vietnam's cement industry. We find that rising demand, evolving regulation, cleaner-production programs, and the adoption of EMS are pushing firms toward stronger environmental responsibility. Prioritizing the environmental pillar can simultaneously improve efficiency and cost control, enhance worker well-being and community outcomes, strengthen stakeholder trust, ensure compliance, and attract capital, while aligning with growing customer demand for low-carbon products.

Synthesizing the literature, three channels by which the environmental pillar influences social and governance performance stand out. First, EMS and energy-efficiency measures (kiln/grinding upgrades, WHR, better process control) reduce emissions and operational risk while improving safety, retention, and transparency. Second, low-clinker, low-carbon products (greater SCM and $LC^3$ use) connect environmental gains with market reputation and procurement advantages, reinforcing disclosure and assurance practices. Third, fuel and power transitions (higher alternative-fuel substitution and cleaner electricity) embed monitoring and governance disciplines across the supply chain. Against this backdrop, the decarbonization pathway requires intensity to fall to ~0.45 $tCO_2$ per ton of cement by 2030. Achieving this calls for accelerated deployment of no/low-regret measures now and targeted innovation (e.g., CCUS pilots at suitable sites) to enable deeper cuts.

Despite progress, evidence gaps remain. Most studies do not yet quantify the relative contribution of specific environmental actions to social and governance outcomes, and sector-specific, Vietnam-focused datasets at a plant/facility level are scarce. Future studies should focus on developing robust methodologies to address this gap, providing cement manufacturers with actionable insights to optimize their ESG strategies and maximize their positive impact on the environment and society. Furthermore, research into the life-cycle assessment of products among Vietnamese cement manufacturers could further our understanding of how ESG integration contributes to product competitiveness. Ultimately, a holistic and quantifiable understanding of ESG's components is crucial for driving truly sustainable practices in the cement industry and beyond.

**Use of AI tools declaration**

The authors declare they have not used Artificial Intelligence (AI) tools in the creation of this article.

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**Conflict of interest**

All authors declare no conflict of interest in this paper.

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**Appendix: List of abbreviations**

| No. | Abbreviation | Full form |
|---|---|---|
| 1 | ANN | Artificial neural network |
| 2 | BAU | Business as usual |
| 3 | CCUS | Carbon capture, utilization, and storage |
| 4 | COP26/COP27 | Conference of the Parties 26/27 |
| 5 | CSR | Corporate social responsibility |
| 6 | EMS | Environmental management system |
| 7 | EPD | Environmental product declaration |
| 8 | ESG | Environment, social, and governance |
| 9 | GDP | Gross domestic product |
| 10 | GHG | Greenhouse gas |
| 11 | IEA | International Energy Agency |
| 12 | IFC | International Finance Corporation |
| 13 | IPCC | Intergovernmental Panel on Climate Change |
| 14 | LULUCF | Land use, land use change, and forestry |
| 15 | NDC | Nationally Determined Contribution |
| 16 | PLS-SEM | Partial least squares structural equation modeling |
| 17 | SCM | Supplementary cementitious materials |
| 18 | WHR | Waste heat recovery |