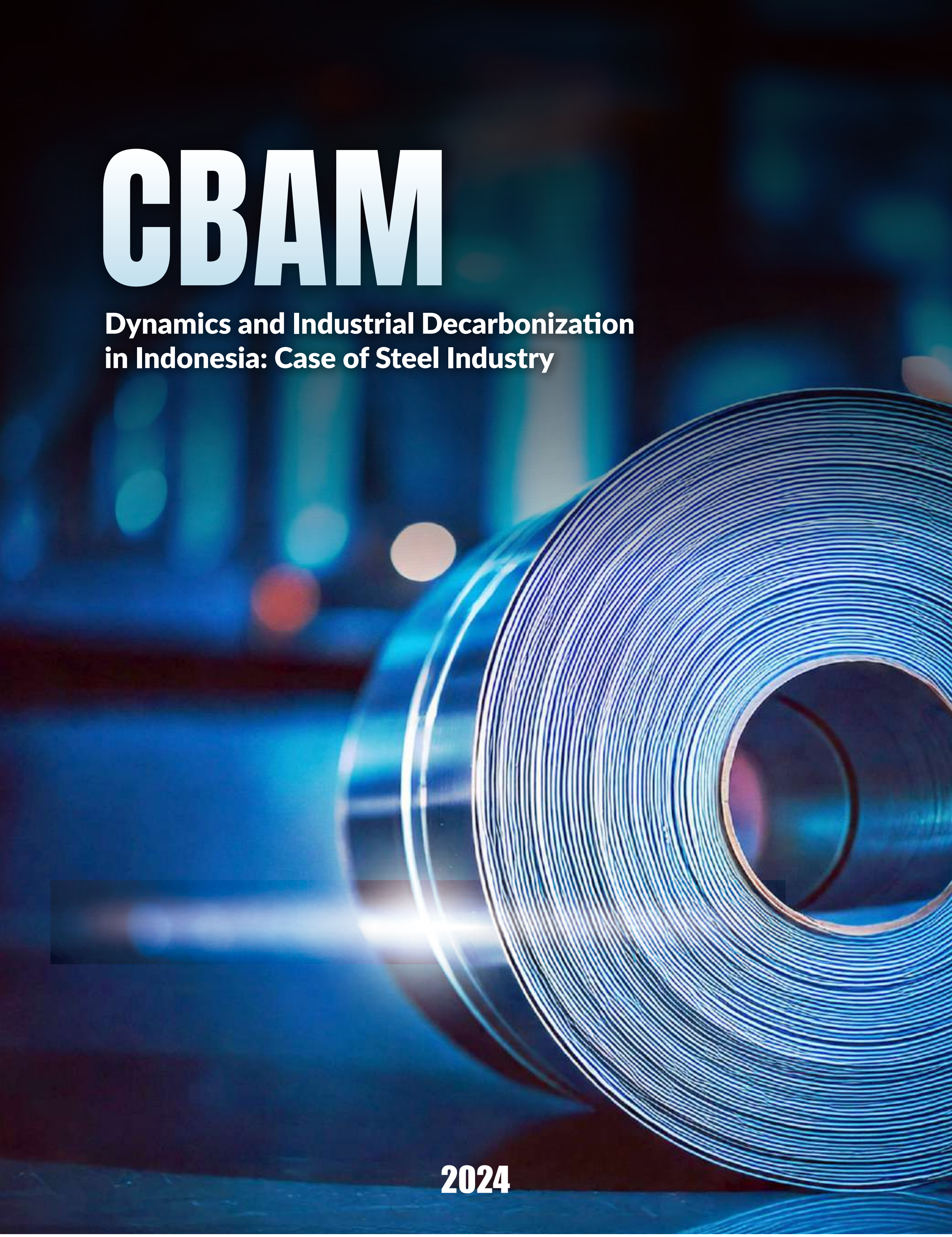

CBAM

Dynamics and Industrial Decarbonization in Indonesia: Case of Steel Industry

2024

UNIVERSITAS GADJAH MADA
PUSAT STUDI ENERGI

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FOREWORD

It is with great pride and anticipation that we present this final report, "CBAM Dynamics and Industrial Decarbonization in Indonesia: Case of Steel Industry." This work reflects the collective efforts and expertise of our dedicated team, aiming to address one of the most pressing challenges of our time: achieving sustainable industrial practices amidst evolving global environmental policies.

The global landscape is witnessing an urgent shift toward decarbonization, driven by international commitments such as the Paris Agreement and policies like the EU's Carbon Border Adjustment Mechanism (CBAM). These initiatives underscore the critical need for industries worldwide, including Indonesia's steel sector, to embrace cleaner, more sustainable technologies. As a key player in the global steel market, Indonesia is uniquely positioned to leverage these changes, transforming challenges into opportunities for growth and innovation.

This report delves into the technical, economic, and regulatory dimensions of industrial decarbonization. It provides a comprehensive analysis of the implications of CBAM on Indonesia's steel industry and offers actionable recommendations for policymakers and industry stakeholders. By fostering collaboration and aligning national policies with global standards, we can not only mitigate potential economic impacts but also drive the transition towards a greener, more sustainable future for Indonesia.

We extend our heartfelt gratitude to our partners and contributors for their invaluable support. It is our hope that this report serves as a catalyst for informed dialogue and effective action, paving the way for a resilient and sustainable industrial sector in Indonesia.

Thank you,

Prof. Sarjiya
Director
Pusat Studi Energi (PSE, Center for Energy Research)
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Executive Summary

Background and Context

Energy transition has emerged as a global priority driven by the urgent need to combat climate change and achieve environmental sustainability. A key milestone was the ratification of the Paris Agreement in 2015, emphasizing the commitment to limit global temperature rise to below 2°C. In this context, the European Union (EU) introduced the European Green Deal in 2018, aiming for climate neutrality by 2050 and a 55% reduction in greenhouse gas emissions by 2030 compared to 1990 levels. The Fit for 55 Package, launched in 2021, outlines legislative proposals supporting these goals, reinforcing the EU's leadership in the transition towards a sustainable economy.

One significant measure within this framework is the Carbon Border Adjustment Mechanism (CBAM), designed to prevent carbon leakage from high-emission imports. This mechanism will require exporters to report carbon emissions during the transition phase (2023-2025) and mandate CBAM certificate purchases from 2026, in alignment with the EU Emissions Trading System (EU ETS). CBAM encompasses products like iron and steel, fertilizers, aluminum, cement, hydrogen, and electricity, aiming to reduce emissions while maintaining the competitiveness of European industries.

As a steel-exporting country, doubtless Indonesia will be significantly impacted by the implementation of CBAM. Between the year 2015 and 2023, Indonesian steel exports to the EU had grown at an annual rate of 70%, positioning the country among the top ten steel exporters to the EU. However, Indonesia's steel production remains heavily reliant on high-emission coal, posing a risk to competitiveness of the country's steel unless appropriate decarbonization strategies are implemented. Addressing CBAM's implementation will require collaboration among industry stakeholders, policymakers, and academics to create a comprehensive policy framework.

This study aims to analyze the Indonesian iron and steel industry's current conditions from economic, technical, and legal perspectives, identifying bottlenecks in developing an energy transition framework - especially amid the dynamics of CBAM implementation by the EU. The findings are expected to provide valuable insights for both the government and the industry itself.

Global Overview of Steel Production and Decarbonization Effort

Over the last two decades, the steel industry has experienced an upward trend in steel production, with a global annual increase of 3.54%, peaking at 1,892 million metric tons (mmt) in 2023, with BF-BOF as the leading technology. Although certain regions, such as North America, Africa, and the Middle East, have increased their adoption of EAF technology since 2013, the continued prevalence of BOF in the Asian region - which accounted for 73.74% of the global production volume in 2023, will have a significant impact on the steel industry's overall carbon footprint.

Despite the dominance of BF-BOF technology, the iron and steel industry has begun to explore decarbonization technologies, one prominent example being the use of hydrogen in direct reduced iron (DRI) production processes, or as a co-injected element alongside coal. Several strategies are available to steel manufacturers to improve energy efficiency and reduce carbon emissions. These include the use of pulverized coal to enhance energy efficiency, the adoption of waste heat and gas recovery technologies, and electrification via electric arc furnaces (EAF) and electric induction furnaces.

Indonesia’s Steel Production

Indonesia has been experiencing a consistent rise in steel production, achieving an annual growth rate of 20.5% since 2013. While Indonesia's steel production accounts for approximately 0.89% of the global steel volume, the country has established itself as the fourteenth largest crude steel producer in the world.

Indonesia in the Global and EU Steel Market: Rise of Opportunity

In the context of Indonesia, despite its relatively low domestic steel demand of only 16.60 mmt in 2023, there was a commendable annual demand growth rate of 3.90%, which surpassed the global average. The steel trade balance of Indonesia had also been steadily increasing, marked by an annual export growth rate of 21.82% since 2015. Despite having a relatively small global market share of approximately 2.55% for steel goods, Indonesia secured the 15th position among the world's largest steel exporters in 2023. China is Indonesia's primary steel export destination, with an export percentage of 51.72%. The EU is the other leading destination for the country's steel exports, with an export percentage of 5.92%.

Significant shifts have occurred regarding the entities engaged in the EU's steel market. In early 2014, China and Ukraine were prominent, contributing around 30% of the EU's steel imports. However, since 2015, there has been a notable decline in steel imports from China and Ukraine, which now represent only 8.6% and 4.57% of total imports, respectively. South Korea and India are presently the leading contributors, with a combined market share of 23.6% in the EU's steel market. Conversely, it is noteworthy that while the volume of Indonesia's steel exports to the EU remains relatively low at just 3%, the country has experienced a significant annual increase of 70% in its steel exports to the EU. As a result, Indonesia maintains significant opportunities within the EU steel market.

Impact of Energy Transition and CBAM Implementation on Indonesia

Implementing an energy transition may initially lead to a downturn in certain economic indicators. Nonetheless, transitioning to cleaner energy sources is essential for reducing CO_2 emissions and improving social welfare, by decreasing the negative externalities associated with fossil fuel consumption. Regarding employment, this shift will initially cause job displacement; however, as renewable energy projects scale up, substantial job opportunities are expected to emerge.

The implementation of CBAM is expected to impact Indonesia's economy, measurable through various macroeconomic indicators. The anticipated effect on economic growth could range from a decline of approximately 0.00013% to 0.0003%, depending on the CBAM application rate, which ranges from 5% to 15%. In terms of trade balance, CBAM adoption is projected to decrease Indonesia's trade balance by between USD 29.56 million and USD 66.49 million. Additionally, the steel export sector is likely to experience a reduction in export value, potentially declining by USD 6.67 million to USD 15.01 million as CBAM tariffs increase. These potential negative impacts of CBAM further highlight the critical importance of pursuing energy transition and industrial decarbonization in Indonesia.

Several issues have been identified for the government and industry in the event that CBAM is fully implemented in the EU, particularly if Indonesia's iron and steel industry aims to maintain its export market in that region.

Issues and Challenges: Industry Perspective

1. Technological Challenge

The blast furnace–basic oxygen furnace (BF-BOF), which uses a lot of energy—roughly 21GJ per ton of steel product—continues to be the main method used in Indonesia to produce iron and steel. The emissions intensity produced by BF-BOF is 2.33 tons of CO2 per ton of crude steel, which is higher than the global average of 1.91 tons of CO2 per ton of crude steel. Therefore, the usage of BF-BOF in Indonesia contributes to the highest emissions in the iron and steel industry. The technological shift to reduce the carbon footprint for steel frequently necessitates alterations to pre-existing infrastructure, which add complexity to implementation and can be costly and time-consuming. These challenges include the requirement to adapt existing machinery, procedures, and systems to make them compatible with new technologies.

2. Inconsistencies in Emission Calculations

A further problem arises due to inconsistencies between the emission calculation methods used in CBAM and Indonesian legislation, especially in the direct emission calculation formula. This makes it challenging to harmonize emission estimates, resulting in two differing estimation outcomes. Furthermore, because emissions may be generated outside the industrial system, the approach used in Indonesia is susceptible to overestimation.

3. Supply-side Bottleneck

On the other hand, the supply of scrap remains limited, even though it is an essential resource that allows the steel industry to step closer towards achieving carbon neutrality. Due to the long lifespan of steel products, scrap availability is limited in emerging economies like Indonesia, where industrialization began more recently compared to developed nations. Additionally, the lack of regulation surrounding the collection and classification of scrap metal could exacerbate this shortage.On the other hand, the supply of scrap remains limited, even though it is an essential resource that allows the steel industry to step closer towards achieving carbon neutrality. Due to the long lifespan of steel products, scrap availability is limited in emerging economies like Indonesia, where industrialization began more recently compared to developed nations. Additionally, the lack of regulation surrounding the collection and classification of scrap metal could exacerbate this shortage. On the other hand, the supply of scrap remains limited, even though it is an essential resource that allows the steel industry to step closer towards achieving carbon neutrality. Due to the long lifespan of steel products, scrap availability is limited in emerging economies like Indonesia, where industrialization began more recently compared to developed nations. Additionally, the lack of regulation surrounding the collection and classification of scrap metal could exacerbate this shortage.

Issues and Challenges: Government Perspective

1. Implementation Challenge of Renewable Energy Regulation in Indonesia

An analysis of Indonesia's regulatory framework reveals that various laws and regulations govern the country's use of renewable energy, but their implementation still faces several challenges. Despite targets for new and renewable energy (NRE) to contribute at least 23% by 2025 and 31% by 2050, progress towards the achievement of these targets remains doubtful. Article 12 of PP KEN states that the EBT targets should be achieved by keeping economic feasibility in consideration, suggesting a government priority on energy security and price stability over environmental sustainability. Indonesia also faces an energy trilemma in the context of energy transition that encompasses energy security, energy equity, and environmental sustainability. Energy security is a top priority due to the country's high dependence on fossil fuels, as stipulated in Article 7 of Law No. 30/2007, which emphasizes on ensuring energy availability and accessibility. However, the issues of energy equity and environmental sustainability are often overlooked, negatively impacting communities and ecosystems.

2. Effectiveness of Carbon Tax Implementation in Indonesia

Under the Tax Harmonization Law (Law No. 7 of 2021), the carbon tax rate is determined by an unusual provision requiring it to be at least equal to the domestic carbon market price per kilogram (kg) CO_2e and not less than IDR 30/kg Co_2e. This provision allows for the carbon tax to fluctuate along with market carbon prices, which contrasts with the fixed and predictable nature of taxes. On the other hand, the current carbon price in Indonesia is still relatively low at IDR 58,000 per ton of CO_2. Whereas the EU Emissions Trading System (ETS) price has reached EUR 62, equivalent to approximately IDR 1,000,000. This disparity calls into question the effectiveness of Indonesia's carbon tax in promoting emission reductions and green technology investments.

3. Green Industry Standard (SIH) as a Measure to Promote Sustainable Industry Practices

As part of this regulatory framework, Indonesia has established the Green Industry Standard (Standar Industri Hijau or "SIH") as part of its efforts to promote sustainable and environmentally-friendly industrial practices. The SIH was introduced by the Ministry of Industry and applies to 17 types of industries, providing guidelines on various aspects, such as raw materials, energy use, production processes, waste management, and overall business management. The SIH is designed not only to reduce the environmental impact of industrial activities but also to enhance the global competitiveness of Indonesian industries by aligning them with international sustainability standards. Currently, the implementation of SIH is voluntary, allowing companies to adopt these standards at their discretion. However, recognizing the critical importance of environmental sustainability, the Indonesian government has outlined plans to transition SIH into a mandatory framework for certain key sectors in the future.

4. SIH and CBAM Compatibility

Despite these proactive measures, a critical analysis of the EU's CBAM reveals a significant limitation. CBAM's regulations do not recognize or accept green certificates, including Indonesia's SIH, as valid evidence for carbon emissions calculations. CBAM requires EU importers to account for the embedded carbon emissions of their products, and it stipulates specific methodologies and verification processes to which adherence is required. This lack of recognition means that SIH certifications are not currently considered sufficient under CBAM's stringent requirements. As a result, Indonesian exporters who have invested in and complied with SIH standards may find that these efforts do not facilitate compliance with CBAM regulations. The infeasibility of using SIH certifications for CBAM purposes could potentially place Indonesian industries at a disadvantage in the EU market.

5. Further Improvement for SIH

However, it's important to note that while SIH certificates may not directly satisfy CBAM requirements, they are not without value in the broader context of Indonesia's climate change mitigation efforts. There is potential for SIH to play a crucial role in Indonesia's national carbon emission calculations, presenting an opportunity for better alignment between domestic and international sustainability efforts. To bridge the gap between SIH and CBAM requirements, Indonesia could consider enhancing SIH standards to align more closely with international carbon accounting methodologies, developing conversion mechanisms to help companies translate SIH compliance into CBAM-compatible emissions data, engaging in bilateral negotiations with the EU to explore possibilities for partial recognition of SIH, and supporting industries in developing dual reporting capabilities that satisfy both SIH and CBAM requirements.

Key Recommendation

Based on our findings, we have formulated several key recommendations below:

1. The differences in emission calculations implemented in CBAM and Indonesian legislation will pose a challenge and, consequently, complicate the alignment of emission estimates, creating discrepancies in emission reporting between Indonesian and CBAM standards. Therefore, **aligning emission calculation methodologies** can eliminate the inconsistencies in the emission value.

2. The CBAM implementation will limit the volume of high-emission products to be exported to the EU. Hence the **adoption of cleaner technologies is necessary to reduce the emission footprint in the manufacturing processes.** This study excludes Carbon Capture, Utilization, and Storage (CCUS) as a recommended option, citing concerns about the long-term effectiveness of CCUS and the potential risk of prolonging fossil fuel dependency through practices like Enhanced Oil Recovery (EOR).

3. **Provision of incentives for industries to transition towards low-carbon technologies is essential.** This need arises from the high upfront capital costs associated with clean technologies, and because many steel plants in Indonesia are relatively new; investing in new technologies could impact the overall economic viability of these projects.

4. The implementation of CBAM will likely limit the volume of high-emission steel imports by the EU. Consequently, there is a possibility that exports of high-emission steel may be redirected to countries with less stringent carbon policies, such as Indonesia. Therefore, **a policy response, including protective measures, is necessary to safeguard the domestic industry.**

5. Indonesia has several emission reporting frameworks under different ministries, each focusing on specific sectors. These disparate frameworks must be integrated into a unified

national system to align with international mechanisms such as CBAM and streamline the reporting process. **This alignment would involve creating a centralised system for calculating, reporting, and verifying carbon emissions and a registry consolidating data from all relevant ministries and sectors.** Maintaining detailed records of emissions data and related documentation is also necessary to support compliance, as these may be subject to regulatory requirements.

6. **The government must extend the cap and carbon tax policy to the industrial sector.** By broadening the scope of the carbon tax, Indonesia can better align with international carbon pricing mechanisms, such as the EU's CBAM. This would also address challenges in implementing the economic value of carbon in Indonesia, such as the suboptimal application of carbon pricing mechanisms and the significant disparity between Indonesia's and the EU's carbon prices.

CHAPTER I
INTRODUCTION

This report presents an in-depth examination of the implications of CBAM on Indonesia's industrial sector. As the global landscape shifts towards more stringent environmental standards, exemplified by mechanisms like the CBAM, Indonesia faces critical challenges and opportunities in aligning its industrial sector with these evolving norms. The urgency of this alignment stems from the growing international consensus on climate change mitigation, which has led to the implementation of robust environmental policies worldwide. Countries are increasingly adopting measures to limit greenhouse gas emissions and promote renewable energy sources, creating a competitive global market for sustainable products. This global shift is driven by the pressing need to address the adverse impacts of climate change, reduce dependency on fossil fuels, and ensure long-term energy security. The CBAM, introduced by the European Union (**"EU"**), exemplifies these measures to prevent carbon leakage and maintain fair competition among industries by imposing a carbon price on imports based on their embedded emissions.

Central to this report is an analysis of Indonesia's current technical, economic, and regulatory environment, particularly concerning its industrial energy consumption and reliance on fossil fuels. Indonesia's industrial sector significantly contributes to the country's greenhouse gas emissions, accounting for over 60% of the national total. This heavy reliance on fossil fuels exacerbates environmental degradation and exposes the sector to the volatility of global fuel prices. Such fluctuations can have profound economic repercussions, affecting the cost of production and the competitiveness of Indonesian exports in the international market. Moreover, Indonesia's existing regulatory frameworks are often scrutinized for their effectiveness in promoting sustainable energy practices and reducing emissions. The country has made some progress in this regard, with policies aimed at increasing the share of renewable energy in the national energy mix and improving energy efficiency. However, insufficient enforcement, lack of financial incentives, and technological barriers often hampered these efforts. The introduction of the CBAM adds another layer of complexity to this scenario, as it imposes potential trade restrictions on Indonesian exports to the EU, a significant trading partner.

The implications of the CBAM for Indonesia's industrial sector are multifaceted. On one hand, it presents a challenge, requiring industries to adopt greener practices to avoid additional costs associated with carbon pricing. On the other hand, it offers an opportunity for Indonesia to accelerate its energy transition, improve environmental sustainability, and enhance its global competitiveness. By embracing renewable energy technologies and improving energy efficiency, Indonesian industries can reduce their carbon footprint, mitigate the risks associated with fuel price volatility, and comply with international environmental standards.

This report will delve into the potential pathways for Indonesia to navigate these challenges and seize the opportunities presented by CBAM implementation. It will explore the feasibility of adopting various renewable energy technologies, the role of government policies and incentives, and the importance of international cooperation and investment. Additionally, the report will provide case studies of successful energy transitions in other countries, offering valuable insights and lessons that can be applied to the Indonesian context.

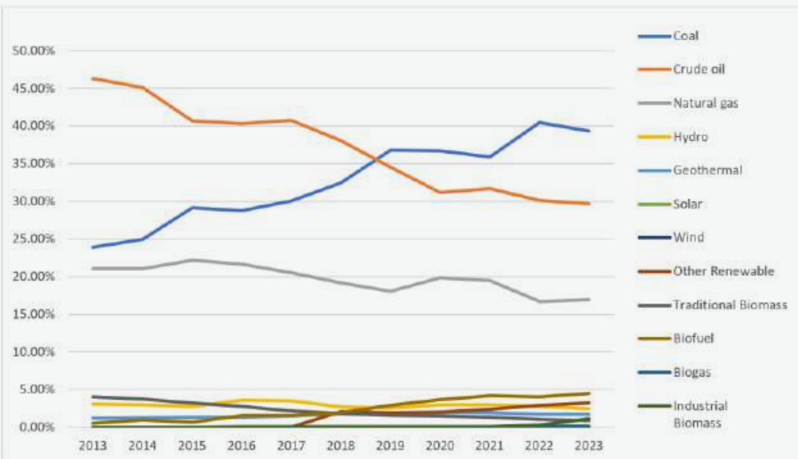
1.1 The Importance of Decarbonization

An increase in economic activity (hence, an increase in economic growth) typically would result in the increase of carbon emissions. The trends between regions and countries could be different depending on the energy efficiency measures taken by each country and the extent of the transition to cleaner fuel or energy sources. Comparing GDP growth and emissions trends across various countries and regions reveals that in advanced economies such as the United States, EU, Japan, Korea, Australia, and New Zealand, emissions tend to decrease as GDP grows. In contrast, regions like Southeast Asia and the Middle East see emissions rise alongside economic growth.

As the economic activity has continued to rebound after the COVID pandemic, which started in 2019, Indonesia's economy has seen positive growth in its GDP. In 2023, the economy expanded by 5.05%, a slightly lower rate compared to the 5.35% growth in 2022, but the overall economic growth has been positive in the last four years (National Statistic Agency, 2024). The growth was largely bolstered by the increase in the Transportation and Warehousing sector, which grew at 13.96 percent year-on-year, followed by the Other Services Sector with a 10.52% year-on-year growth. Nevertheless, the sectoral breakdown of the contribution to GDP numbers reveals that, by and large, Indonesia's economy has been supported significantly by the Manufacturing sector, which constituted 20.39% of GDP in 2023.

The influence of the Manufacturing sector on the overall economy also is further evidenced by its output multiplier. According to calculations from the Input Output Table, the output multiplier of the Manufacturing sector is 1.77, surpassing the national average of 1.62. The number implies that every IDR 1 investment in the Manufacturing sector generates a IDR 1.77 increase in total output in the long run. The sector's significant share in GDP and its high output multiplier indicates the importance of Manufacturing sector in Indonesia's economy.

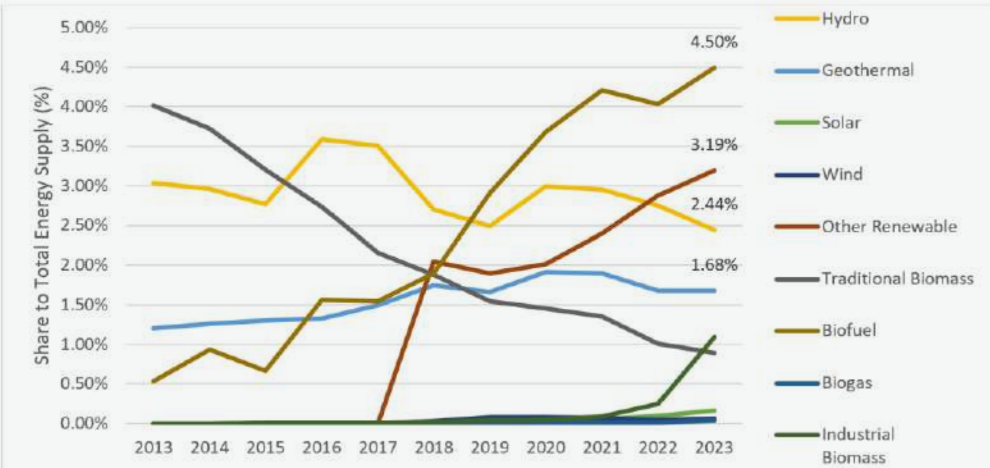
On the other hand, Indonesia's economy has long been profoundly reliant on fossil fuel energy, which has provided the country with the bulk of its domestic energy supply, as can be seen in Graph 1 below.



Graph 1. *Indonesia's Energy Supply Share by Type of Fuel*
Source: MEMR[2]

[1] BPS (2024). *Produk Domestik Bruto atas Dasar Harga Konstan 2010 Menurut Lapangan Usaha (Berbagai Tahun).* Badan Pusat Statistik
[2] MEMR (2024). *Handbook of Energy and Economic Statistics of Indonesia 2023*. Ministry of Energy and Mineral Resource Republic of Indonesia

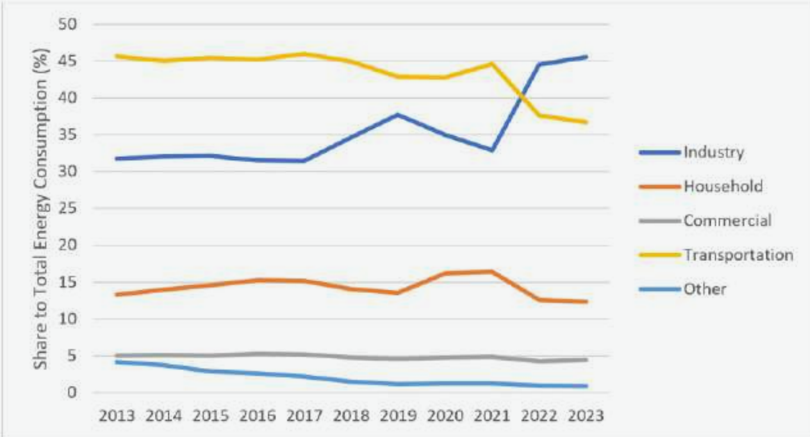
Graph 1 shows that the share held by fossil fuels in Indonesia's total energy supply reached 85.94% in 2023. Until 2018, the country's total energy mix was dominated by oil, which accounted for 38.06% of the total supply. However, oil's share has been declining, ultimately being overtaken by coal in 2019, which comprised 34.51% of the total. A similar downward trend is observed in the share of natural gas. Conversely, the share of coal in the energy supply has exhibited a positive trend, consistently increasing since 2013. Specifically, the share of coal in the total energy supply rose from 23.86% in 2013 to 39.34% in 2023.



Graph 2. *Indonesia's Energy Supply from Renewable Energy*
Source: MEMR (2023)[3]

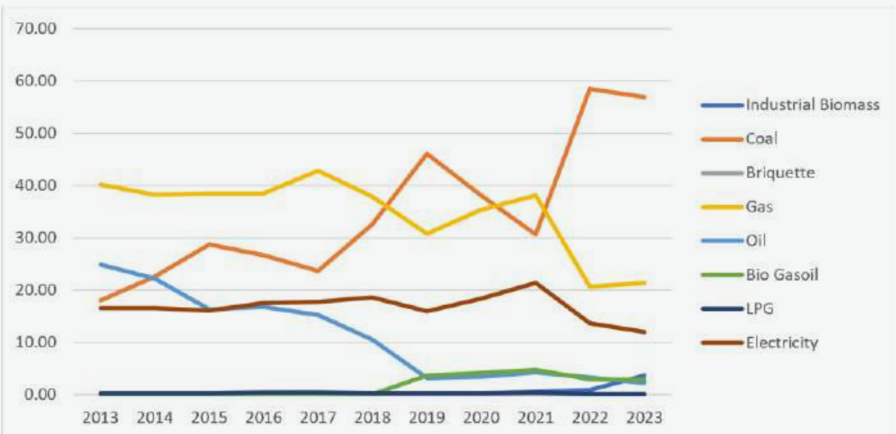
In terms of renewable energy supply, in 2023, the energy supply was predominantly comprised of biofuels (4.50%), hydro (2.44%), and geothermal (1.68%). Certain renewable energy sources, such as biofuels and industrial biomass, exhibited a positive trend in 2023. Additionally, the figure above demonstrates that the share of traditional biomass has declined from 4.02% in 2013 to 0.89% in 2023. Despite the observed increases in some renewable energy sources, their contributions have remained significantly small in comparison to the overwhelming share of fossil fuels in the national energy supply.

[3] Ibid



Graph 3. *Indonesia's Energy Consumption by Sector*
Source: MEMR (2023)[4]

In 2023, national energy consumption was predominantly driven by the industrial sector, accounting for 45.60%, followed by the transportation sector at 36.74%. From 2013 to 2021, the transportation sector had consistently dominated national energy consumption; however, it began to experience a downward trend in 2021. In contrast, the industrial sector has seen an increase in its share of national energy consumption. A notable surge in energy consumption share within the industrial sector is evident in 2022, where it increased by approximately 11.64 percentage points compared to 2021. This rise is likely attributable to rapid industrial development, as indicated by a 6.6% growth in the manufacturing sector's GDP in the same year.



Graph 4. *Industrial Energy Consumption Profile by Fuel Type*
Source: MEMR (2023)[5]

[4] Ibid
[5] Ibid

However, when examining the fuel consumption profile of the industrial sector, it is evident that it is dominated by fossil fuels, which accounted for 80.76% in 2023. Specifically, coal supplied 56.90% of industrial energy consumption in that year. This predominance of fossil fuels is likely linked to high industrial emissions. The accompanying graph of energy consumption in the industrial sector shows that the majority of fuel types have experienced a decline in their share of the industrial consumption profile. This trend may indicate a shift in industrial fuel consumption towards coal. Notably, one fuel type, industrial biomass, exhibited a positive trend in 2023, increasing by 2.79 percentage points compared to the previous year.

As discussed in the previous subsection, Indonesia has set a target to reduce industrial sector emissions by 7 million tons of CO_2 by 2030, in line with the Enhanced Nationally Determined Contributions (NDC) document (further elaboration on the emission profile of the industrial sector will be addressed in the subsequent subsection). On a global scale, various countries have adopted frameworks and commitments aimed at reducing emissions in the industrial sector. The prevailing trend in the global economy towards green industry and carbon reduction will undoubtedly impact domestic industries, particularly those oriented towards export. Given that the Indonesian industrial sector remains dependent on fossil fuels, it is essential for industries to initiate decarbonization measures in their production processes as a strategy to achieve these targets while maintaining competitiveness in the international market.

1.2 Energy Transition

The global push towards sustainable energy represents a monumental shift in how societies produce and consume energy. This energy transition is driven by the urgent need to address climate change, reduce greenhouse gas emissions, and ensure energy security in the face of dwindling fossil fuel reserves. Around the world, countries are increasingly adopting renewable energy sources such as solar, wind, and hydroelectric power, and moving away from carbon-intensive fossil fuels. This transition is supported by international agreements like the Paris Agreement, which aims to limit global warming to below 2 degrees Celsius above pre-industrial levels.

In Europe, the energy transition is marked by the European Green Deal, an ambitious plan to make the continent climate-neutral by 2050. The Green Deal encompasses a wide array of initiatives to reduce emissions, promote clean energy, and ensure that the transition to a green economy is just and inclusive. For instance, Germany has been a leader in renewable energy adoption through its *Energiewende* policy, which focuses on phasing out nuclear power and reducing dependence on coal by significantly increasing the share of renewables in its energy mix. As of 2023, renewable energy sources accounted for over 40% of Germany's electricity consumption, with significant contributions from wind and solar power.

Similarly, China, the world's largest emitter of greenhouse gases, has committed to peaking its carbon emissions by 2030 and achieving carbon neutrality by 2060. To meet these goals, China heavily invests in renewable energy and electric vehicle infrastructure. By 2023, China had become the world's largest producer of solar panels and wind turbines, with renewable energy capacity reaching nearly 1,000 gigawatts. Additionally, China's Belt and Road Initiative now includes a green component to export renewable energy technology and build green infrastructure in partner countries.

The United States, under its re-commitment to the Paris Agreement, has set aggressive targets for reducing emissions and expanding clean energy technologies. The Biden administration's climate plan aims to achieve a carbon-free power sector by 2035 and net-zero emissions across the economy by 2050. Key initiatives include significant federal investments in clean energy research and development, tax incentives for renewable energy projects, and stricter emissions standards for vehicles and power plants. States like California and New York pioneered aggressive renewable energy mandates, further driving the national transition.

Various mechanisms have been implemented worldwide to facilitate this transition, each tailored to different countries' specific economic and environmental contexts. These mechanisms include regulatory measures, market-based instruments, and financial incentives designed to promote the adoption of renewable energy and improve energy efficiency. Regulatory measures often involve setting mandatory renewable energy targets, establishing emission standards, and enforcing energy efficiency standards across industries. For example, the EU has set binding renewable energy targets for its member states, aiming for a 32% share of renewables in the total energy mix by 2030. Additionally, countries like Denmark have implemented stringent building codes that require new constructions to meet high energy efficiency standards, significantly reducing their overall energy consumption.

Market-based instruments, such as carbon pricing, emissions trading systems (ETS), and carbon taxes, are designed to internalize the environmental cost of carbon emissions, making fossil fuels more expensive relative to renewable energy sources. Financial incentives, including subsidies, tax breaks, and grants for renewable energy projects, help lower the cost of clean energy technologies, making them more competitive with traditional energy sources. For instance, the United States offers the Investment Tax Credit (ITC) for solar energy, which provides a significant tax credit for residential and commercial solar installations. Similarly, the Production Tax Credit (PTC) supports wind energy projects by offering a per-kilowatt-hour tax credit for the first ten years of electricity generation. Moreover, governments are also investing in research and development to spur innovation in green technologies, and, in the modernization of energy infrastructure, such as smart grids, to support the integration of intermittent renewable energy sources.

The importance of energy transition in Indonesia's development and sustainability agenda cannot be overstated. The Indonesian government has set ambitious targets for renewable energy utilization, aiming for 23% of the energy mix to come from renewable sources by 2025 and 31% by 2050. This commitment aligns with Indonesia's broader goals of reducing carbon emissions by 29-41% by 2030 and achieving net-zero emissions by 2060. The transition to renewable energy is crucial for meeting these targets and fostering economic growth, creating jobs, and improving energy access for the population. Furthermore, the shift towards renewables can enhance energy independence, reduce reliance on imported fossil fuels, and promote energy equity across different regions in Indonesia.

The urgency of decarbonization within Indonesia, particularly for the steel industry, has become a critical issue in light of the EU's impending implementation of CBAM. This policy is designed to adjust the prices of goods entering the EU market based on their carbon content. It aims to level the playing field between European producers, often subject to stricter and more costly environmental regulations, and their global counterparts. For Indonesia, a major steel-producing nation, the implications of this policy are profound and multifaceted.

The immediate influence of the CBAM on the Indonesian steel industry is currently minimal, attributable primarily to the relatively minor proportion of steel exports directed towards the EU, as we will discuss in more detail later. However, as the EU moves towards stricter environmental standards, the carbon intensity of products becomes a pivotal factor in trade dynamics. If not aligned with these greener production methods, Indonesian steel will likely face higher tariffs under CBAM. The additional costs imposed by CBAM could render Indonesian steel less attractive compared to products from regions that have made greater strides in reducing carbon emissions.

Additionally, this situation underscores a broader challenge: the global shift towards sustainability is reshaping market access and preferences. For the Indonesian steel industry, this shift demands urgent action to decarbonize. The industry must adopt cleaner technologies and practices to comply with international regulatory demands and ensure its long-term viability in a competitive global market increasingly driven by environmental considerations. Failure to adapt could diminish its standing in the EU and other markets that might adopt similar measures to CBAM, further isolating Indonesia from key global value chains.

Moreover, the move towards decarbonization is not merely about compliance but also leveraging opportunities. Engaging in sustainable practices can open up new markets, particularly as more consumers and corporations demand environmentally responsible products. It can also lead to innovations that may reduce costs, improve efficiency, and ultimately enhance profitability. For the steel industry, which is traditionally energy-intensive and high in carbon emissions, the transition to greener methods can also mitigate future risks associated with carbon pricing mechanisms and environmental regulations that will likely become more stringent over time.

The urgency of decarbonization for the Indonesian steel industry is driven by the immediate impact of policies like the EU's CBAM and the broader global trend towards sustainability. The industry faces significant challenges and potential opportunities in transforming its operations to be less carbon-intensive. Proactive steps towards sustainability could safeguard its export markets, enhance its competitive edge, and position it well in the global economic landscape that increasingly values environmental sustainability.

1.3 Carbon Border Adjustment Mechanism (CBAM)

The EU's commitment to the Paris Agreement and its ambitious goal to become climate-neutral by 2050 necessitates innovative regulatory measures. Building on the momentum of the Paris Agreement, the EU launched the European Green Deal in 2018. This comprehensive plan aims to make Europe the first climate-neutral continent by 2050. One of the key objectives of the Green Deal is to reduce greenhouse gas emissions by at least 55% by 2030, compared to 1990 levels. The European Green Deal represents a holistic approach to sustainability, integrating climate action across various sectors, such as energy, transport, agriculture, and industry. By promoting renewable energy, enhancing energy efficiency, and preserving biodiversity, the Green Deal seeks to create a sustainable and resilient economy while ensuring that the transition is just and inclusive for all member states.

To operationalize the ambitious goals of the European Green Deal, the EU introduced the 'Fit For 55 Package' in 2021. This package consists of a series of legislative proposals aimed at achieving the 55% emission reduction target by 2030. It includes measures to revise and strengthen the EU Emissions Trading System (“**ETS**”), enhance energy efficiency standards, promote the use of renewable energy, and implement comprehensive carbon pricing mechanisms. Additionally, it addresses the need for infrastructure development to support electric vehicles and the decarbonization of key industries. By aligning regulatory frameworks with these ambitious climate goals, the Fit For 55 Package ensures that the EU is on a clear path to meet its 2030 and 2050 targets, reinforcing its leadership in global climate action.

A critical component of the Fit For 55 Package is the CBAM. CBAM is designed to prevent carbon leakage, which occurs when companies relocate production to countries with less stringent climate policies to avoid the costs associated with carbon pricing. By imposing a carbon price on imports of high-carbon products, such as cement, steel, and aluminium, from countries that do not have equivalent carbon pricing measures, CBAM ensures that the environmental costs of carbon emissions are reflected in the price of imported goods. This mechanism levels the playing field for European industries and encourages global efforts to reduce emissions. CBAM is a crucial tool in the EU's strategy to drive global climate action, supporting the transition to a low-carbon economy and reinforcing the international commitment to sustainability.

Figure 1-1. Regulation Tree

CBAM is regulated under Regulation (EU) 2023/956 of the European Parliament and of the Council of 10 May 2023, which establishes a carbon border adjustment mechanism, and Commission Implementing Regulation (EU) 2023/1773 of 17 August 2023, which lay down the rules for the application of Regulation (EU) 2023/956, as regards reporting obligations for the carbon border adjustment mechanism during the transitional period and its Annexes.

Regulations are legal acts that apply automatically and uniformly to all EU countries as soon as they enter into force without needing to be transposed into national law.[6] This means that CBAM is binding in its entirety on all EU countries. It is also worth noting that EU law is superior to national law, meaning member states cannot pass national laws that contradict EU Law, and at the same time, EU Law can overrule national law, even if the national law was enacted before the EU law came into effect.[7]

[6] European Commission, "Implementing EU Law", https://commission.europa.eu/law/application-eu-law/implementing-eu-law_en, April 19th 2024.
[7] Citizen Information, "EU Law", https://www.citizensinformation.ie/en/government-in-ireland/european-government/eu-law/how-eu-law-works/, April 19th 2024.

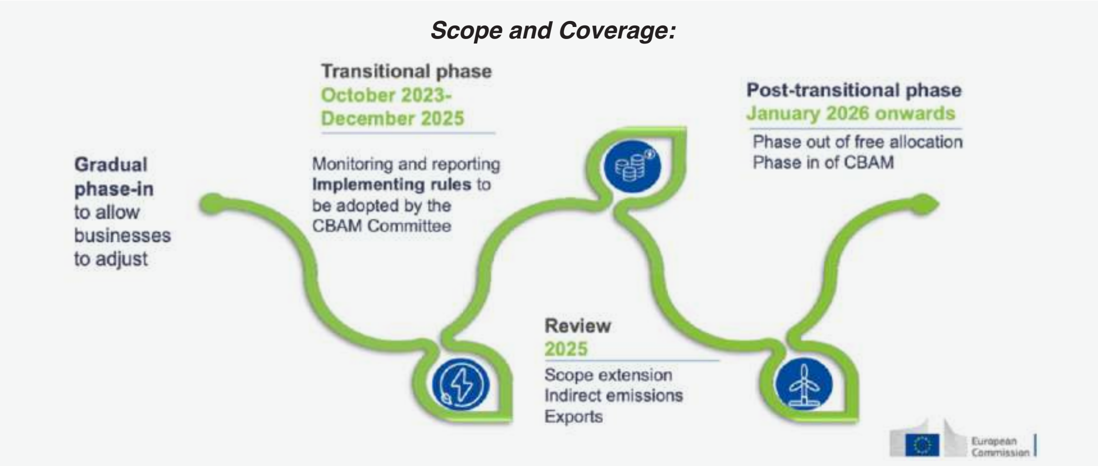


Figure 1-2. CBAM' Stages

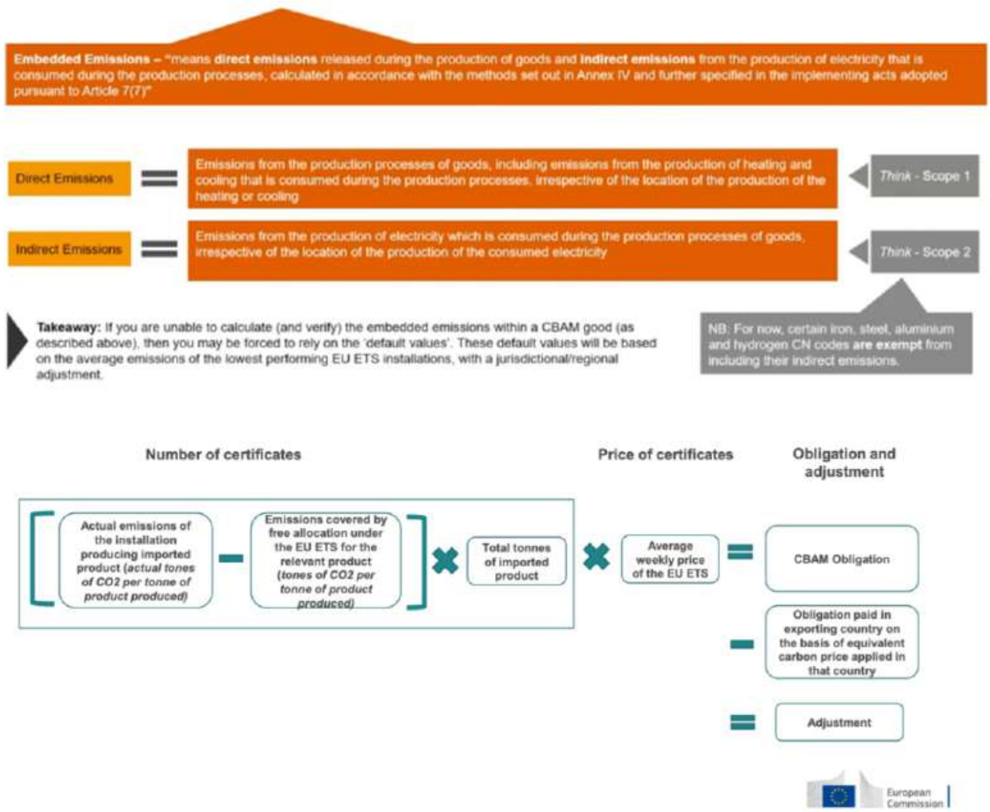
- Transitional Phase: A period for data collection and reporting, allowing companies to adjust to the new requirements.
- Review Phase: This phase is specifically designated for evaluating the scope of CBAM, particularly focusing on its potential extension to include a wider range of sectors and indirect emissions.
- Post-Transitional Phase: CBAM will become fully operational, with financial obligations coming into effect.

Figure 1-3. CBAM' Scope and Coverage

Initially targeting sectors with high risk of carbon leakage, sectors covering more than 45% of CO2 emissions, and based on practical feasibility, such as cement, electricity, fertilizers, iron and steel, and aluminum. The list may expand based on carbon intensity and trade exposure. CBAM is applicable to imports from all non-EU countries, with potential exemptions based on certain criteria like carbon pricing measures in the exporting country.

Issue	CBAM good					
	Cement	Fertilisers	Iron/Steel	Aluminium	Hydrogen	Electricity
Reporting metrics	(per) Tonne of good					(per) MWh
Greenhouse gases covered	Only CO_2	CO_2 (plus nitrous oxide for some fertiliser goods)	Only CO_2	CO_2 (plus perfluorocarbons (PFCs) for some aluminium goods)	Only CO_2	Only CO_2
Emission coverage during transitional period	Direct and indirect					Only direct
Emission coverage during definitive period	Direct and indirect		Only direct, subject to review			Only direct
Determination of direct embedded emissions	Based on actual emissions, unless they cannot be adequately determined					Based on default values, unless several cumulative conditions are met
Determination of indirect embedded emissions	Based on default values, unless conditions are met (i.e. direct technical connection or power purchase agreement)					Not applicable

Figure 1-4. CBAM's Calculation Mechanism



1.4 CBAM's Implication for Indonesia

The implementation of the EU's CBAM presents a complex array of trade implications for Indonesian exports. This policy particularly impacts commodities with high carbon footprints, such as steel, cement, and certain chemicals, which are significant export goods from Indonesia to the European market. Under the CBAM, these products could face increased costs due to the carbon price levied on imports, aligning with the EU's stringent environmental standards. This pricing adjustment poses a challenge for Indonesian exporters; unless they adapt their production processes to lower their carbon intensity, their goods risk becoming less competitive in the EU market. For instance, Indonesian steel, an industry traditionally reliant on carbon-intensive processes, might find its market share in the EU shrinking unless it adopts cleaner production methods.

Figure 1-2. CBAM' Stages

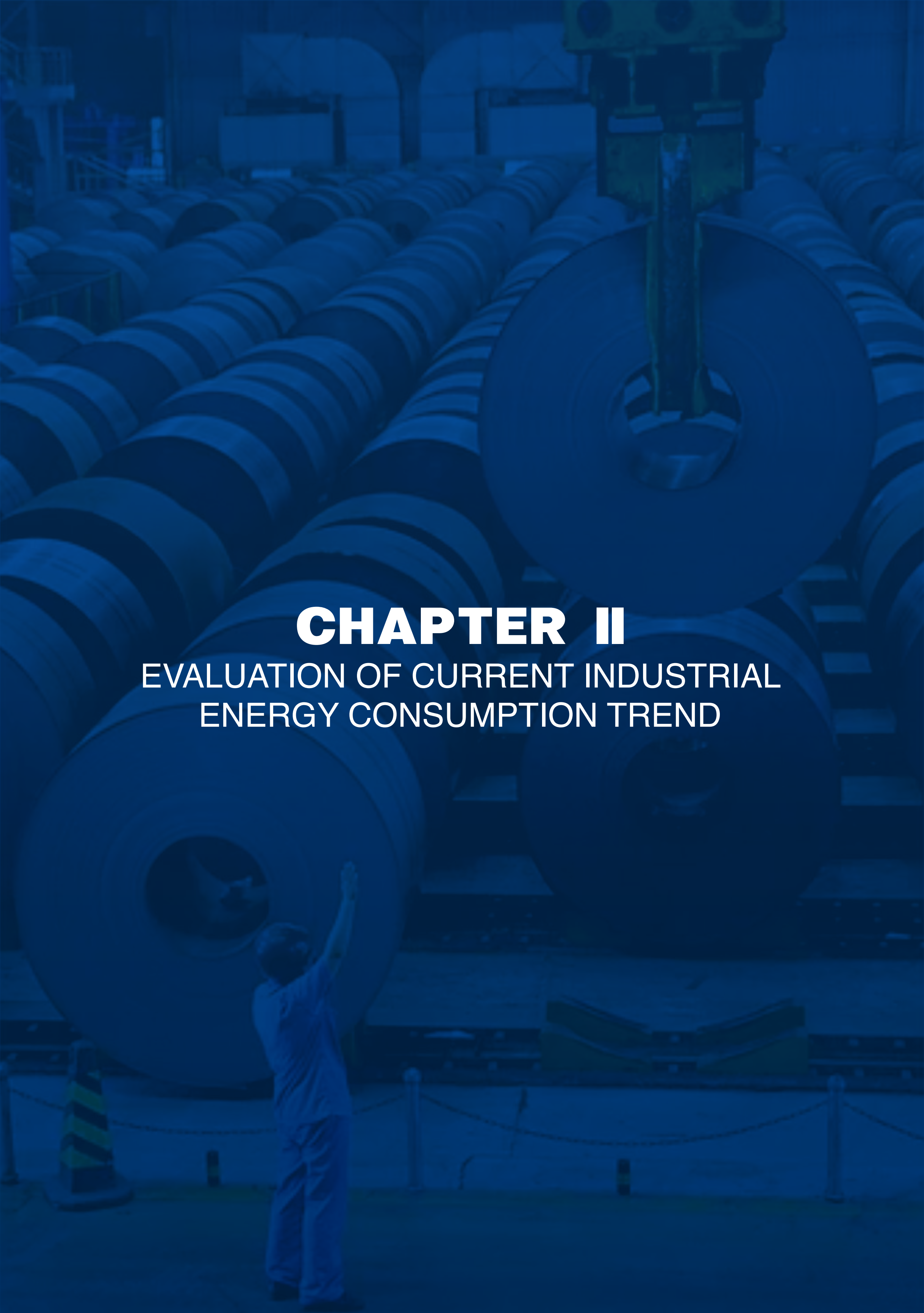
No	Commodity	Quantity (kg)		FOB Value (USD)	
		2022	2023	2022	2023
1	Cement	177	-	1,188	-
2	Electricity	-	-	-	-
3	Fertilizer	192,183,176	972,204	148,410,123	352,374
4	Iron and Steel	902,391,080	1,056,244,616	1,019,919,229	617,567,115
5	Aluminum	41,046,349	6,544,876	130,986,089	25,224,735

In response to these trade implications, economic adjustments within Indonesian industries are imminent. Industries that are pivotal to the country's exports to the EU will likely need to invest in cleaner, more sustainable technologies. This transition, while potentially costly in the short term, holds long-term benefits. By reducing their carbon footprint, these industries not only comply with international standards like the CBAM, but also position themselves for future global market trends that increasingly favor sustainability. Such investments could lead to significant energy savings and modernization of industrial processes, enhancing overall efficiency and competitiveness. For example, the cement industry in Indonesia, facing potential cost increases due to the CBAM, might invest in alternative, lower-carbon methods of production, such as by using alternative raw materials or renewable energy sources.

Moreover, the CBAM serves as a catalyst for policy responses within Indonesia. To mitigate the impact of the CBAM and align more closely with international climate goals, the Indonesian government might be incentivized to implement or strengthen its own carbon pricing mechanisms. This policy adaptation could manifest in several ways, such as introducing a carbon tax, expanding existing emissions trading schemes, or increasing investment in renewable energy and low-carbon technologies. By proactively adjusting its climate policies, Indonesia not only lessens the financial impact of mechanisms like the CBAM, but also contributes to global efforts to combat climate change. Such policy shifts would demonstrate Indonesia's commitment to sustainable development and responsible environmental stewardship on the international stage.

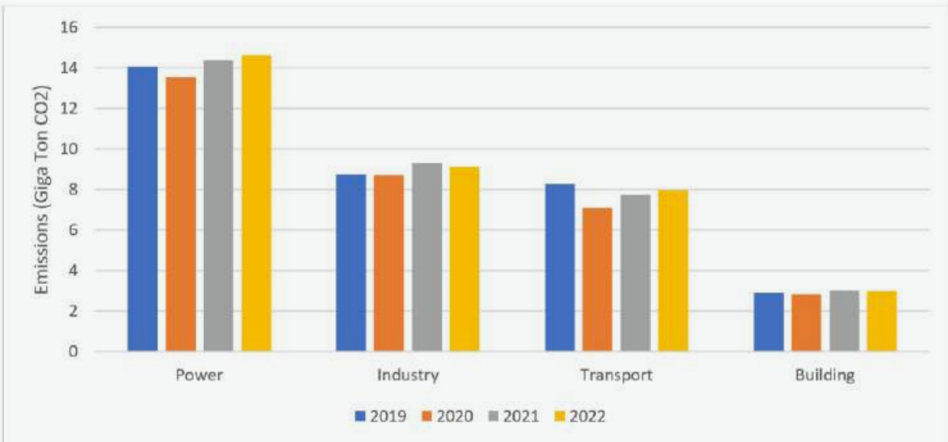
CHAPTER II

EVALUATION OF CURRENT INDUSTRIAL ENERGY CONSUMPTION TREND



2.1 Overview of Current Emission in Industry and Steel Sector

Global emissions from 2019 to 2023 have continued to be dominated by the energy sector, which reached 14.65 gigatons of CO2 in 2023, marking an increase of 1.81% compared to the previous year. The industrial sector ranks second, with emissions amounting to 9.15 gigatons of CO2.[8] Graph 5 presents a decrease of 0.16 gigatons of CO2 compared to the previous year, contributing 24.40% of global emissions (including emissions from energy combustion). The reduction in industrial emissions is primarily attributed to the economic slowdown in China[9].



Graph 5. *Global CO_2 Emissions by Sector*

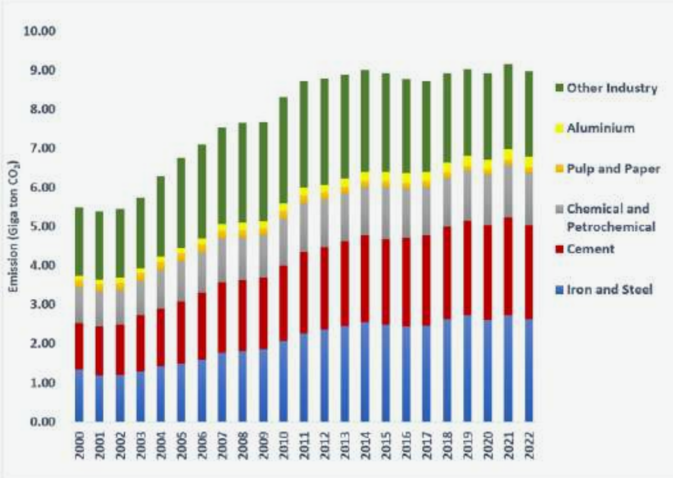
Source: IEA[10]

A closer examination of the breakdown of emissions in the industrial sector reveals two primary subsectors with significantly high emissions: the iron and steel sector and the cement industry. Together, these two industries contribute over 50% of total industrial emissions. Overall, emissions from the iron and steel sector have shown an increasing trend, rising from 2.45 gigatons of CO_2 in 2013 to 2.62 gigatons of CO_2 in 2022, representing a growth of 6.94%. Emissions from the iron and steel sector, amounting to 2.62 gigatons of CO_2, contribute 7.12% of total global emissions. Although the absolute value of emissions is lower in the cement industry compared to the iron and steel sector, it has experienced a significantly higher growth rate, reaching 11.52% over the same period. Historical data on the breakdown of emissions in the industrial sector can be observed in Graph 6.

[8] IEA (2023). *Global CO_2 emissions by sector,* 2019-2022. International Energy Agency. https://www.iea.org/data-and-statistics/charts/global-co2-emissions-by-sector-2019-2022 Accessed at October 19th 2024

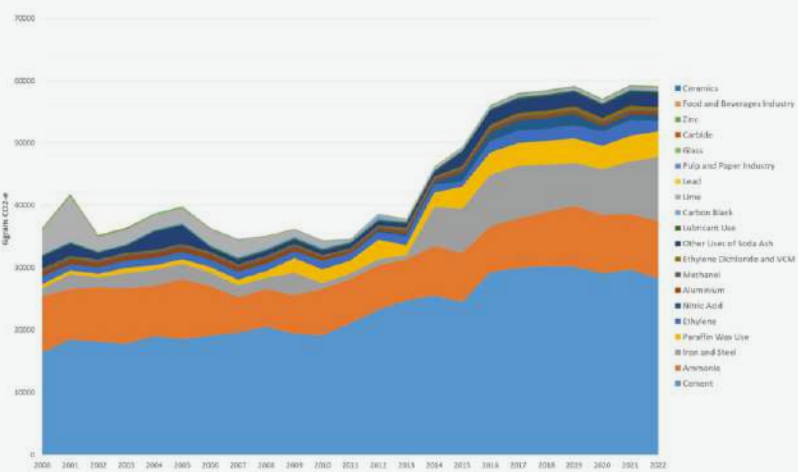
[9] IEA (2022). *CO_2 Emissions in 2022*. International Energy Agency

[10] Op cit



Graph 6. *Industry Emissions Breakdown by Sector*
Source: IEA[11]

An examination of the emission profile of the industrial sector in Indonesia reveals an overall rising trend, with emissions increasing by more than 50% from 2000 to 2022. A decline was observed between 2019 and 2020, likely due to a slowdown in economic activity caused by the COVID-19 pandemic. Following the end of the pandemic and the resumption of economic activities, industrial sector emissions rebounded, continuing to rise through 2022.

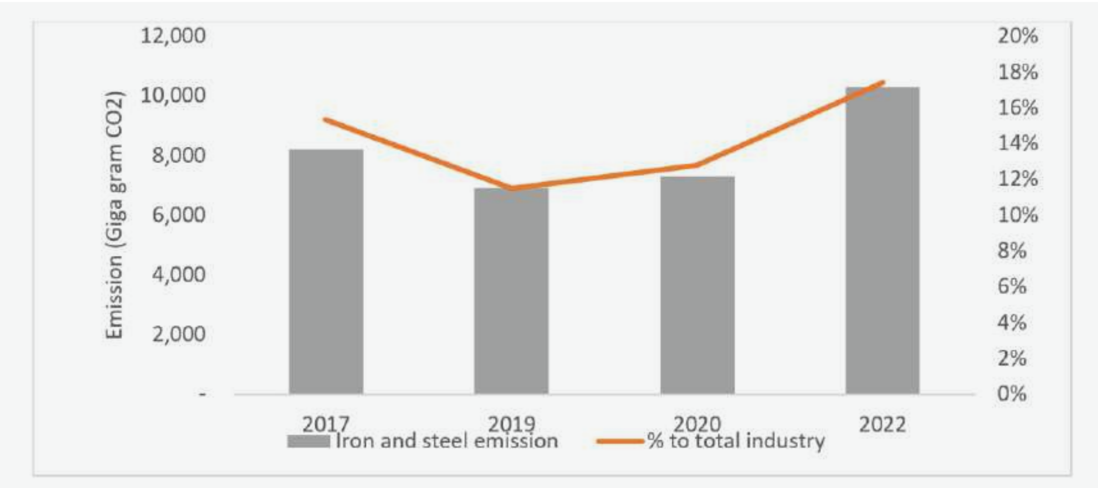


Graph 7. *Indonesia's Industrial Emission Breakdown by Sector*
Source: MoEF[12]

[11] IEA (2023). Direct CO2 emissions from industry in the Net Zero Scenario, 2000-2030. International Energy Agency. https://www.iea.org/data-and-statistics/charts/direct-co2-emissions-from-industry-in-the-net-zero-scenario-2000-2030-2 Accessed at August 25th 2024

[12] MoEF (2024). Laporan Inventarisasi Gas Rumah Kaca (GRK) dan Monitoring, Pelaporan, Verifikasi (MPV) 2023. Ministry of Environment and Forestry.

Graph 7 indicates that emissions in the industrial sector are primarily driven by several key subsectors: cement (28.323 gigatons of CO_2), iron and steel (10.304 gigatons of CO_2), ammonia (9.128 gigatons of CO_2), and paraffin wax use (4.117 gigatons of CO_2). The majority of these emissions result from the production processes specific to each industry.



Graph 8. *Iron and Steel Emissions (Indonesia)*
Source: MoEF[13]

Examining emissions trends in the iron and steel sector reveals a continuous increase in quantity, rising from 8.196 gigatons of CO_2 to 10.304 gigatons of CO_2 by 2022. However, an analysis of annual trends indicates that fluctuations are evident in 2019 and 2020. Moreover, although emissions increased in 2020, the absolute value remained lower than that of 2017. Despite the fluctuations, the share of emissions from this sector in relation to total industrial emissions rose from 15% in 2017 to 17% in 2022. The increase in emissions from the iron and steel sector, coupled with the impending implementation of CBAM in the EU, underscores the urgency for this industry—and the industrial sector as a whole—to initiate decarbonization efforts.

2.2 Global Steel Industry Energy Outlook

The steel industry prioritizes efficient energy use, recognizing that conserving energy in steel production is important for maintaining the industry's competitiveness and for minimising environmental harm, such as that caused by greenhouse gas emissions. Steel is energy-efficient because it is fully recyclable, long lasting, and lightweight. It accounts for 8% of global energy demand and emits 7% (2.6 Gt CO_2) of total emissions generated from the energy sectors[14].

[13] Ibid
[14] International Energy Agency, “Iron and Steel Technology Roadmap – Towards more sustainable steelmaking”, https://www.iea.org/reports/iron-and-steel-technology-roadmap June 8th, 2024.

In 2023, global crude steel production reached 1,892 million tons[15,16]. Steel usage is expected to rise steadily in the coming years to meet the demands of our growing population.

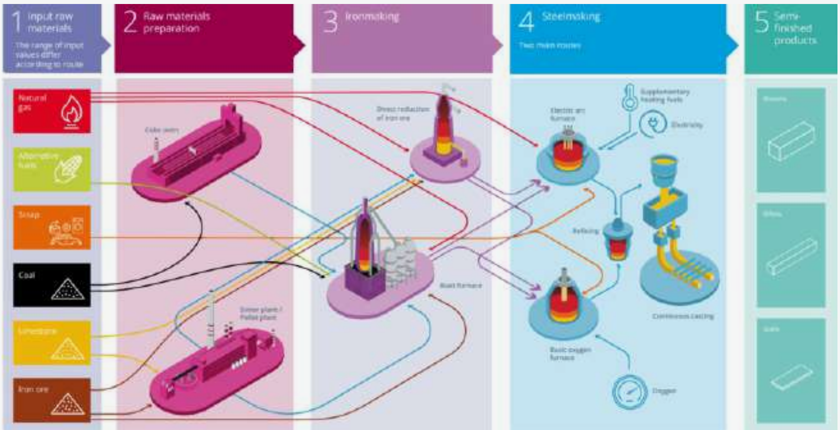


Figure 2-1. Steelmaking process[17]

Since steel production is an energy-intensive process, a robust system for energy management is needed to ensure efficient energy use and recovery. According to calculations by the World Steel Association, improvements in energy efficiency have reduced the amount of energy consumed to produce one ton of crude steel by about 60% since the 1960s (Figure 2-2).

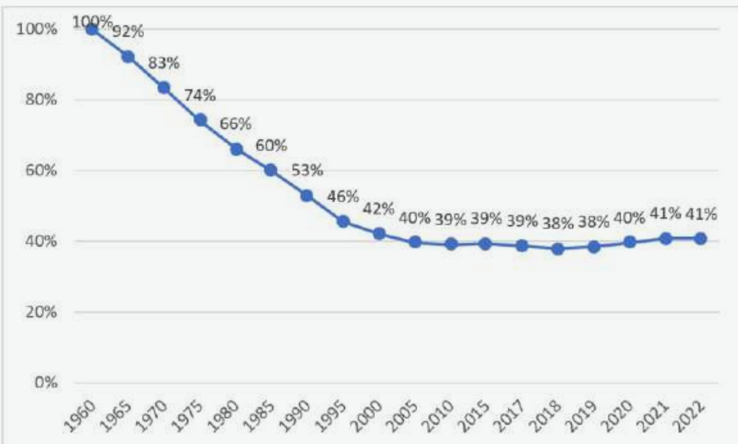


Figure 2-2. The recorded global energy consumption/ton of crude steel production (in %)[18]

[15] World Steel Association, "Total production of crude steel", https://worldsteel.org/data/annual-production-steel-data/?ind=P1_crude_steel_total_pub/CHN/IND June 8th 2024.
[16] Asia Pacific Partnership for Clean Development and Climate, "The State-of-the-Art Clean Technologies (SOACT) for Steelmaking Handbook, 2nd Edition", asiapacificpartnership.org 2010
[17] World Steel Association, "Overview of steelmaking process", https://worldsteel.org/publications/bookshop/overview-of-the-steelmaking-process/ June 8th 2024
[18] World Steel Association, "Energy use in the steel industry", https://worldsteel.org/wp-content/uploads/Fact-sheet-Energy-use-in-the-steel-industry.pdf June 8th 2024.

Energy makes up a significant portion of steel production, ranging from 20% to 40%, so improving energy efficiency would reduce production costs and enhance competitiveness[19]. The energy efficiency of steelmaking facilities varies based on factors such as production route, type and quality of iron ore and coal used, the steel product mix, operation control technology, and material efficiency. Additionally, energy is used indirectly for mining, preparing, and transporting raw materials. In the blast furnace-basic oxygen furnace (BF-BOF) route, this indirect energy use accounts for about 9% of the total energy needed for steel production, including raw material extraction and processing, while in the electric arc furnace (EAF) route, it accounts for about 6% of total energy requirements. In the BF-BOF route, about 89% of energy comes from coal, 7% from electricity, 3% from natural gas, and 1% from other sources. In the EAF route, 11% of the energy comes from coal, 50% from electricity, 38% from natural gas, and 1% from other sources.[20]

2.3 International Steel Industry Benchmark for Energy and Carbon Footprint and Carbon Reduction Efforts

The steel industry's attempts at reducing carbon footprint and using energy efficiently can be challenging and need to be controlled using a specified benchmark. The average carbon footprint and energy intensity emitted by the global steel industry (Table 2-1), taken from 77 steel companies, can be used as a benchmark for future control. It shows steady metrics for crude steel casting from 2020 to 2022, during which CO_2 emissions' intensity slightly increased to 1.91 tons per ton of steel, while steel intensity varied slightly, peaking at 21.02 GJ per ton before a slight decrease in 2022. The material efficiency stayed high, just below 98%, and the environmental management system score remained consistent, at around 96%. This reflects stable sustainability practices with room for improvement in emissions and energy efficiency.

Table 2-1. Environmental Performance[21].

No	Indicators	Unit	2020	2021	2022
1.	CO_2 emissions intensity	ton CO_2/ ton crude steel cast	1.88	1.91	1.91
2.	Energy intensity	GJ/ ton crude steel cast	20.38	21.02	20.99
3.	Material efficiency	%	97.86	97.56	97.65
4.	Environmental management system	%	96.13	95.66	96.15

[19] American Iron and Steel Institute, “Saving One Barrel of Oil per Ton (SOBOT)”, 2005.
[20] World Steel Association, “Energy use in the steel industry”, https://worldsteel.org/wp-content/uploads/Fact-sheet-Energy-use-in-the-steel-industry.pdf June 8th 2024.
[21] World Steel Association, “Sustainability Indicators 2023 Report”, https://worldsteel.org/wp-content/uploads/Sustainability-indicators-report-2023.pdf June 8th 2024.

Table 2-2 shows the CO_2 emissions and energy intensity by crude steel cast production chain of blast furnace-basic oxygen furnace, electric arc furnace with scrap and direct reduced iron. The BF-BOF route recorded higher emissions, with 2.33 tons of CO_2 per ton of steel, due to the utilization of coal in the ore reduction process. In comparison, the scrap-EAF and DRI-EAF routes had significantly lower emissions, at around 0.66-0.68 and 1.37-1.39-ton CO_2 per ton product, respectively. In terms of energy usage, the global average also remained steady at around 21 GJ per ton of product. BF-BOF was the most energy-intensive, at over 24 GJ, while scrap-EAF required about 10 GJ, and DRI-EAF used roughly around 22.5 GJ per ton. This data highlights the emissions and energy reduction potential in alternative production routes, especially Scrap-EAF.

Table 2-2. 2021 - 2022 CO_2 emissions and energy intensity[22].

	CO_2 emissions intensity by production route		Energy Intensity by production route	
	ton CO_2 per ton of crude steel cast		GJ per ton of crude steel cast	
	2021	2022	2021	2022
Global average	1.91	1.91	21.02	20.99
BF-BOF	2.33	2.33	24.13	23.98
Scrap-EAF	0.66	0.68	10.07	10.20
DRI-EAF*	1.39	1.37	22.58	22.37

*Data on global crude steel production using DRI is not currently collected. Therefore, the denominator for this calculation is derived by the worldsteel data management team based on information from worldsteel's collective databases.

CO_2 emissions intensity and energy intensity can be calculated using the formula below:

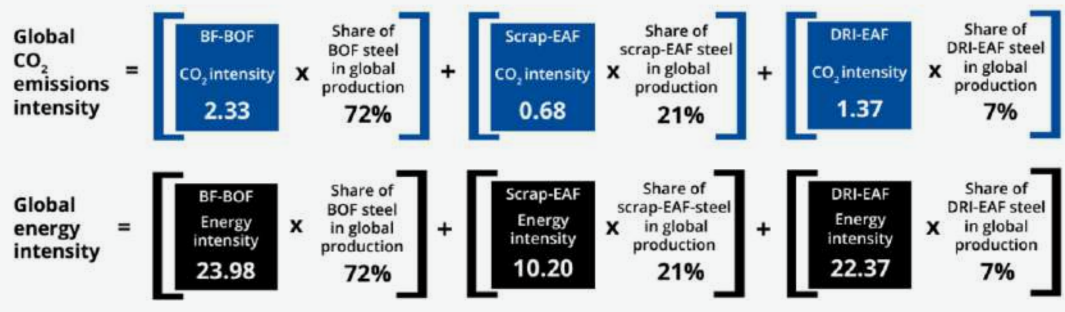


Figure 2-3. Global Carbon Emissions and Energy Intensity Calculations[23]

[22] World Steel Association, “Sustainability Indicators 2023 Report”, https://worldsteel.org/wp-content/uploads/Sustainability-indicators-report-2023.pdf June 8th 2024.
[23] Ibid, page 77

The calculation methodology and definition for each indicator for environmental performance can be seen in the table below:

Table 2-3. Definitions and Calculations[24].

No.	Indicator	Definition	Calculation
1.	CO_2 emissions intensity	This indicator calculates tons of CO_2 emissions per ton crude steel production as cast. It is calculated with the World Steel CO2 Data Collection methodology, which includes all scopes (1, 2, and some scope 3). Global CO_2 emissions intensity represents a weighted average between blast furnace basic oxygen furnace (BF-BOF), scrap-based electric arc furnace (EAF), and direct reduced iron (DRI)-based EAF steel production.	Tons of CO_2 emitted / tons of crude steel cast
2.	Energy intensity	This indicator measures the energy used to process the crude steel volume in GJ per ton of crude steel production as cast. Global energy intensity represents weighted average between blast furnace basic oxygen furnace (BF-BOF), scrap-based electric arc furnace (EAF) and direct reduced iron (DRI)-based EAF steel production.	GJ of energy used / tons of crude steel cast
3.	Material efficiency	This indicator calculates the percentage of crude steel and co-products compared to total solid and liquid output material (i.e. crude steel, co-products and waste landfilled or incinerated). Process gases are not included in the calculation.	(crude steel + co-products) / (crude steel + co-products + waste)
4.	Environmental management system	This indicator measures the percentage of employees and contractors working in steel production facilities registered under an environmental management system .	Number of employees and contractors working in registered production facilities / total number of employees and contractors working in production facilities

2.3.1 International steelmaking technology benchmark

The technologies used for steelmaking vary widely across the globe, with each region adopting different methods, resulting in the energy consumption and carbon emissions levels associated with steel production to differ significantly. The most common technologies used these days are still predominantly the Blast Furnace with Basic Oxygen Furnaces (BF-BOF) (Figure 2-4), while the combined technology of Direct Reduced Iron (DRI) and Electric Arc Furnace (EAF) (Figure 2-5) is still in the pilot project stage in several countries, pushing the trend towards more sustainable, environmentally friendly and adaptable production methods. Table 2-4 shows the comparison and forecast of operating cost for BF-BOF with coal, DRI-EAF using gas and conventional electricity, Scrap-EAF with conventional electricity, and Scrap-EAF using green electricity from year 2020 until 2050, with BF-BOF operating cost peaking at 2050 at 903 USD/t crude steel, while the other methods can be cheaper at up to 300 USD/t crude steel[25].

[24] Ibid, page 77
[25] Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the industry behave?", E3WG JETP Workshop, 2024.

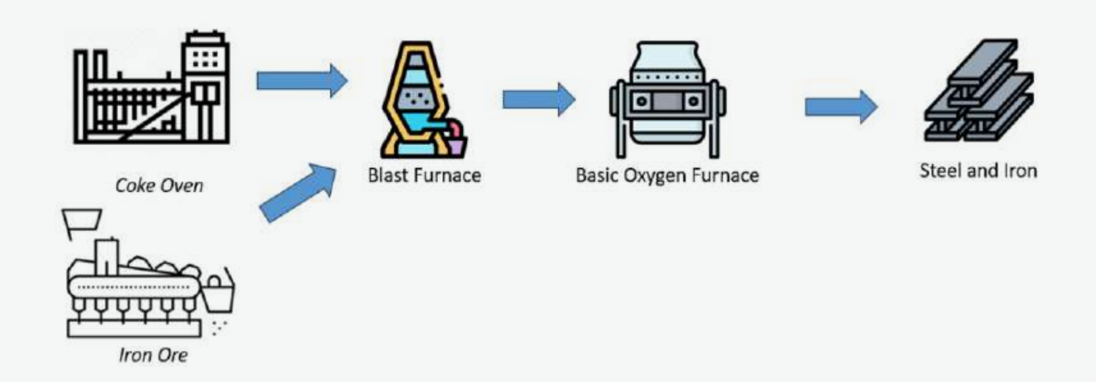


Figure 2-4. Simplified iron and steel production process through BF-BOF.

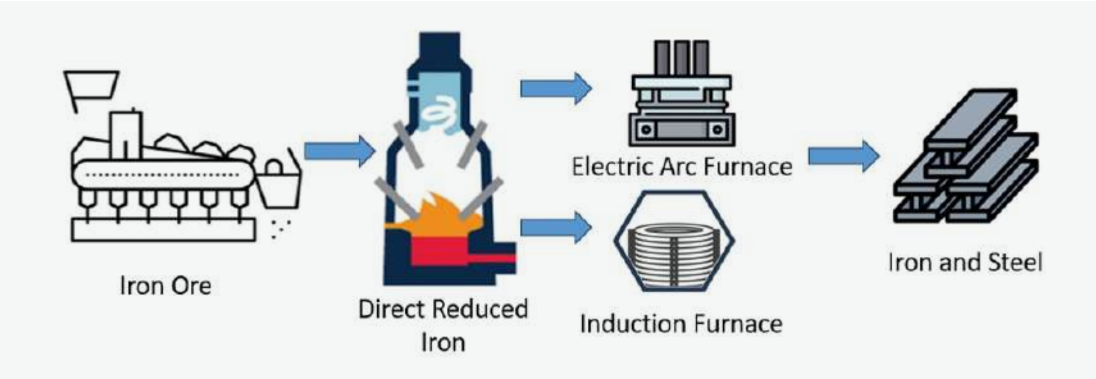


Figure 2-5. Simplified iron and steel production process through DRI-EAF / IF.

Table 2-4. Technology comparison of CO_2 emissions of steelmaking from the mine to finished product[26].

Type	Emission (t CO_2/ t crude steel)	Operating cost (USD/ t crude steel)
BF-BOF (coal based)	Iron + Steelmaking: 1.6 Downstream: 1.8 Indirect Emission: 1.9	2020: 480 2030: 525 2050: 903
DRI-EAF (gas based DRI, conventional electricity)	Iron + Steelmaking: 0.6 Downstream: 0.2 Indirect Emission: 1.1	2020: 528 2030: 533 2050: 715
Scrap-EAF (conventional electricity)	Iron + Steelmaking: 0.1 Downstream: 0.3 Indirect Emission: 0.5	2020: 500 2030: - 2050: 570
Scrap-EAF (green electricity)	0	510

[26] Krakatau Steel, “How will Decarbonization Impact the Steel Industry and How should the industry behave?”, E3WG JETP Workshop, 2024.

Direct emissions (Iron + steelmaking + downstream) are emissions from sources that are owned or controlled by the company, including[27]:

- Fuel combustion in fleet vehicles (owned by the company),
- Fuel combustion in stationary sources, like boilers, furnaces and incinerators,
- Manufacturing or processing of materials and chemicals, like cement manufacturing, aluminum smelting and petrochemical processing,
- Fugitive emissions, including methane emissions from coal mines, and
- Coal combustion in electricity production.

In the steel industry, the downstream segment includes storage of steel processing plants, distribution, and processing of finished products[28]. On the other hand, indirect emissions are emissions released to the atmosphere from the use of purchased energy. Currently, the most promising iron and steel technologies for carbon reduction, aside from scrap-based EAF technology, remain largely underdeveloped. Scrap-based EAF technology, while effective at reducing emissions, is constrained by the limited scrap availability, making it a challenge to scale up to meet demand.

Another promising technology, Molten Oxide Electrolysis (MOE) accompanied by the Electric Arc Furnace (EAF), which only converts the iron ores into liquid metal using electricity as its sole energy source. This process heats up the cells to 1600°C and splits the bonds in the iron ore, producing pure liquid metal and can potentially reduce carbon emissions by 100%, depending on the energy source of the electricity used. Furthermore, the MOE can eliminate several of the usually needed steps, such as iron ore sintering, pelletizing, blast furnace reduction, or basic oxygen furnace refinement, and with better energy efficiency at 4MWh of electricity/ton of crude steel product, while the Integrated Steel Mill needs 5 MWh of coal/ton crude steel product, saving around 27% in energy use in the process[29]. While there are various advantages proposed by this technology, the drawback itself is the near total reliance on electricity , which makes implementation difficult in certain places[30]. Currently, it still under development with Technology Readiness Level (TRL) of 2 in the year 2020, and is projected to improve to TRL 3-4 in the year 2030 and TRL 9 by 2050[31].

2.3.2 Emission Calculation by CBAM & Indonesian

A discrepancy has been identified between the CO_2 emissions calculation methods used by the CBAM and Indonesian regulatory authorities. While both aim to accurately measure emissions, the approaches they adopt lead to different results. CBAM is currently developing a new

[27] Work for Climate," What's the difference? Scope 1, 2 and 3 corporate emissions", https://www.workforclimate.org/post/whats-the-difference-scope-1-2-and-3-corporate-emissions?gad_source=1&gclid=CjwKCAjwvIWzBhAlEiwAHHWgvZIm0U7LR53S_wIPw07JUCs0cZUsrNeJ2pOm_kQhFCOiePeEw5T-xxoCc7IQAvD_BwE, June 8th 2024.

[28] https://www.linkedin.com/pulse/supply-chain-steel-industry-gaurav-gupta/

[29] Boston Metal, "Steel production through electrolysis: impacts for electricity consumption", https://iea.blob.core.windows.net/assets/imports/events/288/S5.4_20191010BostonMetalIEADecarbonization2019.pdf, 31st October 2024.

[30] Boston Metal, "Decarbonizing steelmaking for a net-zero future", https://www.bostonmetal.com/green-steel-solution/, 31st October 2024.

[31] Green Steel for Europe, "Technology Assessment and Roadmapping", https://www.estep.eu/assets/Projects/GreenSteel4Europe/GreenSteel_Publication/EXEC_Sum/Technology-Assessment-and-Roadmapping.pdf, 31st October 2024.

methodology to address double counting of emissions during the production process. This issue arises when multiple steps in the production chain attribute emissions to the same activity, inflating the overall carbon footprint. CBAM's new method seeks to ensure that emissions are counted once, providing a more precise assessment of the carbon intensity of products as shown in the equation below:

$$\mathrm{Emissions_{direct}} = \mathrm{DirEm} + \mathrm{E_{m_{H,import}}} - \mathrm{E_{m_{H,export}}} + \mathrm{WG_{corr,import}} - \mathrm{WG_{corr,export}} - \mathrm{E_{m_{el,produced}}}$$

With:

$\mathrm{Emissions_{direct}}$	:	Attributed direct emissions of the production process
$\mathrm{Dir_{Em}}$	:	Directly attributable emissions as linked to source streams (exceptions for heat and waste gases)
$\mathrm{E_{m_{H,import}}}$	:	Emissions related to the attribution of measurable heat imported
$\mathrm{E_{m_{H,export}}}$	:	Emissions related to the attribution of measurable heat exported
$\mathrm{WG_{corr,import}}$	:	Correction for imported waste gases
$\mathrm{WG_{corr,export}}$	:	Correction for exported waste gases
$\mathrm{E_{m_{el,produced}}}$	:	Emissions related to electricity production

$$\mathrm{Embedded\ Emissions_{indirect}} = \mathrm{E_{el,cons}} \times \mathrm{EF_{el}}$$

With:

$\mathrm{E_{el,cons}}$	:	electric consumption
$\mathrm{EF_{el}}$	:	electric emission factor

$$Specific\ Embedded\ Emissions_{direct\ /\ indirect} = \frac{Embedded\ Emissions_{direct\ /\ indirect}}{AL_{goods}} + \sum_{i=1}^{n} m_i\ .Specific\ Embedded\ Emissions_i$$

With:

$\mathrm{Embedded\ Emissions_{direct\ /\ indirect}}$	:	Specific embedded emissions (direct or indirect)
$\mathrm{AL_{goods}}$	:	Directly attributable emissions as linked to source Amount of goods produced
$\mathrm{m_i}$	:	Amount of precursors used per goods produced
$\mathrm{Specific\ Embedded\ Emissions_i}$	:	Specific embedded emissions (direct or indirect) of the precursors

On the other hand, Indonesian regulatory bodies, such as the Ministry of Environment and Forestry (KLHK) and the Ministry of Energy and Mineral Resources (ESDM), follow the guidelines established by the Intergovernmental Panel on Climate Change (IPCC) 2006 methodology. This approach is widely accepted and serves as a global benchmark for calculating greenhouse gas (GHG) emissions. The IPCC method focuses on standardized emission factors and national-level data collection, ensuring consistency across sectors and countries. However, it may not fully account for complexities within certain industrial processes, such as those seen in steel production, where emissions can be double-counted across different stages. Further, Table 2-5 and Table 2-6 show the global warming potential (GWP) of the GHG index and the standard emission factors for fossil fuel combustion related to the CO_2, CH_4 and N_2O emissions.

$$CO_{2\,equivalent} = (AD \times EF)_{CO_2} + \left(GWP\ CH_4 \times (AD \times EF)_{CH_4}\right) + \left(GWP\ N_2O \times (AD \times EF)_{N_2O}\right)$$

With:

With:	CO_2 equivalent	:	Total emission CO_2 from production process
	GWP	:	Index value for GHG potential to heat the earth with the potential of carbon dioxide (-Table 25).
	AD	:	Activity data for fossil fuel usage
	EF	:	Emission Factor of fossil fuel (according to IPCC 2006)

Specific Emission Calculation:

$$CO2\ specific\ equivalent = \frac{(AD \times EF)_{CO_2} + (GWP\ CH_4 \times (AD \times EF)_{CH_4}) + (GWP\ N_2O \times (AD \times EF)_{N_2O})}{total\ actual\ product},$$

Table 2-5. GWP GHG value

No.	Type of GHG	GWP
1.	Carbon Dioxide (CO_2)	1
2.	Methane (CH_4)	21
3.	Dinitrogen Oxide (N_2O)	310

Table 2-6. Indonesia Fuel Heat Value

Fossil Fuels		Standard Emission Factor (kg GHG/ TJ)*		
		CO_2	CH_4	N_2O
Crude oil		73300	3	0.6
Orimulsion		77000	3	0.6
Liquified Natural Gas		64200	3	0.6
Gasoline	Motor Gasoline	69300	3	0.6
	Aviation Gasoline	73000	3	0.6
	Jet Gasoline	73000	3	0.6
Jet Kerosene		71500	3	0.6
Kerosene		71900	3	0.6
Shale Oil		73300	3	0.6
Diesel		74100	3	0.6
Residual Oil		77400	3	0.6
Ethane		61600	1	0.1
Naphtha		73300	3	0.6
Bitumen		80700	3	0.6
Lubricants		73300	3	0.6
LPG		63100	1	0.1
Petroleum coke		97500	3	0.6
Refinery Feedstocks		73300	3	0.6
Other Oil	Refinery Gas	57600	1	0.1
	Paraffin Waxes	73300	3	0.6
	White Spirit and SBP	73300	3	0.6
	Other Petroleum Products	73300	3	0.6
Anthrasit Coal		98300	10	1.5
Cooking coal		94600	10	1.5
Bituminous Coal		94600	10	1.5

Fossil Fuels		Standard Emission Factor (kg GHG/ TJ)*		
	Type	CO_2	CH_4	N_2O
Sub-bituminous Coal		96100	10	1.5
Lignit		101000	10	1.5
Oil Shale and Tar Sands		107000	10	1.5
Brown Coal Briquettes		97500	10	1.5
Patent Fuel		97500	10	1.5
Coke	Coke Oven Coke and Lignite Coke	107000	10	1.5
	Gas Coke	107000	10	1.5
Coal Tar		80700	10	1.5
Derived Gases	Gas Works Gas	44400	1	0.1
	Coke Oven Gas	44400	1	0.1
	Blast Furnace Gas	260000	1	0.1
	Oxygen Steel Furnace Gas	182000	1	0.1
Natural gas		56100	1	0.1
Municipal Wastes	(non-biomass fraction)	91700	30	4
Industrial Wastes		143000	30	4
Waste Oils		73300	30	4
Peat		106000	2	1.5
Solid Biofuels	Wood / Wood Waste	112000	30	4
	Sulphite lyes (Black Liquor)	95300	3	2
	Other Primary Solid Biomass	100000	30	4
	Charcoal	112000	200	4
Liquid Biofuels	Bio gasoline	70800	3	0.6
	Biodiesels	70800	3	0.6
	Other Liquid Biofuels	79600	3	0.6

Fossil Fuels		Standard Emission Factor (kg GHG/ TJ)*		
		CO_2	CH_4	N_2O
Gas Biomass	Landfill Gas	54600	1	0.1
	Sludge Gas	54600	1	0.1
	Other Biogas	54600	1	0.1
Other non- fossil fuels	Municipal Wastes (biomass fraction)	100000	30	4

* These factors assume that carbon is not oxidized (Source: NCASI, 2005).

In relation to emission calculations, the method used by CBAM and the one prescribed by Indonesian regulations do show inconsistencies, especially in the direct emissions formula. These differences complicate efforts to harmonize emissions estimates and will potentially lead to variations in calculation results. Additionally, Indonesia's methodology may overestimate emissions as it includes those generated outside the production system.

2.4 Indonesian Steel Industry Energy and Carbon Footprint

The iron and steel industry is one of the largest consumers of energy worldwide, accounting for 7% of global energy consumption in 2019 because of the significant amount of energy needed to heat the furnaces to high temperatures to smelt iron ore[32]. Also, the steel industry has a significant carbon footprint, contributing around 7% of global CO_2 emissions, largely due to its reliance on energy-intensive processes[33]. The blast furnace-basic oxygen furnace (BF-BOF) route uses coal as both a fuel source and reducing agent, generating high levels of CO_2.

Figure 2-6 shows a comparison between the current emission factors of some iron and steel-producing countries. China's production is significantly higher than that of the other countries, remaining steady at around 1,000 million tons over the three-year period. A closer view of other top producers shows that India has experienced a gradual increase in production, rising from about 120 million tons in 2021 to nearly 140 million tons in 2023. Japan, the United States, and South Korea maintain relatively stable production levels between 60 and 100 million tons. Indonesia's steel production, as shown in Figure 2-6, is relatively low compared to other major steel-producing countries, with output consistently at just under 20 million tons from 2021 to 2023. This positions Indonesia at the bottom among the highlighted countries, reflecting its smaller share in global steel production.

[32] Metron Energy, "Steel Industry: How to Make Significant Energy Savings", https://www.metron.energy/blog/steel-industry-energy-savings/, 28th October 2024.
[33] Suer, J., Traverso, M. and Jäger, N., 2022. Carbon footprint assessment of hydrogen and steel. Energies, 15(24), p.9468.

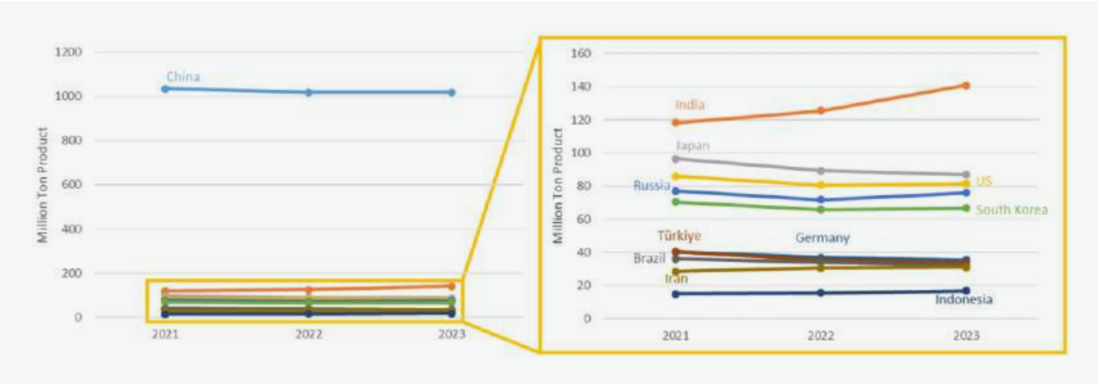


Figure 2-6. Top 10 steel production (processed by PSE UGM)[34]

Heavy reliance on coal-based blast furnace-basic oxygen furnaces (BF-BOF), with about 89% of the primary energy coming from coal[35], can significantly increase the energy footprint in the industry. Furthermore, the energy demand from coal is higher than that of others, which is illustrated in Figure 2-7, which shows that the energy footprint of the iron and steel industry is dominated by the usage of coal. The total energy demand is expected to be quite stable from 2018 to 2030, and even though the coal demand was projected to decrease, it will still dominate the energy demand in the projection until 2030.

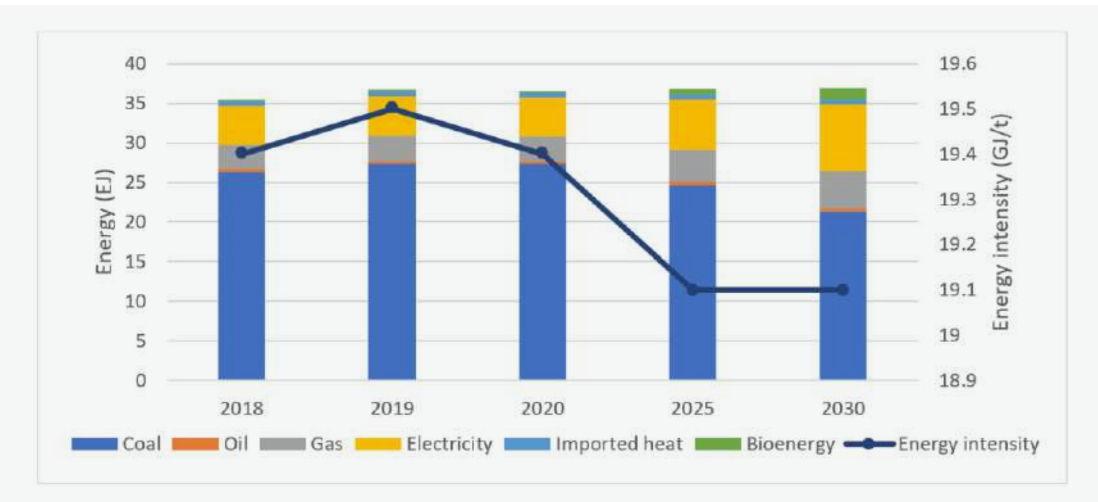


Figure 2-7. Energy Intensity based on Energy Sources (processed by PSE UGM)[35]

[34] World Steel Association,
[35] World Steel Association, "Energy use in the steel industry", https://worldsteel.org/wp-content/uploads/Fact-sheet-Energy-use-in-the-steel-industry.pdf, 9th October 2024.
[36] International Energy Agency, "Iron and steel final energy demand and energy intensity in the Net Zero Scenario, 2018-2030", https://www.iea.org/data-and-statistics/charts/iron-and-steel-final-energy-demand-and-energy-intensity-in-the-net-zero-scenario-2018-2030, 9th October 2024.

In Indonesia itself, the ironmaking capacity is dominated by blast furnaces with a total of 10,560 TTPA, while the steelmaking capacity is dominated by Basic Oxygen Furnace (BOF) with a total of 11,480 TTPA (58%) and the rest using Electric Arc Furnace (42%)[37]. This data suggests that the BF-BOF route is still dominant in this industry, which is characterized by a high energy intensity in the process. Figure 2-8 illustrates that the energy intensity from the usage of BF-BOF is higher than that of other technologies implemented.

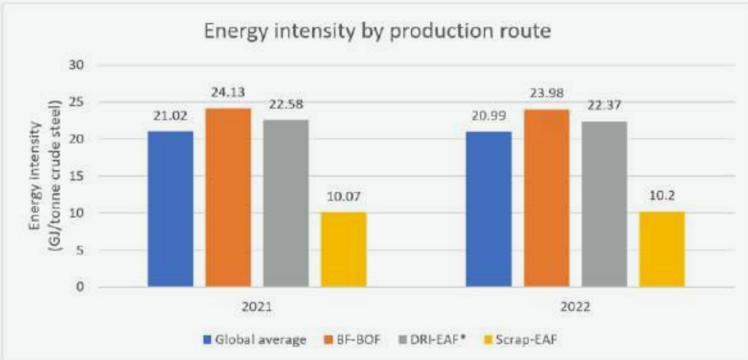


Figure 2-8. Energy intensity based on Production Route[38]

Figure 2-9 reveals that Indonesia has an emission factor of 1.29 kg CO_2 per kilogram of crude steel, placing it in the mid-to-high range among the listed countries. While Indonesia's emission factor is lower than India's (2.03 kg CO_2/kg) and similar to Brazil's (1.32 kg CO_2/kg), it is higher than that of countries like the United States (0.58 kg CO_2/kg) and Turkey (0.53 kg CO_2/kg). This suggests that Indonesia's steel production is relatively carbon-intensive, largely due to traditional production methods and reliance on fossil fuels.

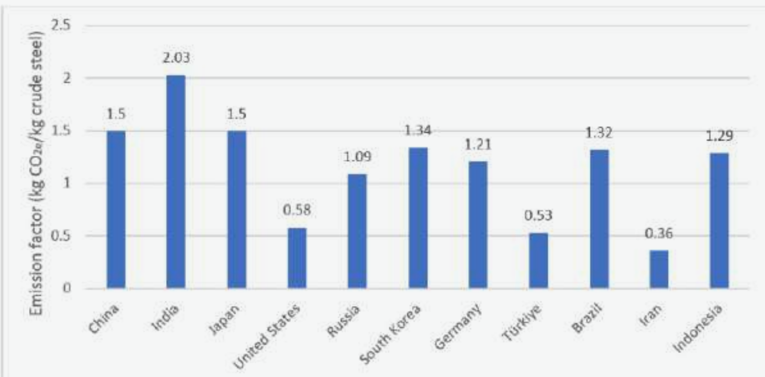


Figure 2-9. The CO_2 emission intensity of several countries' iron and steel in 2021 (processed by PSE UGM)[39]

[37] Global Energy Monitor, https://globalenergymonitor.org/projects/global-steel-plant-tracker/summary-tables/, 9th October 2024.
[38] Worldsteel Association, “Sustainability Indicators 2023 report”, https://worldsteel.org/steel-topics/sustainability/sustainability-indicators-2023-report/, 9th October 2024.
[39] Climatiq Explorer, https://www.climatiq.io/data/explorer?search=metals-type_steel_production&data_version=%5E18, June 8th 2024.

Figure 2-10 further illustrates the CO_2 emission intensity for Indonesia's iron and steel production across different technologies and years. It clearly shows that the BF-BOF (Blast Furnace-Basic Oxygen Furnace) process (Industry A in Indonesia), which heavily relies on coal-based direct reduction, has the highest CO_2 emission intensity. In comparison, the Scrap-EAF (Electric Arc Furnace) process, which utilizes a significant amount of recycled scrap metal, has a significantly lower CO_2 footprint. The figure also highlights the influence of "PLN's Grid Intensity" on the CO_2 emissions in the Scrap-EAF process. This indicates that the carbon intensity of electricity sourced from the national grid plays a crucial role in determining the overall CO_2 emissions for this production method.

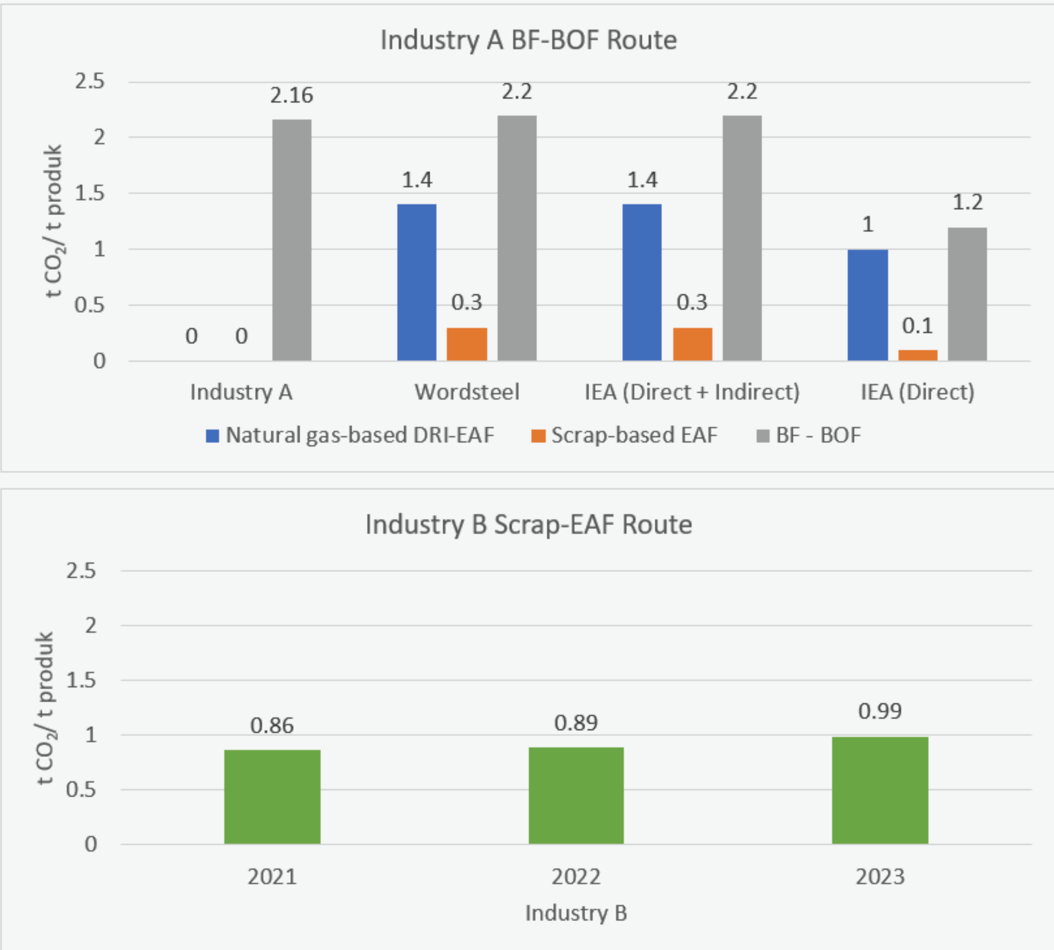


Figure 2-10. Indonesian Iron and Steel CO2 Emission Intensity.

CHAPTER 3

ECONOMIC ASSESSMENT OF TRANSITIONING TO RENEAWABLE ENERGY

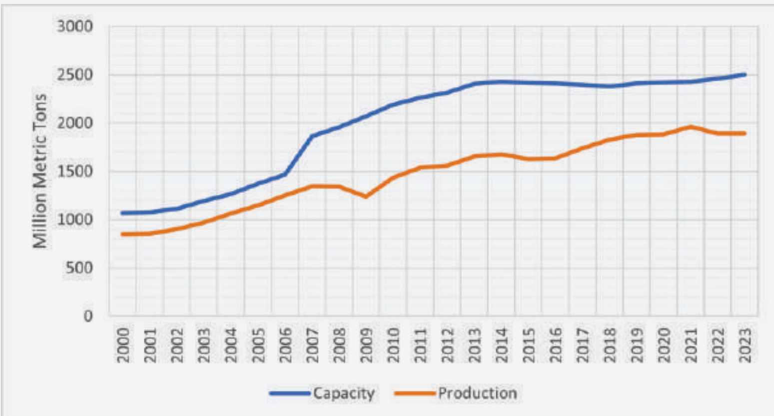
3.1 Overview of Steel Industry Market

This part will examine the market landscape of the steel industry, covering an analysis of global and Indonesian steel supply and demand, as well as an evaluation of Indonesia's steel trade balance and the EU's steel market.

3.1.1 Steel Supply

3.1.1.1 World Steel Supply

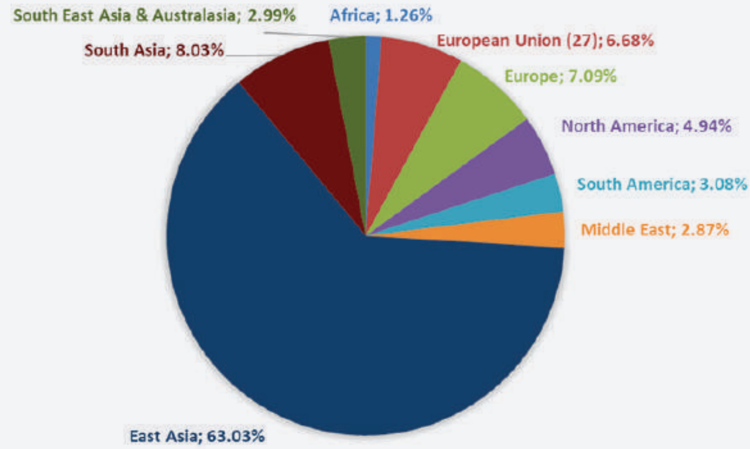
Over the past two decades, the steel industry has had a surge in production capacity, with an annual increase in world production capacity of 3.76%. The initial decade until 2012 witnessed the most substantial growth, with an annual rate of 6.65%. The steel industry then experienced a stagnant state in 2013, with a mere 0.37% annual increase in capacity. However, world crude



Graph 9 World Crude Steel Capacity and Production, 2000-2023
Source: worldsteel[40] and OECD (various years)[41]

steelmaking capacity reached its highest peak in 2023, at 2,498.6 million metric tons (mmt)On On the other hand, total steel production had an annual growth rate of 3.54%, which is approximately 0.2 percentage points lower than the growth rate of its production capacity. Despite a reduction in growth since 2013, overall output achieved an annual growth rate of 1.35%, which is about 1% greater than the growth rate of production capacity during the same period. The global steel production in 2023 is 1,892 million metric tons (mmt).

[40]World Steel Association (2002 - 2024). *World Steel in Figures.*
[41]EOCD (2024). "Steelmaking capacity by economy". *OECD Statistics on Measuring Globalisation (database).* <https://doi.org/10.1787/2ae1e9c7-en>. Accessed on 5 July 2024.



Graph 10. Regional Distribution of Steel Production, 2023
Source: worldsteel[42]

China, the world's largest steel producer, accounts for 1,019 million metric tons (mmt), or 53.86% of global steel production. Japan and South Korea, two other East Asian countries, are also among the top 10 greatest steel producers globally, contributing 4.60% and 3.52%, respectively. The European region, which includes the EU, is the second largest steel producer, accounting for 13.77% of global production, following East Asia. Russia, Germany, and Turkey are the primary producers of steel in the European region. Russia produces 4.02% of the world's total steel, while Germany and Turkey produce 1.87% and 1.78%, respectively. In addition, the South Asia region is a significant player in the steel industry, accounting for 8.03% of global steel production. Indian steel products alone contribute 7.44% to the world's total steel output. Furthermore, the United States, Brazil, and Iran are among the top 10 steel manufacturers, contributing 4.30%, 1.68%, and 1.64%, respectively.

According to its production process, the volume of steel produced using the Basic Oxygen Furnace (BOF) method is significantly greater than that produced using the Electric Arc Furnace (EAF) technique. In 2023, the proportion of BOF steel reached 71.1%, with an average CO_2 intensity of 2.33 tons of CO_2 emitted per ton of basic steel produced. However, the proportion of EAF steel was merely approximately 28.6%, with an average CO_2 intensity of 1.37 tons CO_2 per ton of crude steel produced using the DRI-EAF method and 0.68 tons CO_2 per ton of crude steel produced using the scrap-EAF method.[43]

[42] World Steel Association (2024). *World Steel in Figures 2024.*
[43] World Steel Association (2024). *World Steel in Figures 2024.*

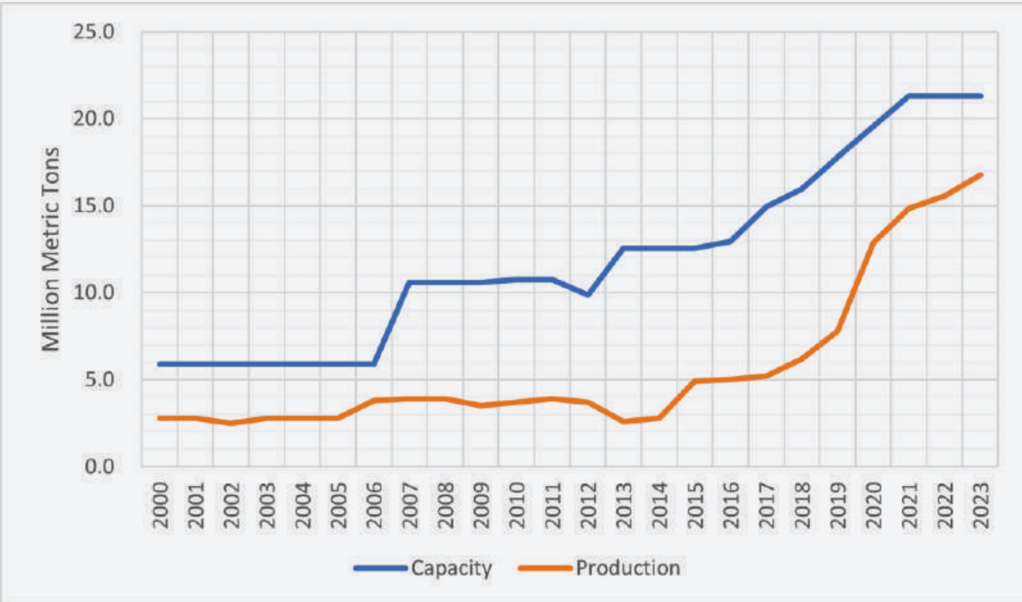
Graph 11. Evolution of Steel Production Process by Region, 2013-2023
Source: worldsteel[44]

The graph above demonstrates that the global steel production technology choices are consistent with the pattern observed in the Asian region. North America, Africa, the Middle East, and Europe have predominantly adopted electric arc furnace (EAF) technology, which is comparatively less carbon-intensive than basic oxygen furnace (BOF) technology. Since 2013, the proportion of EAF has increased in the majority of regions, including North America, Africa, and the Middle East. Nevertheless, the continued prevalence of BOF technology in the Asian region, which accounts for 73.74% of the global production volume in 2023, significantly impacts the steel industry's overall carbon production.

[44]World Steel Association (2002-2024). *World Steel in Figures.*

3.1.1.2 Indonesia Steel Supply

Indonesia's steel manufacturing capacity has been steadily increasing at an annual growth rate of 5.74%. Between 2021 and 2023, Indonesia's crude steelmaking capacity reached its highest point of 21.31 million metric tons per year.



Graph 12. Indonesia Crude Steel Capacity and Production, 2000-2023
Source: worldsteel[45] and OECD (carious years)[46]

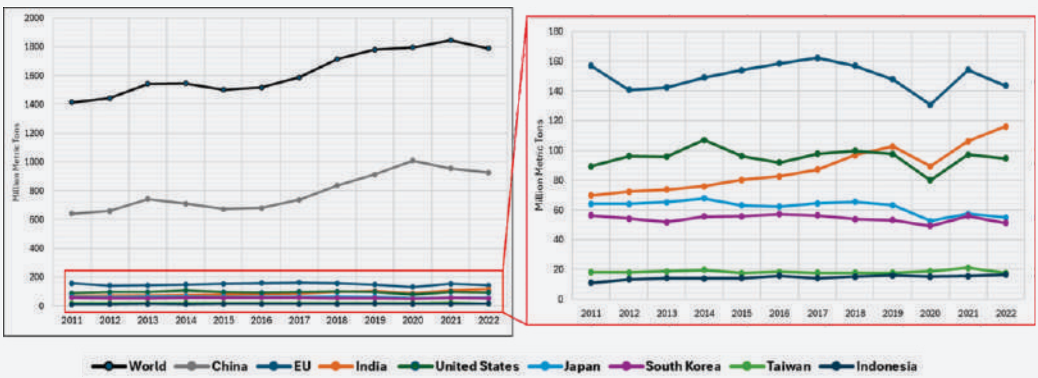
Indonesia's total steel production increased in line with the country's capacity increase, at a rate of 8.10% per year, or approximately 2.36 percentage points higher than the growth in production capacity. Construction, infrastructure development, increasing population, and urbanization have all contributed to the most substantial growth in total production, which has averaged 20.5% annually since 2013. This increase is significantly greater than the 1.35% development in global steel production during the same decade. In 2023, Indonesia's crude steel production reached 16.8 million metric tons (mmt), making it the world's fourteenth largest crude steel producer. However, Indonesia's total production only represents about 0.89% of the global steel production volume.

[45]World Steel Association (2002-2024). *World Steel in Figures.*
[46]OECD (2024). "Steelmaking capacity by economy". *OECD Statistics on Measuring Globalisation (database).* <https://doi.org/10.1787/2ae1e9c7-en>. Accessed on 5 July 2024.
[47]IESR (2024). "Decarbonization of the Iron and Steel Industry Needs a Comprehensive Roadmap". *Institute for Essential Services Reform.* <https://iesr.or.id/en/decarbonization-of-the-iron-and-steel-industry-needs-a-comprehensive-roadmap>. Accessed on 4 July 2024.
[48]Badan Pusat Statistik (2023). *Energy Balances of Indonesia 2018 – 2022.* Badan Pusat Statistik

In Indonesia, blast furnace technology (BF-BOF) continues to account for 80% of the steel production technology, which is primarily powered by coal, as is the case in other Asian countries. Since 2019, Indonesia has experienced a substantial increase in emissions due to the investment in coal-based technology in the steel sector. In Indonesia, the iron and steel industry is one of the main energy-consuming industries, contributing approximately 8% of the country's industrial final energy consumption in 2022. In terms of its energy sources, the iron and steel industry utilizes 93.67% coal energy, 2.85% natural gas, 2.38% electricity, and the remaining 0.79% from other sources. This demonstrates that the steel industry has a substantial potential for decarbonization.

3.1.2 Steel Demand

Global steel demand has exhibited a consistent upward trend, with an annual growth rate of 2.16% since 2011, reaching 1,788 million metric tons (mmt) in 2022. The graph below illustrates the demand for steel in several nations, including the top five countries with the biggest apparent steel consumption (China, India, the United States, Japan, and South Korea), as well as the countries of interest in this study, which are Indonesia and the EU. Taiwan is included in this research due to its status as one of Indonesia's primary export destinations for iron and steel.



Graph 13. Apparent Steel Use, 2011-2022
Source: worldsteel[49]

Notes:

1. Apparent steel use (ASU) is one method of measuring steel demand (finished steel product), which is expressed in volume terms as deliveries minus net exports of steel industry goods.
2. The right graph is a magnified version of the main graph excluding data for the World and China.

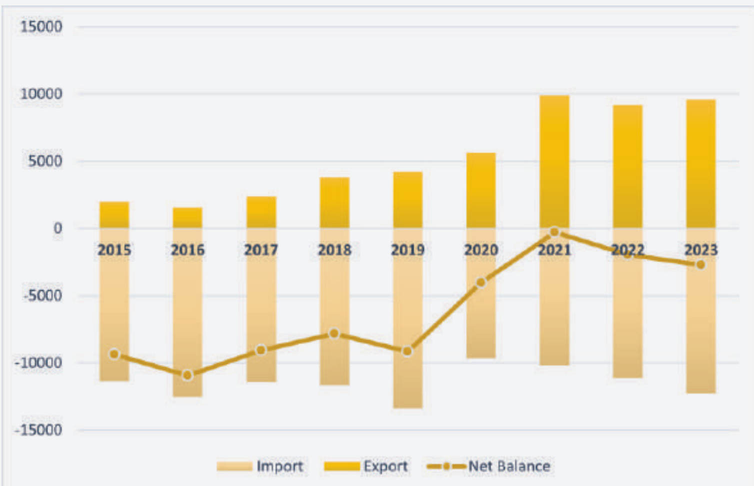
[49]World Steel Association (2002-2024). *World Steel in Figures.*

According to the graph above, China is the dominant consumer of steel, accounting for 51.77% of the global steel volume. China's demand for steel has consistently risen since 2011, with an annual growth rate of 3.39% and a consumption level of 925.65 million metric tons in 2023. The use of steel products in China has had a growth rate that is 1.24% greater than the growth rate of global steel demand. However, despite Indonesia's relatively low steel demand of only 16.60 mmt in 2023, the country's demand is increasing at a notable rate of 3.90% each year. In contrast to the two preceding countries, the demand for steel in the EU is actually fluctuating, with a tendency to decrease. Steel demand in the region had seen a decline starting from 2018, continuing until the onset of the COVID-19 epidemic, with an annual decrease rate at 0.82% compared to 2011 figures. In 2020, amidst the COVID-19 pandemic, most countries witnessed a decline in steel consumption as a result of the disruption of various economic activity. Nevertheless, the majority of these countries experienced a significant recovery in the subsequent year.

3.1.3 Steel Trade

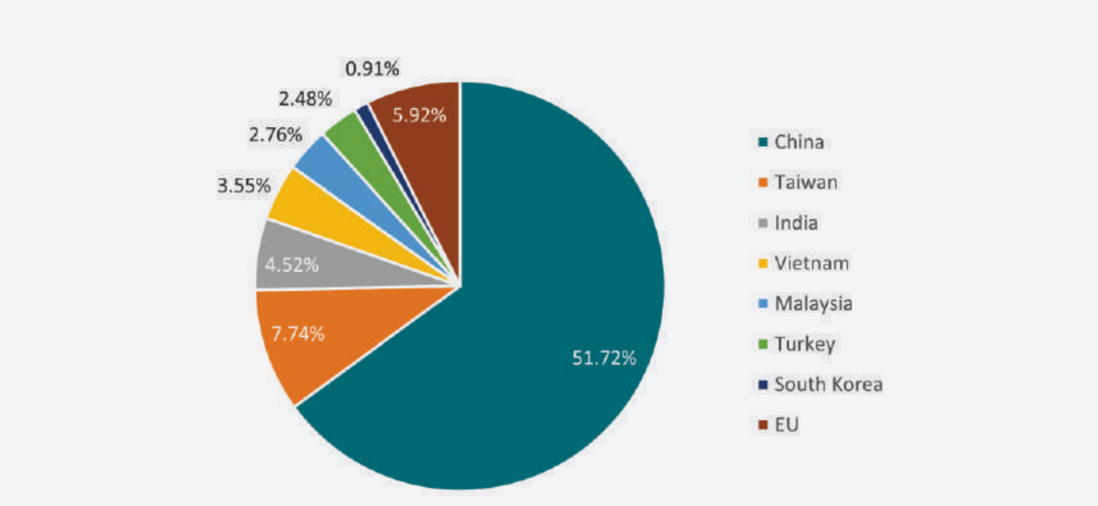
3.1.3.1 Indonesia's Steel Trade Balance

According to available transaction volume data, Indonesia remains a net importer of steel in the global steel trade. In 2023, Indonesia imported 11.12 million metric tons (mmt) of steel from various countries and exported 9.17 mmt. From a valuation perspective, Indonesia's steel product exports amounted to12.1 billion USD, while imports are valued at 10.86 billion USD in the same year. This is an indication of a consistently improving trade balance in Indonesia's steel sector.



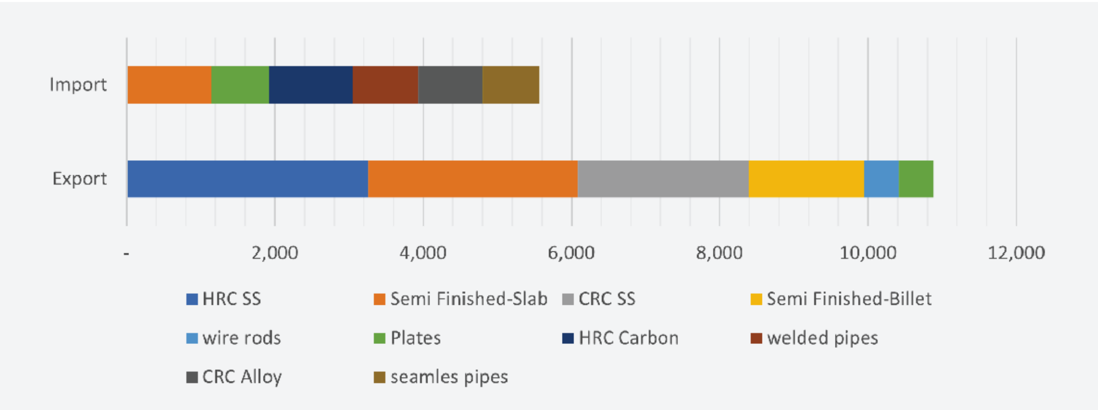
Graph 14. Indonesia's Steel Trade Balance by Volume
Source: IISIA[50]

[50] IISIA (2024). "Dashboard Export and Import of Indonesian". *Indonesian Iron & Steel Industry Association*. <https://dashboard-export-import.iisia.or.id/>. Accessed on 19 July 2024.



Graph 15. Main Export Destination for Steel Products
Source: IISIA[51]

Based on the destination country data, China is Indonesia's primary steel export destination, with an export percentage of 51.72%, equivalent to 10.16 mmt in 2023. Following China, Taiwan and the EU are the next leading destinations for steel exports, with export shares of 7.74% and 5.92%, respectively. Apart from Turkey and the EU, Indonesia's steel exports continue to be concentrated in the Asian market.



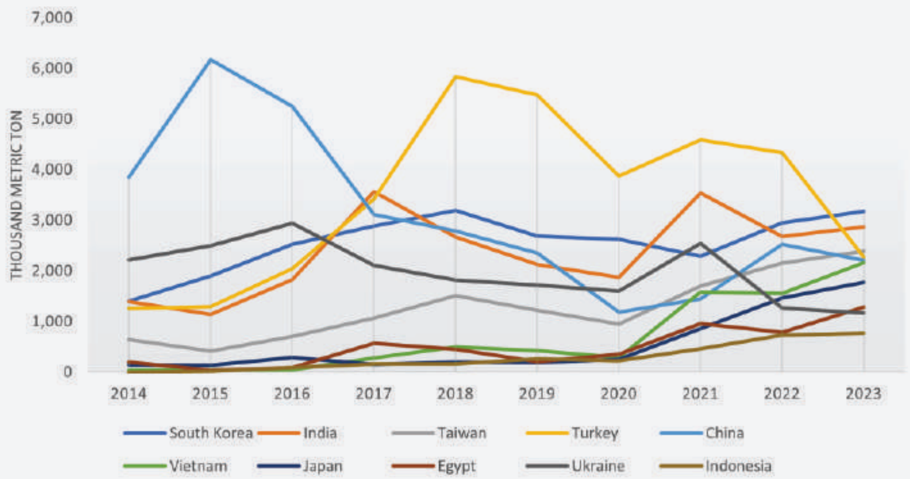
Graph 16. The Primary Steel Commodities Exported by Indonesia
Source: IISIA[52]

[51]IISIA (2024). "Dashboard Export and Import of Indonesian". *Indonesian Iron & Steel Industry Association.* <https://dashboard-export-import.iisia.or.id/>. Accessed on 19 July 2024.
[51]IISIA (2024). "Dashboard Export and Import of Indonesian". *Indonesian Iron & Steel Industry Association.* <https://dashboard-export-import.iisia.or.id/>. Accessed on 19 July 2024.

A diverse range of steel goods are exported and imported by Indonesiato meet different needs. The steel goods imported to fulfill domestic demands include hot-rolled coil carbon, semi-finished slabs, welded pipes, cold-rolled coil (CRC) alloys, plates, and seamless pipes. Conversely, the worldwide market has a high demand for some Indonesian steel products, including hot-rolled coil stainless steel (HRC SS), semi-finished slabs, cold-rolled coil (CRC) SS, semi-finished billets, wire rods, and plates. Indonesian stainless steel products typically have a positive trade balance, and export figures regularly exceed those for imports.

3.1.3.2 Eu’s Steel Market

An analysis of the EU steel market is necessary to assess Indonesia's export potential in light of the implementation of CBAM.



Graph 17. Steel Imports To The EU
Source: Eurofer[53]

There have been substantial shifts in the participants involved in steel imports to the EU. China and Ukraine held a dominant position in early 2014, together accounting for approximately 30% of steel imports to the EU. Since 2015, steel imports from China have consistently decreased and now account for only 8.6%. The market share of Ukrainian steel imports has also decreased to approximately 4.57%. South Korea and India are currently the primary participants in the EU's steel market, as indicated by data from 2023. Collectively, these two entities have the capacity to dominate 23.6% of the steel market in the EU.

On the other hand, Indonesia's contribution to the EU steel market remains modest at only 3%, which amounts to 676 thousand metric tons. Despite this comparatively low figure, Indonesia's steel exports to the EU are increasing by 70% annually, indicating the country's substantial potential to further expand in the EU's steel market.

[53]Eurofer (2024). *European Steel in Figure 2023*. The European Steel Association.

3.2 Decarbonization Strategy

3.1.1 General Decarbonization Strategy

The decarbonization of the industrial sector requires strategic measures and a multisectoral approach. To facilitate the formulation of these measures, this study will adopt the four pillars of decarbonization as a framework to categorize the decarbonization strategies that can be implemented by the industry.

3.2.1.1 Energy Efficiency

A review of the literature reveals numerous definitions of the term 'energy efficiency', each shaped by different perspectives on how it is viewed. In general terms, energy efficiency is understood as the ratio between energy expenditures and the benefits derived from it. In the industrial context, energy efficiency refers to the amount of energy required to produce one ton of product. Therefore, 'energy efficiency' in the industrial setting can be defined as a condition in which an industry uses less energy to produce the same amount of output (goods or services).[54]

Energy efficiency represents one of the short-term decarbonization measures that industries can implement immediately and at the lowest cost. This is because energy efficiency initiatives can often be applied as add-ons without necessitating a complete overhaul of the existing production processes. Generally, energy efficiency can be achieved through the development and utilization of energy-efficient technologies and the implementation of a Strategic Energy Management (SEM) system.

Based on a review of literature from various sources, including research institutions and government agencies, several key energy efficiency measures in the industrial sector can be outlined as follows:

a. Smart manufacturing and data analytics

This approach aims to enhance energy efficiency across both individual equipment and entire factory systems. One of the key challenges associated with this approach is ensuring sufficient data storage capacity and maintaining data security.

b. Combined Heat and Power (CHP)

CHP is a technology that simultaneously produces electricity and thermal energy. Energy efficiency is achieved by reducing the number of devices needed to deliver the same level of service output. However, for CHP to provide emissions reduction benefits, the emissions generated by CHP systems installed in factories must be lower than those produced by the electricity grid.

c. Energy Conservation

Energy conservation can be achieved by changing the material input or the material size to reduce the energy consumption required for other production steps. This option will be discussed further in our guideline.

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[54]Patterson, M. G. (1996). What is energy efficiency?: Concepts, indicators and methodological issues. *Energy policy*, *24*(5), 377-390.

3.2.1.2 Industrial Electrification

In this second approach, industrial decarbonization can be advanced through the electrification of industrial processes rather than the combustion of fossil fuels. To achieve optimal decarbonization benefits, the electricity used in these processes should ideally come from low-carbon or renewable energy sources.

One key area for industrial electrification is in heating processes. The type of electrification technology suitable for heating will vary across industries, depending on their specific temperature requirements. Electrification technologies such as induction heating, radiative heating, and advanced heat pumps can be applied for low to-medium temperature processes.

3.2.1.3 Low Carbon Fuels, Feedstocks, and Energy Sources

In the third approach, industrial decarbonization can be achieved by transitioning to lower-carbon or low-emission energy sources, such as renewable energy (solar, wind, hydro) and emerging energy alternatives, like hydrogen. In addition to being used as a fuel, hydrogen can serve as a feedstock for industries that cannot rely solely on electricity, such as ammonia and methanol production, and oil refining. Other potential low-carbon feedstocks include recycled materials, end-of-life products like scrap metal for the steel industry, and bio-based feedstocks.

3.2.1.4 Carbon Capture, Utilization, and Storage (CCUS)

Carbon Capture, Utilization, and Storage (CCUS) is one of the decarbonization strategies applicable to industries that are difficult to decarbonize. The generated can be captured and then either stored or repurposed for use in other sectors. However, CCUS is considered a short-term solution. In the long term, its implementation may serve as a disincentive for industries to transition to greener technologies. Additionally, several risks, such as carbon leakage and concerns about the overall effectiveness of CCUS, remain subjects of ongoing debate.

3.2.2 Decarbonization Strategies for Steel Industry

Each industry will have different decarbonization options. At a global level, decarbonization projects in the iron and steel industry have emerged in several countries. Utilizing existing databases, a mapping of the various decarbonization progress made in the steel sector has been completed.

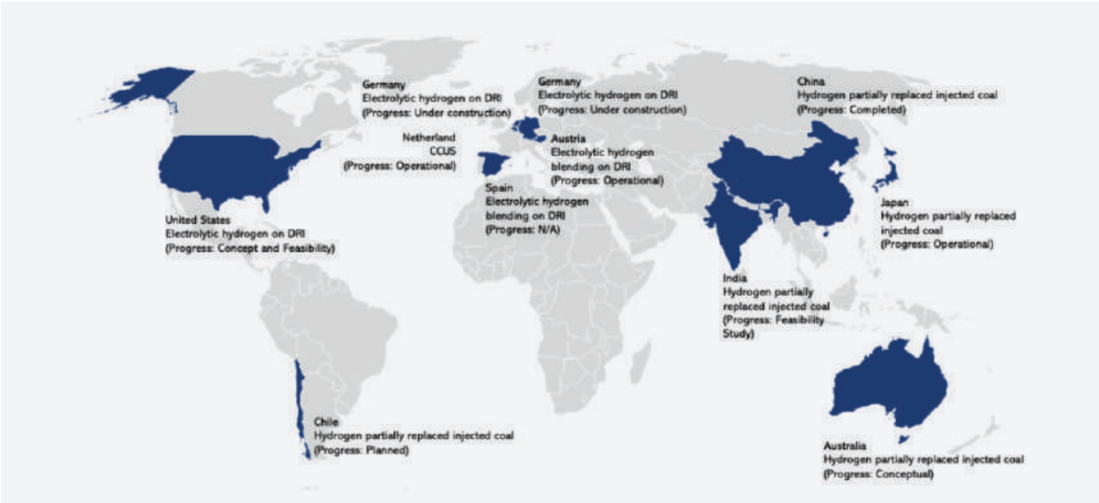

Figure 3-1. Global Iron and Steel Decarbonization Progress[55]

Figure 3-1 presents several of the countries that have initiated the decarbonization process in the iron and steel sector through technological development. Most of these countries are utilizing hydrogen as an energy option, both in the Direct Reduced Iron (DRI) process and for direct injection. Additionally, countries such as the Netherlands are advancing Carbon Capture, Utilization, and Storage (CCUS) technologies in smelting processes that are currently operational. This section will also more broadly discuss other options available to the iron and steel industry. These options are derived from a review of literature sourced from decarbonization roadmaps and reports from various research institutions.

In terms of energy efficiency options, several strategies can be implemented, including reducing coke usage by increasing the injection of pulverized coal or utilizing coke dry quenching (CDQ) to enhance heat recovery.[56] The injection of pulverized coal is advantageous as it requires less energy due to its greater combustibility compared to coke. For steel producers still reliant on coke, an alternative to consider is the implementation of coke dry quenching (CDQ). This technology, which operates on a closed-loop cycle, can create an efficient system for the subsequent drying of coke. However, it should be noted that the adoption of CDQ in the steel production process necessitates a new capital expenditure (CAPEX) investment.

Furthermore, another option involves the implementation of waste heat and gas recovery

[55] IEA (2024). "Clean Energy Demonstration Database". *International Energy Agency.* https://www.iea.org/data-and-statistics/data-tools/clean-energy-demonstation-projects-database? Accessed on July 19th 2024.
[56] DOE (2022). "Industrial Decarbonization Roadmap". *U.S. Department of Energy.*

technologies, particularly in relation to blast furnace gas. The gas generated from this process can be reused for reheating furnaces or for electricity generation. Additionally, modifications to the inputs utilized, such as employing iron ore pellets and increasing coal injection relative to coke (as previously discussed), represent other viable strategies for enhancing energy efficiency in the iron and steel sector.

In terms of industry electrification, one of the electrification options in the iron and steel industry that has gained significant focus is the utilization of Electric Arc Furnaces (EAF) for steel production. EAFs can be directly fed with inputs, such as scrap metal, and can serve as an alternative to the Basic Oxygen Furnace (BOF) process following the blast furnace. The adoption of EAF technology will necessitate new investments by the industry.

Another electrification option that can be employed in steel production is the Electric Induction Furnace (EIF).[57] To optimize emission reductions, it is preferable that the electricity used in this process is sourced from renewable energy. However, the use of renewable energy presents challenges related to availability and cost competitiveness when compared to electricity derived from fossil fuels. Nonetheless, the Electric Induction Furnace offers superior energy efficiency compared to traditional furnaces that rely on combustion technology.

Further, another relatively viable option to implement is the transition to alternative fuel types. For instance, in the short term, a shift toward low-carbon fuels such as natural gas, biomass, and biofuels can be pursued. In the long term, hydrogen emerges as a viable low-carbon fuel, serving both as a fuel source and as a reduction agent through Direct Reduced Iron (DRI) technology. However, the utilization of biomass and biofuels may face challenges related to the availability of feedstock sources, as competition for biomass feedstock from other users may arise, along with site-specific considerations.

Last, out of 13 flagship, large-scale CCUS projects, an IEEFA study from 2022 revealed that five had materially underperformed, two had been suspended, one had been mothballed, and two lacked data necessary to evaluate performance. According to the study, enhanced oil recovery (EOR) uses nearly three-quarters of captured CO_2, allowing for greater extraction of fossil fuels and, consequently, higher carbon emissions. Uncertainty regarding the long-term efficacy of geological CO_2 storage exacerbates the substantial financial, technological, and environmental concerns that CCUS is vulnerable to.

CO_2 storage and transportation in safe, designated geological locations present several difficulties, necessitating thorough research for every project separately. Each CCUS project is unique, which restricts cost savings and technological learning. While the cost of alternative technologies like battery storage and renewable energy has fallen and will continue to do so, the cost of implementing carbon capture has barely decreased in the last 40 years. Integrated steel facilities that use blast furnaces today manufacture the bulk of the world's steel.

fact that blast furnace-based steel factories emit carbon from a variety of sources is one of the main reasons CCUS has not had an impact and is not likely to in the future. It would be quite expensive to retrofit several CCUS systems to such units. Potential CCUS developers frequently claim that a high carbon price is required to encourage the technology's adoption because of its expensive cost. Europe's steel CCUS has made little to no commercial headway, despite a strong and distinct carbon price signal in the EU. It is unrealistic to expect steel CCUS to make

[57]Chaabet and Dotsch. (2012). “Steelmaking based on inductive melting. *Induction Technology*

progress in developing Asia, where steel consumption is likely to expand significantly, if it is unable to do so in Europe, where carbon prices are high. It is unlikely that CCUS will contribute to decarbonization.

To recycle steel in EAFs and DRI-based technologies that can transition to green hydrogen, global steelmakers will be moving away from blast furnaces. This process is well underway already. The manufacturing of low-carbon steel is made possible by the use of green hydrogen in DRI and renewable energy to power EAFs, an accomplishment that CCUS is unable to duplicate.[58]

3.3 Impact of Transition: Macroeconomic Perspective on Decarbonication

Transitioning to renewable energy sources for reducing emissions is a critical aspect of addressing climate change, as highlighted in various studies. However, it is widely recognized that this transition is not without cost; it necessitates careful calibration of economic growth targets to accommodate the associated challenges. From a more optimistic perspective: while the initial shift to renewable energy may have a negative impact on economic growth, it plays a crucial role in reducing CO_2 emissions and increasing social welfare by reducing the negative externalities of fossil-fuel energy. This underscores the importance of considering the long-term benefits of transitioning to sustainable energy sources despite potential short-term economic challenges.

In the context of the Middle East and North Africa (MENA) region, the need for a balance between renewable and non-renewable electricity consumption to effectively mitigate CO_2 emissions has been discussed.[59] The study highlights the ongoing environmental challenges despite efforts to promote renewable energy development mechanisms. Another study further supports this notion by demonstrating that renewable energy consumption significantly reduces emissions, with a more pronounced impact at higher quantiles.[60] These findings underscore the potential of renewable energy sources in curbing carbon emissions in regions with high energy consumption.

The impact of transitioning to renewable energy sources extends beyond specific regions, as evidenced in the EU.[61] The study emphasizes the intricate link between deep decarbonization policies and the transition of economies towards renewable energy sources, emphasizing the role of policy frameworks in driving decarbonization efforts. The importance of sustainable energy transition through improved access and consumption of renewable energy sources has

[58]IEEFA, (2024). “Carbon Capture for Steel? CCUS will not play a major role in steel decarbonisation”. Institute for Energy Economics and Financial Analysis. <https://ieefa.org/resources/carbon-capture-steel>. Accessed on 29 October 2024.
[59]Farhani, S., & Shahbaz, M. (2014). What role of renewable and non-renewable electricity consumption and output is needed to initially mitigate CO2 emissions in MENA region? Renewable and Sustainable Energy Reviews, 40, 80-90. https://doi.org/10.1016/j.rser.2014.07.170
[60]Alharthi, M., Doğan, E., & Taşkın, D. (2021). Analysis of CO2 emissions and energy consumption by sources in MENA countries: Evidence from quantile regressions. Environmental Science and Pollution Research, 28(29), 38901-38908. https://doi.org/10.1007/s11356-021-13356-0
[61]Nagaj, R. (2024). The impact of deep decarbonization policy on the level of greenhouse gas emissions in the European Union. Energies, 17(5), 1245. https://doi.org/10.3390/en17051245

been highlighted, emphasizing the need for efficient technologies and supportive policies to reduce reliance on fossil fuels.[62]

Examining the broader implications of renewable energy transition, the effects of economic growth, investment, and unemployment on renewable energy transition in OECD countries have been explored.[63] The study underscores the role of green energy utilization and risk mitigation in reducing CO_2 emissions, emphasizing the importance of addressing economic and political factors in sustainable energy transitions. Additionally, considering the energy transition in reducing greenhouse gas and air pollutant emissions in China's residential sector case highlights the co-benefits of emission reductions through efficient technologies.[64]

In the UK context, a study has been conducted to delve into government policies and legislation driving renewable energy uptake and greenhouse gas reduction commitments. The study underscores the pivotal role of governmental actions in promoting renewable energy and decentralizing energy networks to achieve emission reduction targets.[65]

The global perspective on renewable energy transition is further explored by analysing global implementation experiences of renewable energy sources. The study underscores the importance of policy frameworks and community engagement in facilitating the adoption of renewables, emphasizing the need for collaborative efforts in transitioning towards sustainable energy sources. Additionally, another study examines the effects of renewable energy and economic growth on carbon emissions in Canada, emphasizing the role of renewable energy as a substitute to reduce CO_2emissions and combat climate change.[67]

The transition to renewable energy sources plays a pivotal role in reducing emissions and combating climate change. By considering the economic, environmental, and policy dimensions highlighted in the referenced studies, countries like Indonesia can develop comprehensive strategies to align with their updated nationally determined contributions and drive sustainable development through renewable energy adoption.

National Economic Implications

Transitioning to renewable energy and the decarbonization of industry represent pivotal shifts in Indonesia's macroeconomic landscape. These shifts impact various economic dimensions, including employment, industrial competitiveness, energy security, and long-term GDP growth.

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[62]Kabeyi, M., & Olanrewaju, O. (2022). Sustainable energy transition for renewable and low carbon grid electricity generation and supply. Frontiers in Energy Research, 9. https://doi.org/10.3389/fenrg.2021.743114
[63]Güler, İ., Atan, M., & Adalı, Z. (2024). The effect of economic growth, investment, and unemployment on renewable energy transition: evidence from OECD countries. Environmental Science and Pollution Research, 1-16.
[64]Xing, R., Hanaoka, T., Kanamori, Y., & Masui, T. (2017). Greenhouse gas and air pollutant emissions of China's residential sector: The importance of considering energy transition. Sustainability, 9(4), 614. https://doi.org/10.3390/su9040614
[65]Raybould, B., Cheung, W., Connor, C., & Butcher, R. (2019). An investigation into UK government policy and legislation to renewable energy and greenhouse gas reduction commitments. Clean Technologies and Environmental Policy, 22(2), 371-387. https://doi.org/10.1007/s10098-019-01786-x
[66]Nazarov, A. (2024). Renewable energy sources: Global implementation experience. E3S Web of Conferences, 474, 01030. https://doi.org/10.1051/e3sconf/202447401030
[67]Erdoğan, E., Serin Oktay, D., Manga, M., Bal, H., & Algan, N. (2024). Examining the effects of renewable energy and economic growth on carbon emission in Canada: evidence from the Nonlinear ARDL Approaches. Evaluation Review, 48(1), 63-89.

Employment and Industrial Transformation

The push for decarbonization in the steel industry necessitates a transformative approach to how industries operate and manage their energy use. While this may initially lead to job displacements in carbon-intensive sectors such as coal and oil, it opens up new employment opportunities in greener industries. The renewable energy sector—encompassing solar, wind, and bioenergy—can create numerous jobs in manufacturing, installation, maintenance, and research and development. Upskilling and reskilling the workforce to meet the demands of these new industries will be crucial, as will developing of a robust educational framework to support ongoing human capital development.

Investment and Fiscal Implications

Significant investments are required to support the decarbonization of industries, including upgrading technologies and infrastructures to reduce carbon emissions. These investments, driven by both public initiatives and private ventures, will likely stimulate economic activity across various sectors. Government policies, potentially involving subsidies for clean energy projects or tax incentives for reducing industrial emissions, will shape the financial landscape. While these policies may strain public finances in the short term, they are expected to foster long-term economic sustainability and resilience.

Energy Prices, Inflation, and Cost Efficiency

The transition might initially increase energy prices due to the higher costs associated with renewable technologies. This could lead to inflationary pressures, affecting overall living and production costs. However, as renewable energy technologies mature and scale up, coupled with increased efficiency in industrial operations through decarbonization efforts, long-term energy costs are projected to decrease. This reduction in energy costs can mitigate inflation over time and lower operational costs across industries, enhancing overall economic efficiency.

Trade and Global Competitiveness

Decarbonizing industries not only helps in meeting global climate commitments but also boosts Indonesia's competitiveness on the international stage. As global markets increasingly favour sustainable practices and products, Indonesian industries that embrace decarbonization can gain a competitive edge. This strategic positioning can improve Indonesia's trade balance, particularly as the nation becomes less reliant on imported fossil fuels, enhancing its energy security and improving its balance of payments.

Long-term Economic Resilience and Sustainability

Ultimately, the combined effects of transitioning to renewable energy and decarbonizing industries contribute significantly to Indonesia's economy's long-term resilience and sustainability. These efforts reduce vulnerability to global economic shocks, environmental changes, and volatile fossil fuel markets. Furthermore, a strong commitment to sustainable practices is likely to attract foreign investment and foster international collaborations, positioning Indonesia as a global leader in sustainability.

While the shift towards renewable energy and industrial decarbonization presents considerable short-term challenges, it promises of significant long-term benefits. These include enhanced sustainability, economic stability, reduced environmental impact, and strengthened international competitiveness, ensuring a robust foundation for Indonesia's future economic development.

3.4 The Impact of CBAM on Indonesia's Economy

The EU's implementation of the CBAM poses a significant challenge to Indonesia's export-oriented industries, particularly the steel sector. This policy, aimed at levelling the playing field between EU producers and their international counterparts, charges a tariff on imports based on their carbon emissions. The introduction of CBAM is expected to have profound implications across several dimensions of Indonesia's economy, ranging from immediate operational costs to long-term industrial strategies and economic policies.

Direct Impact on Export-Based Industries

One of the most immediate effects of the CBAM will be felt in Indonesia's export-based steel industry. As the EU constitutes a significant market for Indonesian steel, the CBAM could potentially diminish the competitiveness of these exports due to increased costs associated with higher tariffs on higher-emission products. This could lead to a reduction in export volumes, impacting the revenue streams of these industries. The steel industry, known for its high carbon emissions, will need to adapt swiftly either by investing in green technologies or by shifting its market focus to less stringent regions, albeit potentially at the cost of forsaking a lucrative market.

Rising Production Costs from Green Technology Adoption

Transitioning to green technology to comply with international standards such as the CBAM is another challenge. Initially, this transition is likely to lead to increased production costs. The financial burden of adopting cutting-edge, low-emission technologies may strain the resources of existing industries. However, these costs are an investment into the future, potentially leading to greater efficiency, reduced energy consumption, and alignment with global environmental standards, which could reduce costs and enhance competitiveness in the long term.

Short-term Economic Slowdown

In the short run, the Indonesian economy might experience a deceleration in growth. The adaptation costs and potential reduction in export revenues, as industries adjust to the CBAM, can temporarily curb economic output. This phase is critical as it represents a realignment of economic activities to more sustainable and globally compliant practices, setting the stage for more stable and sustainable economic growth in the future.

Policy Adaptations for Long-term Stability

The CBAM may also prompt significant policy shifts within Indonesia, pushing the government to implement more aggressive measures to support industrial adaptation to environmental norms. These policy adjustments can help mitigate the initial economic shock by facilitating a smoother transition through incentives for green technology adoption and support for industries most affected by the CBAM. Over time, these policies are expected to foster a more resilient economic framework capable of withstanding similar international pressures and standards.

Changes in Supply Chain

Adjustments in the supply chain are another key area of impact. Industries might need to seek more sustainable raw materials and modify their production processes to reduce emissions. These changes could lead to more sustainable supply chains, reducing long-term costs and improving compliance with international environmental standards.

Incentives for Green Technology

Finally, the role of incentives in facilitating the transition to green technology cannot be overstated. The government may need to provide financial support through subsidies, tax incentives, or grants to offset the high upfront costs of adopting new technologies. These incentives will ensure that industries can make necessary changes without detrimental financial impacts.

While the CBAM represents a significant challenge for Indonesia, it also offers an opportunity to accelerate its transition to sustainable industrial practices. By embracing these changes, Indonesia can enhance its long-term economic stability and environmental sustainability, positioning itself as a leader in global efforts to combat climate change. aAlthough fraught with challenges, this transition is a crucial step toward ensuring a more resilient and prosperous future for the nation's economy.

We estimate the expected economic consequences of CBAM on Indonesia's macroeconomic indicators, specifically on the iron and steel industry based on a computable general equilibrium (CGE) simulation utilizing the Global Trade Analysis Project-Environment (GTAP-E) model. This modelling framework is widely used to understand the complex interconnections between economic sectors and the environment, particularly how policies aimed at reducing carbon emissions could impact national economies.

Nevertheless, it is important to acknowledge that CGE models depend on a series of assumptions and simplifications, including the assumption of perfect competition in markets and homogeneous goods, to make complex economic interactions manageable. Although these assumptions facilitate analysis, they may not accurately represent real-world market dynamics in which imperfect competition and product differentiation are present. The analysis conducted in this study using the GTAP-E model utilizes a database compiled by contributing researchers associated with GTAP. This database is then adjusted to align with the sectoral structure of the Indonesian economy.

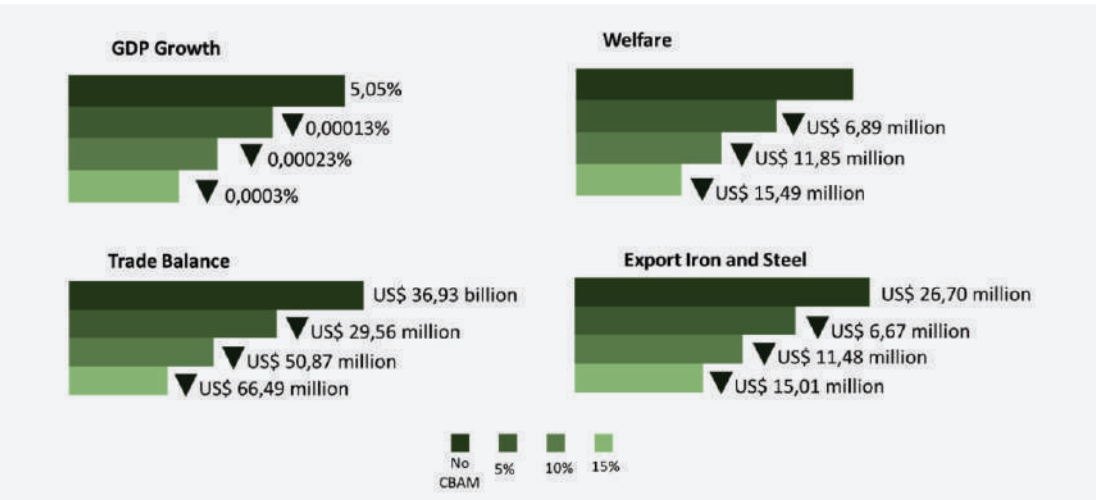

Figure 3-2. Potential Impact of the CBAM on Indonesia's Macroeconomic Indicators and Steel Industry

The CGE simulation predicts a nuanced impact on Indonesia's GDP growth as a result of the CBAM. With a baseline growth rate of 5.05%, the model forecasts a marginal decline to 0.00013% at a CBAM rate of 5%, which progressively worsens to 0.00023% at 10% and 0.0003% at 15%. While seemingly insignificant, these figures underscore the subtle yet real economic strains that heightened environmental policies can impose on nations reliant on high-carbon industries like steel production.

In terms of trade balance, the impact of the CBAM is more pronounced. From a substantial baseline surplus of USD 36.93 billion, there is a predicted downturn to USD 29.56 million with a 5% CBAM imposition. This decline becomes more acute at higher rates, decreasing the trade balance by USD 50.87 million and USD 66.49 million at 10% and 15%, respectively. Although the figures may be insignificant economically, they reveal the sensitivity of Indonesia's trade dynamics to international environmental regulations, highlighting the potential reduction in export revenues as the country's products face higher tariffs in markets implementing the CBAM.

The welfare impact mirrors the trends observed in other economic indicators, with welfare expected to diminish as CBAM rates escalate. The welfare value falls significantly with each increment. Welfare decreases by USD 6.89 million at 5% and reaches USD11.85 million at 10% before slightly tapering off by USD 15.49 million at 15%. This declining welfare trajectory indicates the broad socioeconomic challenges posed by the CBAM, affecting not just industrial sectors but the broader populace through potential increases in costs and diminished economic activities.

Particularly for the iron and steel sector, the exports are anticipated to suffer markedly under the weight of CBAM, with a sharp reduction from an initial USD26.70 million to USD6.67 million at 5%, worsening further to USD11.48 million at 10%, and USD15.01 million at 15%. The dire projections for this sector highlight its vulnerability to stringent carbon emission standards, reflecting the urgent need for adaptation and modernisation towards more sustainable production methodologies.

Overall, the results from the GTAP-E model, as depicted in the graph, stress the economic implications of the CBAM for Indonesia, significantly impacting the pivotal iron and steel industry. The policymakers, who must devise strategic responses to mitigate these impacts, must ensure that the economy not only adjusts to but thrives under the evolving global environmental and economic landscape.

3.5 Impact of Energy Transition on Steel Industry

Transitioning the steel industry to renewable energy sources is crucial step to reducing carbon emissions and achieving sustainability goals. The integration of renewable power into steel manufacturing processes presents various opportunities for decarbonization. Techniques such as blast furnace gas recirculation, carbon capture in furnaces, higher utilization of electrical arc furnaces, and the use of direct reduced iron with hydrogen as a reduction agent are key strategies identified in the literature.[68] These methods not only contribute to reducing the industry's carbon footprint but also pave the way for a more sustainable future by leveraging renewable energy sources.

[68]Otto, A., Robinius, M., Grube, T., Schiebahn, S., Praktiknjo, A., & Stolten, D. (2017). Power-to-steel: Reducing CO2 through the integration of renewable energy and hydrogen into the German steel industry. Energies, 10(4), 451.

Studies have highlighted the potential for regions like Mauritania to harness renewable energy sources to produce green hydrogen for steel manufacturing, emphasizing the dual benefits of reducing carbon emissions and enhancing economic value.[69] The shift towards green steel production, facilitated by hydrogen and electricity from renewable sources, not only decarbonizes steel manufacturing, but also potentially fosters the growth of the international hydrogen industry. This transition aligns with the global push towards sustainable practices and underscores the economic viability of integrating renewable energy solutions in energy-intensive industries like steel production.

Policy evaluations have been conducted to assess the effectiveness, feasibility, efficiency, and fairness of early commercialization support for the decarbonization transition of the steel industry in the EU.[70] Such evaluations are crucial for guiding policy decisions and investments in renewable energy infrastructure to support the steel sector's transition. Additionally, forecasting energy consumption and demand in electric arc furnaces is essential for optimizing operations, power purchasing, and grid capacity monitoring in the face of increasing renewable energy deployment and the need for flexibility.

The utilization of hydrogen-based steelmaking systems powered by renewable energy sources offers a pathway to integrate a high proportion of renewables and drive the steel industry towards a low-carbon footprint. This approach, coupled with the deployment of intermittent renewable energy mediated by green ammonia, presents a sustainable future for the steel industry (Ma et al., 2023). By leveraging renewable energy sources like green hydrogen, steelmakers can significantly reduce their environmental impact and contribute to global efforts to combat climate change.

The transition to renewable energy sources in the steel industry is not only driven by environmental concerns but also by economic imperatives. The volatility of renewable energy prices poses challenges for the industry, emphasizing the need to understand and address these fluctuations to ensure a smooth transition to cleaner energy sources.[71] Moreover, the financial feasibility of integrating renewable energy in the construction sector underscores the economic importance of transitioning to sustainable energy solutions.[72] These financial considerations play a crucial role in decision-making processes within the industry.

The nexus between renewable energy and economic growth is a topic of interest, with studies exploring the nonlinear relationship between renewable energy consumption and GDP growth.[73]

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[69]Khlil, B. (2024). Green steel blueprint: Mauritania's strategic pathway to sustainable industrial leadership. https://doi.org/10.31219/osf.io/smzb7

[70]Vogl, V., & Åhman, M. (2019). What is green steel?: Towards a strategic decision tool for decarbonising EU steel. In *ESTAD proceedings* (p. P532). ESTAD 4th.

[71]Reynolds, S., & Bennett, N. (2024). Sustainability Challenges and Opportunities: A Qualitative Inquiry into the Metal Industry's Response to Renewable Energy Price Volatility.

[72]Akram, N., Farooq, P., Haq, M. U., Nabeel, M., & Asghar, F. (2024). Evaluating the Financial Feasibility of Renewable Energy Integration in Construction Sector. THE ASIAN BULLETIN OF GREEN MANAGEMENT AND CIRCULAR ECONOMY, 4(1), 1-15.

[73]Feng, Y., & Zhao, T. (2022). Exploring the nonlinear relationship between renewable energy consumption and economic growth in the context of global climate change. International Journal of Environmental Research and Public Health, 19(23), 15647.

While there may be short-term inhibitions on economic growth, the long-term positive impact of renewable energy consumption on GDP growth highlights the potential for sustainable economic development by adopting clean energy sources. Furthermore, the integration of renewable energy in industrial operations has been studied across different regions, emphasizing the economic, environmental, and technological dimensions of this transformative process.[74]

The economic assessment of transitioning to renewable energy sources in the steel industry is multifaceted, encompassing technological advancements, policy evaluations, financial considerations, and broader economic growth and sustainability implications. By leveraging renewable power, green hydrogen, and innovative steelmaking processes, the industry can reduce its carbon footprint, enhance economic value, and contribute to a more sustainable future. The integration of renewable energy sources in steel production not only aligns with global sustainability goals but also presents economic opportunities for growth and innovation within the industry.

3.6 Dynamics Between SIH Compliance and CBAM Repercussions

The interplay between adherence to Green Industry Standards (Standar Industri Hijau or SIH) and the repercussions stemming from CBAM is critical for Indonesian industries navigating the shifting sands of global economic and environmental policy. This dynamic not only affects regulatory compliance but also has profound implications for market competitiveness, investment attraction, and operational efficiency.

Compliance with SIH is not merely a regulatory necessity; it fundamentally enhances the appeal and competitiveness of Indonesian products in international markets. As environmental and sustainability criteria become increasingly stringent, particularly in key export destinations like the EU, compliance with SIH positions Indonesian products more favorably against competitors. The EU's implementation of the CBAM, which imposes tariffs based on the carbon content of imports, directly affects non-compliant nations. Indonesian industries that align with SIH can significantly mitigate these tariff impacts, thus maintaining competitive access to one of the world's largest markets.

Moreover, this compliance potentially attracts a new wave of investment. Global capital is progressively flowing towards sustainable and environmentally conscious ventures. Investors are particularly keen on projects that demonstrate compliance with rigorous environmental standards, recognizing such investments' long-term viability and potential regulatory benefits.For Indonesian industries, this means not only access to conventional investment but also opportunities to tap into specialized financial instruments such as green bonds and sustainable investment funds. These instruments often offer more favorable terms and are increasingly sought after by a broad spectrum of investors, from institutional to impact-focused entities.

The operational benefits of adopting SIH standards are equally significant. Integrating green technologies and processes often involves upfront costs, but the long-term payoffs for energy savings and reduced waste are substantial. Industries that transition to energy-efficient systems and sustainable practices typically see a decrease in operational costs over time. These savings can be considerable, allowing businesses to reinvest in further innovations or pass on cost savings to consumers, enhancing profitability and market competitiveness.

In addition to these direct economic benefits, SIH compliance significantly enhances a company's brand image and consumer perception. In today's market, a solid commitment to sustainability can be a significant differentiator for brands, especially among younger, more environmentally conscious consumers. This enhanced brand image increases customer loyalty and can open up new market segments that prioritize environmental impact in their purchasing decisions. The reputational gains from SIH compliance extend beyond consumer markets to affect relationships with business partners, regulators, and the international business community.

The broader economic impact of SIH compliance in the context of CBAM is also worth considering. By reducing dependence on carbon-intensive processes and imports, Indonesian industries not only align themselves with global climate goals but also improve their trade balance and reduce exposure to volatile fossil fuel markets. This shift can enhance national energy security and contribute to a more balanced economic development. Furthermore, as more countries adopt carbon pricing and environmental tariffs, early compliance with SIH will position Indonesian industries as leaders rather than followers, potentially setting standards that others may emulate.

The benefits of SIH compliance in navigating the challenges posed by CBAM are extensive and multifaceted. The advantages are clear from enhancing market access and competitiveness to attracting green investments and reducing operational costs. Moreover, the strategic positioning regarding brand value and national economic resilience further underscores the importance of this compliance. For Indonesia, a proactive approach to embracing these green industry standards not only addresses immediate economic and environmental challenges but also secures a foothold in the future of a sustainable global economy.

CHAPTER 4
COMPREHENSIVE REGULATORY REVIEW

4.1 Regulatory Mapping

This subchapter will analyze the current regulatory landscape in Indonesia. Our regulatory analysis will be divided into three main categories: Regulations on the Supply and Demand of Energy, Regulations on the Green Industry, and Regulations on the Financial Aspects of Energy.

4.1.1 Analysis of Regulatory Mapping

An examination of Indonesia's regulatory framework highlights the country's reliance on laws and regulations to manage renewable energy utilization in Indonesia. However, the implementation of these laws faces significant challenges. With Presidential Regulation No. 22/2017 on the National Energy Policy (PP KEN), the country has set its sights on boosting the contribution of new and renewable energy (NRE) to the energy mix, aiming to reach at least 23% by 2025 and 31% by 2050 – although achieving this goal does seem quite out of reach, if reality on the ground is any indication. While the need for a switch to more environmentally friendly energy sources is tangible, the government has historically placed more emphasis on economic aspects rather than environmental.

Article 12 of PP KEN states that the EBT targets has to be achieved by considering economic aspects. This indicates that the government prioritizes energy security and price stability over environmental sustainability. High dependence on fossil energy as the primary source of national energy can hinder the growth of the EBT sector, which in turn affects the achievement of the set targets.

In addition, Article 2 of Law No. 30/2007 on Energy states that energy use must consider environmental sustainability. In reality, however, the policies adopted often do not align with this spirit of sustainability. Projects that focus on the development of fossil energy sources continue to be prioritized, indicating an imbalance in the implementation of national energy policy.

Indonesia faces an energy trilemma in the context of energy transition that includes energy security, energy equity, and environmental sustainability. Energy security is a top priority due to the country's high dependence on fossil energy sources. This is stipulated in Article 7 of Law No. 30/2007, which emphasizes the importance of ensuring energy availability and accessibility. However, energy equity and environmental sustainability are often overlooked, negatively impacting communities and ecosystems.

In the context of carbon credits, they have been regulated through various regulations as part of efforts to reduce greenhouse gas emissions. One of the instruments implemented in this framework is the carbon tax. Under the Tax Harmonization Law (Law No. 7 of 2021), the carbon tax rate is determined by an unusual provision that it is at least equal to the price of carbon in the domestic carbon market per kilogram (kg) CO_2e and cannot be less than IDR 30/kg CO_2e.

This provision creates a situation where the carbon tax can fluctuate with the development of carbon prices in the market, which is inconsistent with the general characteristics of taxes, which are generally fixed and predictable. According to Article 15 of the Tax Harmonization Law, the basic rate of the carbon tax can be revised by issuing a regulation by the Minister of Finance, which means that the carbon tax will follow the market price once the carbon market in Indonesia is established. Thus, the carbon tax in Indonesia will function not only as a mandatory instrument but also as a complement to carbon trading itself.

On the other hand, the current carbon price in Indonesia is still relatively low. Recent reports show that the carbon price in the domestic market is around IDR 58,000 per ton of CO_2, while the carbon price in the EU Emissions Trading System (ETS) has reached EUR 62, equivalent to around IDR 1,000,000. This disparity calls into question the effectiveness of the carbon tax as a tool to encourage emission reductions and investment in green technologies.

The volatility of the carbon tax rate creates uncertainty for market participants. While the carbon tax is mandatory, this could reduce the attractiveness of investment in renewable energy and clean technology sectors, which should be encouraged through clear fiscal incentives. With a tax that follows the market price, there is a risk that the carbon tax will not work optimally in motivating emissions reductions, as the low rate does not provide a strong enough incentive to change business and social behavior.

Thus, while Indonesia has formulated a legal framework for a carbon tax, the implementation challenges reflect the complexity of the interplay between fiscal policy, carbon trading, and market prices. In this context, the carbon tax is not only an instrument to promote environmental sustainability but also subject to price dynamics that may hinder the achievement of emission reduction targets.

4.2 Legal Analysis of the CBAM

4.2.1 Overview of CBAM Legal Framework

The CBAM is designed to impose a carbon price on imports of certain goods into the EU, ensuring that imported products reflect the carbon costs borne by EU producers under the EU Emissions Trading System (ETS). The legal framework of the CBAM is grounded in the EU's commitment to achieving climate neutrality by 2050 and preventing carbon leakage—where production shifts to countries with less stringent emissions regulations.

The legal basis for the CBAM is primarily established by two main pieces of legislation:

1) Firstly, Regulation (EU) 2023/956. This regulation, enacted by the European Parliament and the Council of the EU on 10 May 2023, provides the foundational framework for the CBAM. It sets forth the mechanisms for calculating customs duties at the EU borders, considering carbon dioxide emissions associated with imported goods.

2) Secondly, Implementing Regulations. Following the enactment of Regulation (EU) 2023/956, additional implementing regulations were published to specify detailed reporting obligations for the CBAM during the transitional period. One notable example is the Implementation Regulation adopted on 17 August 2023, which outlines the reporting requirements for importers during this period.

Additionally, Article 192(1) of the Treaty on the Functioning of the EU (TFEU) serves as another legal basis for the CBAM proposal, aligning with the EU's commitment to contributing to environmental protection and combating climate change.

Key components of the CBAM legal framework include:

1) Firstly, the scope of application for the CBAM. The CBAM applies to specific sectors, including steel, cement, and fertilizers, identified as high-emission industries. The

mechanism requires importers to purchase CBAM certificates corresponding to the carbon emissions embedded in their products.

2) Secondly, implementation of carbon accounting methodologies. The CBAM establishes standardized methodologies for calculating the carbon footprint of imported goods, which must align with EU standards. This includes detailed reporting requirements for importers to demonstrate compliance.

3) Lastly, clauses on compliance and enforcement: The CBAM includes provisions for monitoring, reporting, and verification (MRV) to ensure that importers accurately assess and report their products' carbon emissions. Non-compliance can result in penalties, including fines and increased tariffs.

4.2.2 Legal Implications for Indonesian Exporters

It is to be understood that the CBAM does not impose direct legal obligations on Indonesian exporters. However, its implementation has significant indirect implications for these exporters due to their position in the global supply chain. While CBAM primarily targets EU importers, Indonesian exporters are indirectly affected by their role as suppliers to the European market. The mechanism requires EU importers to report and pay for the carbon emissions of certain imported goods. As a result, these importers will need detailed information about the origin of the products and their associated carbon footprint.

This creates an indirect but crucial responsibility for Indonesian exporters. They will need to provide accurate and verifiable data on the carbon emissions related to the production of their goods. This information is essential for EU importers to comply with CBAM regulations and accurately calculate the carbon costs associated with the imported products. The need for transparency and detailed emissions reporting presents challenges and opportunities for Indonesian exporters. While it may require significant changes in data collection and reporting practices, it also offers a chance for Indonesian businesses to demonstrate their commitment to sustainability and potentially gain a competitive edge in the evolving European market.

In essence, although CBAM does not directly regulate Indonesian exporters, its implementation creates a ripple effect throughout the supply chain, necessitating increased cooperation and information sharing between exporters and their EU counterparts.

4.2.3 Interaction with Indonesian Law

While the CBAM is not directly enacted in Indonesia, its implementation by the EU necessitates several legislative and regulatory harmonizations within Indonesia to ensure the country's exporters remain competitive and compliant, such as regulations on carbon pricing, carbon trading, green certificates, green electricity, and regulatory framework for emissions reporting. This report will analyze Indonesia's Green Industry Standard and its potential role in helping Indonesian industries align with CBAM requirements.

4.2.4 CBAM, EU ETS, and Indonesia Carbon Credit

The EU Emissions Trading System (ETS) limits greenhouse gas emissions from power generation and large industrial facilities. Companies must purchase allowances on the ETS market, although a limited number of free allowances are allocated to prevent carbon leakage. The Carbon Border Adjustment Mechanism (CBAM) will gradually serve as an alternative to increase the motivation for decarbonization. Over time, the number of free allowances available under the ETS will decrease across all sectors to maximize its effectiveness in achieving the EU's climate change goals. Starting in 2026, free allowances for industries covered by the CBAM will be phased out as the financial adjustments to the CBAM are phased in.

To complement the ETS, the CBAM will introduce a system of allowances to account for the embedded emissions in products imported into the EU. While the CBAM differs from the ETS in certain aspects necessary for a border adjustment mechanism - as it is not a cap-and-trade system - it is still aligned with ETS pricing, as CBAM allowances reflect the same market price.

Once the complete CBAM system is in place in 2026, it will align with the updated EU ETS, particularly in reducing the free allowances available to the sectors it covers. This means CBAM will only apply to included products, directly correlating with the reduced free allowances under the ETS for these sectors. Until these free allowances are fully phased out by 2034, the CBAM will only target emissions over these allowances, ensuring that importers are treated fairly compared to EU producers. This approach is critical to maintaining a level playing field as the EU transitions to a more sustainable economy.

In essence, the CBAM will guarantee that imported products will receive "no less favorable treatment" than EU products under the following conditions:

- The CBAM considers the "real values" of embedded emissions, which means that the decarbonization efforts of companies exporting to the EU will result in lower CBAM payments.
- The cost of the CBAM allowances required for importing goods will be the same as the prices that EU producers face under the EU Emissions Trading System (EU ETS).
- Effective carbon prices paid outside the EU will be deducted from the adjustment to avoid double pricing.

For example, the carbon price paid in a third country may result from an established emissions trading scheme. The Commission will adopt secondary legislation before the end of the transitional period to develop the rules and procedures for considering the effective carbon price paid abroad. Throughout this transitional period, reports must include the carbon price applicable in the country of origin for the emissions embedded in imported goods, considering any available rebates or compensation for information purposes.

This means that goods from Indonesia, as a country outside the EU and the EU ETS system, can be imported into the EU without purchasing CBAM certificates if they can compensate with carbon costs that already paid domestically. However, as explained above, Indonesia's current carbon price is still relatively low compared to the EU ETS. Indonesia's carbon price is about IDR 58,000 per ton of CO2, while the ETS has reached EUR 62, equivalent to about IDR 1,000,000. This disparity calls into question the effectiveness of the carbon tax as a tool to encourage emission reductions and investment in green technologies.

In Indonesia, the carbon credit system consists of two main components: Persetujuan Teknis Batas Atas Emisi - Pelaku Usaha (PTBAE-PU), which serves as an allowance system, and Sertifikasi Persetujuan Emisi Gas Rumah Kaca (SPE-GRK), an offset mechanism. Currently, PTBAE-PU is exclusive to the coal-fired power subsector, while other sectors and subsectors are not capped, and only the coal-fired power sector can sell PTBAE-PU. Different industries can participate by trading SPE-GRK or using offsets. However, integrating carbon offset projects into the EU ETS framework proved ineffective, resulting in excessively low prices and reducing the scheme's environmental impact. As a result, these carbons offset provisions have been removed from the EU ETS after 2020. Thus, while Indonesia already has a legal framework for regulating carbon credits, the current instrument is still not yet an effective response to the EU ETS, especially given the low carbon price.

4.2.5 CBAM and the WTO

One of the intriguing findings in this study is the question of CBAM's compatibility with World Trade Organization (WTO) regulations. While the EU has consistently maintained that CBAM has been meticulously designed to comply with WTO rules, emphasizing its role as a crucial tool in the fight against climate change and carbon leakage, this assertion is met with skepticism and opposition from those from developing economies who fear that the mechanism could disproportionately affect their export competitiveness.

The question of CBAM's compatibility with WTO rules is far from straightforward, owing to ambiguities in existing WTO jurisprudence and the novel nature of carbon-based border adjustments. Central to this debate are fundamental questions about the permissibility of carbon-content-based taxes under current WTO frameworks and the complex task of determining product similarity based on carbon footprint rather than traditional physical characteristics. Legal experts and trade analysts have pointed out potential prima facie violations of several key GATT Articles, including Articles II, III, XI, and XIII. These concerns stem from the mechanism's nature as a measure that could be interpreted as discriminatory or disguised restriction on international trade, despite its environmental objectives.

As this avenue is explored, the potential for CBAM to be brought before the WTO remains significant, albeit fraught with uncertainties. The outcome of any such dispute could have far-reaching implications not only for the EU's climate policy but also for the broader landscape of international trade and environmental governance. It may well serve as a litmus test for the WTO's ability to navigate the complex interplay between trade regulations and urgent global challenges like climate change.

4.3 Green Industry Standard (Standar Industri Hijau) (SIH)

The Green Industry Standards (SIH) were instituted as an integral component of Indonesia's comprehensive environmental and economic strategy to transition towards a sustainable, green economy. These standards embody an extensive array of criteria that industries must fulfill to attain green certification, encompassing critical aspects such as energy efficiency, waste management, water usage, and pollution control. Compliance with these standards fosters environmental protection and enhances the competitiveness of Indonesian industries in the global marketplace, where sustainability is increasingly becoming a paramount differentiator.

The SIH framework is meticulously crafted to address the multifaceted environmental challenges encountered by various industrial sectors. This framework includes specific guidelines tailored to each sector's unique operational and environmental contexts, ensuring that the standards are both relevant and effective. For instance, the guidelines for the manufacturing sector focus on minimizing energy consumption and waste production, while those for the agricultural sector emphasize sustainable land use and efficient water management practices.

Moreover, the regulatory approach within the SIH framework is product-specific, with distinct regulations issued for different products. This differentiation acknowledges the diverse environmental impacts of various industrial processes and products, allowing for more targeted and effective environmental management. By implementing product-specific regulations, the SIH framework ensures that each industry adheres to the most appropriate and stringent environmental standards pertinent to its operations.

SIH is designed to encourage industries to adopt cleaner and more sustainable practices. This includes efficient use of resources, reduction of environmental impact, and implementation of eco-friendly technologies. The standards encompass various aspects of sustainability, such as energy efficiency, waste management, water conservation, and reducing greenhouse gas emissions. By adhering to these standards, industries can not only improve their environmental footprint but also enhance their operational efficiency and market competitiveness. The creation of the SIH is mandated by Article 79 of Law Number 3 of 2014 on Industrial affairs, which stipulates the need to define and implement Green Industry Standards. This directive underscores the legislative commitment to fostering sustainable industrial practices within Indonesia. Some regulations which have been enacted in relation to this are:

1) Peraturan Menteri Perindustrian Nomor 13 Tahun 2020 tentang Standar Industri Hijau untuk Industri Suku Cadang dan Aksesori Kendaraan Bermotor Roda Empat atau Lebih – Silencer
2) Peraturan Menteri Perindustrian Nomor 37 Tahun 2019 tentang Standar Industri Hijau untuk Industri Penyamakan Kulit dari Sapi, Kerbau, Domba, dan Kambing
3) Peraturan Menteri Perindustrian Nomor 50 Tahun 2020 tentang Standar Industri Hijau untuk Industri Pupuk Nitrogen, Phospor, dan Kalium Padat
4) Peraturan Menteri Perindustrian Nomor 55 Tahun 2020 tentang Standar Industri Hijau untuk Industri Tas atau Kantong Belanja Plastik dan Bioplastik
5) Peraturan Menteri Perindustrian Nomor 46 Tahun 2020 tentang Standar Industri Hijau untuk Industri Perlengkapan Rumah Tangga dari Keramik
6) Peraturan Menteri Perindustrian Nomor 40 Tahun 2022 tentang Standar Industri Hijau untuk Industri Tekstil Penyempurnaan Kain dan Industri Tekstil Pencetakan Kain
7) Peraturan Menteri Perindustrian Nomor 49 Tahun 2020 tentang Standar Industri Hijau untuk Industri Kertas dan Papan Kertas Bergelombang
8) Peraturan Menteri Perindustrian Nomor 41 Tahun 2019 tentang Standar Industri Hijau untuk Industri Minyak Goreng dari Kelapa Sawit
9) Peraturan Menteri Perindustrian Nomor 11 Tahun 2019 tentang Standar Industri Hijau untuk Industri Bubur Kertas dan Industri Bubur Kertas yang Terintegrasi dengan Kertas
10) Peraturan Menteri Perindustrian Nomor 37 Tahun 2022 tentang Standar Industri Hijau untuk Industri Pertenunan yang Menggunakan Alat Tenun Mesin

11) Peraturan Menteri Perindustrian Nomor 51 Tahun 2020 tentang Standar Industri Hijau untuk Industri Cat Berbasis Pelarut Organik
12) Peraturan Menteri Perindustrian Nomor 33 Tahun 2021 tentang Standar Industri Hijau untuk Industri Pengasapan Karet dalam Bentuk Ribbed Smoked Sheet
13) Peraturan Menteri Perindustrian Nomor 11 Tahun 2020 tentang Standar Industri Hijau untuk Industri Biskuit dan Produk Roti Kering Lainnya
14) Peraturan Menteri Perindustrian Nomor 10 Tahun 2020 tentang Standar Industri Hijau untuk Industri Peralatan Saniter dari Keramik
15) Peraturan Menteri Perindustrian Nomor 38 Tahun 2019 tentang Standar Industri Hijau untuk Industri Cat Berbasis Air
16) Peraturan Menteri Perindustrian Nomor 9 Tahun 2020 tentang Standar Industri Hijau untuk Industri Gula Kristal Putih
17) Peraturan Menteri Perindustrian Nomor 12 Tahun 2023 tentang Standar Industri Hijau untuk Industri Baja Lembaran Lapis
18) Peraturan Menteri Perindustrian Nomor 32 Tahun 2021 tentang Standar Industri Hijau untuk Industri Tepung Terigu
19) Peraturan Menteri Perindustrian Nomor 49 Tahun 2020 tentang Standar Industri Hijau untuk Industri Kertas dan Papan Kertas Bergelombang
20) Peraturan Menteri Perindustrian Nomor 40 Tahun 2019 tentang Standar Industri Hijau untuk Industri Kertas Budaya
21) Peraturan Menteri Perindustrian Nomor 47 Tahun 2020 tentang Standar Industri Hijau untuk Industri Air Mineral
22) Peraturan Menteri Perindustrian Nomor 53 Tahun 2020 tentang Standar Industri Hijau untuk Industri Kaca Pengaman Diperkeras
23) Peraturan Menteri Perindustrian Nomor 30 Tahun 2021 tentang Standar Industri Hijau untuk Industri Barang Lainnya dari Kaca
24) Peraturan Menteri Perindustrian Nomor 38 Tahun 2022 tentang Standar Industri Hijau untuk Industri Felt sebagai Material Silencer
25) Peraturan Menteri Perindustrian Nomor 26 Tahun 2018 tentang Standar Industri Hijau untuk Industri Semen Portland
26) Peraturan Menteri Perindustrian Nomor 48 Tahun 2020 tentang Standar Industri Hijau untuk Industri Kemasan dari Kaca
27) Peraturan Menteri Perindustrian Nomor 28 Tahun 2018 tentang Standar Industri Hijau untuk Industri Pengolahan Susu Bubuk
28) Peraturan Menteri Perindustrian Nomor 41 Tahun 2022 tentang Standar Industri Hijau untuk Industri Ubin Keramik

29) Peraturan Menteri Perindustrian Nomor 10 Tahun 2023 tentang Standar Industri Hijau untuk Industri Batik

These regulations comply with Minister of Industry Regulation Number 51/M-IND/PER/6/2015, which sets forth the Guidelines for the Development of Green Industry Standards. This foundational document provides a structured framework for creating and implementing of sustainable practices across various industrial sectors, ensuring that environmental responsibilities are integrated into business operations.

Under the Minister of Industry Regulation Number 39 of 2018's guidelines, concerning the Procedures for Green Industry Certification, industrial companies that have successfully implemented Green Industry practices are eligible to receive a Green Industry Certificate (Article 2). This certification recognizes and validates businesses' adherence to established environmental standards, demonstrating their commitment to sustainable industrial operations.

4.3.1 SIH in Indonesian Standardization and Certification Concept

The standardization concept in Indonesia has a legal basis in Law Number 20 of 2014 on Standardization and Conformity Assessment (Law 20/2014). The Act regulates the the standardization process along with conformity assessment and certification. In substance, Law 20/2014 primarily regulates standardization and conformity assessment, while regulations regarding certification are found within the articles related to these topics, meaning there are no articles that, on their own, regulate certification. In this regard, certification is a sequence of suitability assessment activities.[76] Standardization is closely related to planning, preparing, implementing, and supervising Indonesian National Standards or Standar Nasional Indonesia (SNI). Conformity assessment is closely related to testing activities or other assessments for granting certificates. The certification is part of the conformity assessment activities for parties who can apply for SNI.

Furthermore, the standardization and conformity assessment process shas several objectives asfollows:[77]

1) Enhance quality assurance, production efficiency, national competitiveness, while fostering healthy business competition and trade transparency, business certainty, and developing busines and technological innovations capabilities;
2) Increase protection for consumers, businesses, workers, and other communities, as well as the government, from risks that threaten aspects of safety, security, health, and environmental preservation; and
3) Increase certainty, smoothness, and efficiency in domestic and international trading of goods and/or services.

The differences between standardization, conformity assessment, and certification are presented as follows:

[76] Article 1 poin 1 Law 20/2014.
[77] Article 3 Law 20/2014.

Table 4-1 Differences between Standardization, Suitability Assessment, and Certification

Indicator	Standardization	Conformity Assessment	Certification
Definition	Article 1 paragraph (1) Law 20/2014: Standardization is the process of planning, formulating, establishing, implementing, enforcing, maintaining and supervising standards, which shall be conducted in an orderly manner and in cooperation with all stakeholders.	Article 1 paragraph (2) Law 20/2014: Conformity assessment is the activity of determining whether goods, services, systems, processes, or personnel have fulfilled the reference requirements.	Article 1 paragraph (9) Law 20/2014: Standards are technical requirements or something standardized, including procedures and methods compiled based on the consensus of all relevant parties / government / international decisions, regarding the requirements of safety, security, health, environment, technological and scientific development, experience, as well as present and future development, to obtain the maximum benefit.
Institution	In charge: The National Standardization Agency (BSN) is a non-ministry government agency with duties and responsibilities in the Standardization and Conformity Assessment sector.	In charge: BSN Assessor: Conformity Assessment Institutions are agencies that conduct conformity assessment activities. Accreditation Institution: National Accreditation Committee (KAN) is a nonstructural agency that has duties and responsibilities in the Accreditation of Conformity Assessment Institutions. In the event of a mutual recognition agreement between KAN and an international accreditation body, Conformity Assessment activities can be carried out by an overseas LPK that has been accredited in that country based on the principle of reciprocity. If Indonesia becomes a member of an international organization, Conformity Assessment activities can be carried out by LPKs recognized by the organization.	Since conformity assessment is a set of processes or activities carried out to meet standards, the institutions in charge of certification affairs generally overlap with those in charge of standardization and conformity assessment, with the addition of: • Balai Sertifikasi Indonesia or Balai Standarisasi dan Pelayanan Jasa Industri (BSPJI) for industry certification. • Other Industrial Certification Bodies that have been established or accredited to carry out industrial certification. • A designated or accredited product certification body conducts product certification.

Indicator	Standardization	Conformity Assessment	Certification
Scope	• Planning, formulation, establishment, implementation, enforcement, maintenance, and supervision of **Standards (Standar Nasional Indonesia/ SNI).** • Implementation of the **National Program for Standard Formulation (PNPS),**proposal for draft SNI from Stakeholders that will be formulated in a planned, integrated, and systematic manner.	**Fulfillment of SNI requirements** through a series of activities: **Testing** Activities to determine 1 (one) or more characteristics of materials or processes based on SNI **Inspection** The activity of examining goods, services, processes, installations or any of their designs and determining their conformity to certain requirements based on SNI. **Certification:** Goods Certification, Services Certification, System Certification, Process Certification, Personnel Certification, and other forms of certifications intended to ensure conformity to SNI.	**Product/Goods Certification** (Green Products/Environmentally Friendly Products) **Certificate of Profession** **Process Certificate** • Quality Management System Certificate (ISO 9001) • Environmental Management Certificate (ISO 14001) **Green Industry Certification.** All industries that meet green industry standards, namely sectors such as the Ammonia Industry, the Urea Fertilizer Industry, SP-36 Fertilizer Industry, and Ammonium Sulfate Fertilizer Industry.
Output	**Standard** • **Indonesian National Standard (SNI),** which is a standard set by BSN and applicable in the territory of the Unitary State of the Republic of Indonesia (Article 1 point (7) of Law 20/2014).		**Certificate of Conformity** • **The SNI mark** is a certification mark set by BSN to certify the fulfillment of SNI requirements. • **Conformity Marks** are certification marks other than SNI Marks determined by ministries and/or non-ministerial government agencies or determined based on mutual recognition agreements between international legal subjects. • **Green industry logo**

Indicator	Standardization	Conformity Assessment	Certification
Requirement	**The National Program for Standard Formulation (PNPS) is required**, namely to oversee the proposal of SNI designs by stakeholders, and will be established in a planned, integrated, and systematic manner. International cooperation can be pursued to develop elements of the Standardization and Conformity Assessment as well as LPK Accreditation.	**SNI is required** as per Article 30, paragraph (1) of Law No. 20/2014, Conformity Assessment activities are to be carried out to prove compliance with SNI requirements. International cooperation can be pursued to develop elements of the Standardization and Conformity Assessment as well as LPK Accreditation.	• **Standards (SNI**) and **Certification Bodies** are required according to the scope of certification (certification bodies for goods/products, services, processes, personnel, industry, and so on). • **If SNI has not been established, certification can be carried out based on regulations and/or other standards** (Article 33 paragraph (2) of Law No. 20/2014).
Process	• SNI formulation planning is organized in a PNPS • The formulation of SNI by BSN is based on PNPS • Determination of SNI by Decree of the Head of BSN • Implementation of SNI by applying SNI requirements to goods, services, systems, processes, or persons, either voluntarily or compulsorily. • Maintenance of SNI, which can be done through SN review.	Conformity Assessment activities include testing, inspection, and/or Certification activities carried out by LPKs that have been accredited by KAN in accordance with internationally recognized competency requirements.	The certification process differs for each type of certification. But in general, the certification process consists of • Certification registration • Certification document completeness verification • Auditor appointment • Document sufficiency and eligibility audit • conformance with requirements audit • Certificate Issuance • Installation of certification marks (certification logo, SNI mark, conformity mark, etc.).

From the table above, it can be seen that standardization, conformity assessment and certification are three different concepts and processes. Indonesian laws and regulations govern standardization as the earliest and most fundamental activity producing SNI. The National Program for Standard Formulation (PNPS) prepares the SNI formulation plan.[78] In addition, the Conformity Assessment is designed to demonstrate that the SNI meets the requirements established within the SNI itself.[79] In this context, an SNI is first required for each subject to carry out conformity assessment activities for goods, services, systems, processes, or personnel. Certification then becomes one of the options for performing conformity assessment activities with other options including testing, inspection, or all three.[80] Subsequently, the application of SNIs is evidenced by the possession of a certificate and/or the application of SNIs and/or compliance markings, where the certificate becomes the basis for the approval of the use of SNIs and/or compliance markings, according to Article 20 paragraph (3) jo. with Article 46 paragraph (2) Law of 20/2014.

Based on the above description, it is clear that the concepts of standardization and certification are comprehensively regulated by Law 20/2014. Nevertheless, regulations related to standardization and certification within the green industry are specifically outlined in PP 29/2018 in conjunction with PP 28/2021. The definition of the green industry itself is regulated by Article 1, paragraph (5) of GR 29/2018, in conjunction with GR 28/2021 and Article 1, point 1 of Ministry of Industry Regulation 39/2018 as follows:

"Any industry with a production process that places priority on efficiency and effectiveness in the sustainable use of resources, enables harmonization between industrial development and the preservation of environmental functions, and grants benefits to the community."

Meanwhile, GR 29/2018 in conjunction with GR 28/2021 defines Green Industry Norm, Green Industry Certification, and SIH as follows:

Table 4-2 Differences between Green Industry Standard, Green Industry Certifiation, and Green Industry Certiiacate

Green Industry Standard	Green Industry Certification	Green Industry Certificate
Standard for the realization of green industry, stipulated by the minister.	A series of activities for the issuance of certificates to industrial company for the fulfillment of green industry standards.	Acknowledgement given by a green industry certification agency declaring that the industrial company has fulfilled green industry standard.

[78] Article 10 paragraph 1 Law 20/2014.
[79] Article 30 paragraph 1 Law 20/2014.
[80] Article 30 paragraph 2 Law 20/2014.

Furthermore, Article 33 of the relevant PP a quo states that the Green Industry Norms (SIH) shall at least include provisions related to (a) raw materials, auxiliary materials and energy; (b) production processes; (c) products; (d) business management; and (e) waste management. According to the table above, Green Industry Certificates can be obtained by industry players if they comply with the established SIH, which is consistent with the standardization and certification principles of Law 20/2014. In this regard, it can be considered that Green Industry Certificates are complex, as obtaining this certificate requires compliance with green industry standards that cover almost all types of existing certifications, including product certification (letters a and c), process certification (letter b), and system certification (letters d and e).

However, although the provisions of the SIH are relevant in the context of certificates in Law 20/2014, it does not mean that when an industry complies with SIH provisions in a green industry certification that its activity, products, processes, or systems are automatically certified. This is because each of these elements must undergo specific and distinct certification mechanisms. Therefore, the certification activities must be carried out separately for each one.

4.3.2 SIH and CBAM

While Green Industry Standard certificates are valuable for promoting sustainable practices within Indonesia, they face a significant limitation in the international context, particularly in relation to the CBAM. The core issue lies in CBAM's non-recognition of green certificates—including Indonesia's 'Sertifikat Industri Hijau' (SIH)—as valid evidence for carbon emissions calculations. This poses a substantial challenge for Indonesian exporters attempting to demonstrate low-carbon credentials within the EU markets.[81]

An in-depth analysis of Section D.2 of Annex III of the CBAM Implementing Regulation and along with the guidance documents for non-EU installations reveals that the determination of specific emission factors cannot rely on guarantees of origin or green certificates. The regulation explicitly stipulates that emission factors must be based on actual emissions data, verified according to EU standards. This means that certifications like the SIH, which may not align with the EU's stringent verification methodologies, are insufficient for compliance purposes.

Emission factor for electricity received from the grid:

- The default approach is to use a **default factor** provided by the Commission in the CBAM Transitional Registry, which is an average emission factor of the country of origin's electricity grid, based on data from the International Energy Agency (IEA).
- If you as the operator find it more appropriate, you may use any other emission factor of the country of origin's electricity grid based on **publicly available data** representing either the average emission factor[107] or the CO_2 emission factor[108].
- **Actual emission factors may be used in the case of power purchase agreements,** provided that the emission factor is determined as described above.

The determination of specific emission factors by using market-based instruments such as "guarantees of origin" or "green certificates" for renewable energy sources etc. is not allowed.

Figure 41 Section D.2 of Annex III to the CBAM Implementing Regulation and the Guidance Document for Non-EU Installations.

[81] Section D.2 of Annex III to the CBAM Implementing Regulation and in the guidance document for non-EU installations, Section 6.7.3.2.

Moreover, the CBAM Implementing Regulation mandates that all calculations of embedded emissions are subject to re-verification by accredited EU verifiers. This re-verification process ensures consistency and accuracy in emissions reporting, aligning imported goods with the EU's internal carbon pricing mechanisms. While Section D.2 of Annex III specifically addresses electricity imports, this stringent approach to verification reflects the EU's broader stance on measuring of embedded carbon emissions across all sectors covered by CBAM.

Additionally, as analyzed in Chapter 2, the SIH's emissions calculation method significantly differs from that of the CBAM. The CBAM demands a comprehensive accounting of embedded emissions, including both direct and specific indirect emissions, based on the EU's Emissions Trading System (ETS) methodologies. This includes a more extensive consideration of emissions throughout the supply chain.

Due to the differences in calculation and verification methods, SIH certificates cannot be accepted as valid evidence under CBAM. This means that Indonesian exporters must rely on something other than SIH certification to demonstrate compliance with EU carbon requirements. Companies that have invested in obtaining SIH certification find themselves where their domestic green credentials do not translate into tangible benefits in the EU market. This disconnect could lead to additional costs for Indonesian exporters, as they may need to undergo separate carbon accounting processes to comply with CBAM requirements.

However, it is important to recognize that while SIH certificates may not directly meet CBAM requirements, they still hold significant value in the broader context of Indonesia's climate change mitigation efforts. SIH can potentially play a crucial role in the country's national carbon emission calculations. If the Government of Indonesia can secure international recognition for SIH through bilateral agreements and diplomatic initiatives, these certificates could gain acceptance in the global market, thereby enhancing their impact and utility.

CHAPTER V

INDONESIA CASE STUDY

5.1 Indonesian Steel Industry Energy & Carbon Consumption Rate (Study Case)

5.1.1 PT Gunung Raja Paksi Tbk (GRP)

PT Gunung Raja Paksi Tbk (GRP) is one of the largest private steel companies in Indonesia, having partnerships with more than 10 corporations across the world and various consumers in over 40 countries. As one of the largest steel industries, CBAM implementation will impact the overall cost in this industry. To ensure future sustainability, GRP is committed to driving profitability whilst generating a positive impact on people and the planet, as outlined in GRP's sustainability framework, which consists of 5 core ESG pillars, as shown in -Figure 51.

GRP was committed to ensure environmental and social objectives are met as well as implementing some strategies to respond and manage climate-related risks and opportunities throughout the value chain. GRP also operates in line with the regulatory requirements and manages social and environment-related topics guided by the global standards as well as managing environmental impacts from all the operations with transparency and accountability. To ensure future operations, GRP also provides training and investing in the talent to develop human capital to achieve their vision and missions.

Figure 5-1. GRP's Sustainability Framework[82]

GRP is committed to reducing its carbon footprint by transitioning from traditional blast furnace-basic oxygen furnace (BF-BOF) technology to the more energy-efficient and low-carbon electric arc furnace (EAF) technology. This shift not only reduces reliance on coal but also significantly lowers greenhouse gas emissions. EAF technology uses electricity to melt scrap steel, which is a more sustainable approach compared to the BF-BOF method that relies heavily on burning fossil fuels.

[82]Gunung Raja Paksi, “Our Decarbonization Strategy: A Better Future with Sustainable Steel”.

Table 5-1. GRP production, energy and emissions data[83]

Description	Unit	2021	2022	2023	2022-2023 (%)
Steel sheets and derivatives					
Finished goods production volume	Thousand tons	714.3	872.5	761.1	-12.8%
Total production volume	Thousand tons	1128.5	1390.6	1065.8	-23.4%
Steel bars and derivatives					
Finished goods production volume	Thousand tons	188.9	274.6	233.5	-15.0%
Total production volume	Thousand tons	394.7	582.8	480.7	-17.5%
Energy					
Electric consumption	GJ	2,304,318	3,192,431	2,282,482	-28.5%
Natural gas consumption	GJ	2,127,706	2,958,628	2,470,028	-16.5%
Diesel consumption	GJ	25,445	33,339	28,646	-14.1%
Electricity consumption from PV	GJ			3,365	100.0%
Total energy consumption	GJ	4,457,469	6,184,398	4,784,521	-22.6%
Energy Intensity	GJ/ton	2.926	3.134	3.094	-1.3%
Emission					
GHG emission scope 1	ton CO_2eq	105,873	147,072	122,842	-16.5%
GHG emission scope 2	ton CO_2eq	425,896	590,041	421,860	-28.5%
Total GHG Release	ton CO_2eq	531,769	737,113	544,702	-26.1%
GHG emission intensity	ton CO_2eq/ton	0.86	0.89	0.99	10.6%

[83] PT. Gunung Raja Paksi Tbk. (2023). Sustainability Report. https://gunungrajapaksi.com/upload/public/download/SR_2023_PT_Gunung_Raja_Paksi_Tbk_e-Reporting.pdf

In -Table 51, energy consumption patterns indicate significant changes across various energy sources. Total energy consumption dropped by 22.6% from 6,184,398 GJ in 2022 to 4,784,521 GJ in 2023, primarily due to a substantial decrease in electricity consumption (28.5%) and natural gas consumption (16.5%). Diesel consumption, however, remained relatively stable, while the adoption of photovoltaic (PV) energy grew significantly, with electricity consumption from PV reaching 3,365 GJ, a 100% increase. Despite the drop in overall energy use, energy intensity per ton only saw a slight reduction of 1.3%, from 3.134 GJ/ton in 2022 to 3.094 GJ/ton in 2023, indicating that energy efficiency improvements were modest. Greenhouse gas emissions have also declined in line with reduced energy usage. Scope 1 emissions, related to direct GHG emissions from owned sources, decreased by 16.5%, and Scope 2 emissions, which account for indirect emissions from purchased energy, dropped by 28.5%. Total GHG emissions fell by 26.1%, from 731,735 tons CO_2eq in 2022 to 544,702 tons CO_2eq in 2023. However, the GHG emission intensity per ton of steel produced increased slightly by 10.6%, reaching 0.99 tons CO_2eq/ton in 2023, which may be attributed to the lower production volumes.

Further, as part of its net-zero strategy, GRP is investing in fuel-switching technologies to replace natural gas with hydrogen in its steel production processes. Hydrogen, when used as a fuel, produces only water vapor as a byproduct, thus significantly reducing carbon emissions as planned. It will be produced on-site by using water splitting powered by renewables. This transition supports the company's long-term goal of achieving carbon neutrality and aligns with global efforts to combat climate change by adopting cleaner energy sources.

To enhance production efficiency and resource utilization, GRP is incorporating the use of hot briquette iron (HBI) in its steelmaking process. HBI is a premium form of direct reduced iron (DRI) used in EAFs to improve steel quality and reduce energy consumption. The use of HBI not only optimizes the production process but also minimizes waste, contributing to the overall sustainability of GRP's operations. Investing in developing Roof Solar Power Plants (PLTS) to achieve energy efficiency is one way GRP demonstrates its commitment to sustainability. The development of the Roof Solar Power Plants was funded with a total cost of USD 228,573 in 2023. Stage 1 and stage 2 of the PLTS Rooftop were introduced in 2023.

In comparison with the previously projected renewable electricity production target of 1,032,556 kWh, the Roof Solar Power Plants have effectively produced 841,326 kWh of electricity by December 2023. To optimize the potential of renewable energy and lessen reliance on traditional energy sources, GRP will keep working to increase the performance of the roof solar power plants. To complement its direct emission reduction efforts, GRP invests in carbon offset projects and purchases carbon credits. These initiatives help balance the remaining emissions that cannot be eliminated through technology and process improvements alone. By investing in reforestation, renewable energy, and sustainable development projects, GRP can offset its carbon footprint and contribute to global environmental sustainability. Through these comprehensive strategies, GRP is also willing to collaborate with multiple stakeholders to achieve mutual carbon emission reduction, as shown in -Figure 52.

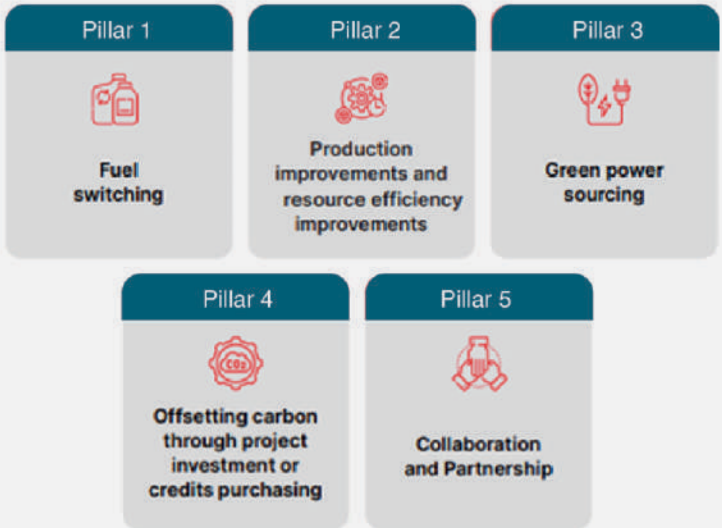

Figure 5-2. GRP's Net Zero Strategy[84]

For summaries and key takeaways, GRP is putting several ideas into practice to address the issues raised by the CBAM policy. Improving energy efficiency in production processes is a crucial tactic to cut both carbon emissions and total operating expenses. To reduce our environmental impact and meet emission reduction targets, GRP is investing in sustainable practices and cutting-edge technologies. To lessen its dependency on fossil fuels and cut carbon emissions, GRP is also concentrating on diversifying its energy sources by incorporating renewable energy solutions into its operations. For collaboration and advocacy efforts to successfully negotiate the regulatory environment, GRP is actively participating in lobbying and cooperation initiatives. To create sustainable solutions and regulatory frameworks that support emission reduction objectives, GRP is collaborating closely with governmental bodies, business associations, and environmental groups. We hope to foster innovation and accelerate the shift to a low-carbon, more sustainable economy by engaging in discussions and collaborations with stakeholders.

[84] Gunung Raja Paksi, "GRP's Net Zero Roadmap", https://www.gunungrajapaksi.com/upload/document/GRPs_Net_Zero_Roadmap_CW_05_Interactive_Spreads.pdf, 8th June 2024.

5.1.2 PT Krakatau Steel (Persero) Tbk

Over the years, Krakatau Steel has built an integrated infrastructure network and complementary businesses in Cilegon and across Indonesia. Krakatau Steel is Indonesia's number one market leader, commanding over 30% of total domestic market share, and has achieved business excellence by leveraging the steel industrial cluster in Cilegon through downstream steel production and support. Nowadays, Krakatau Steel and Krakatau Posco together have over 7.5 million tons of capacity integrated across the value chain.

Tabel 5-2 illustrated below, shows the difference between the years 2022 and 2023 based on the production volume, energy consumption and emissions. Based on Tabel 5-2, production dropped by 1,046,192 tons (55.63%) in 2023, which resulted in a reduction in the consumption of energy compared to that in the year 2022, having dropped by 2,915,991 GJ (47.64%). Overall, based on the data on fuel sources, energy consumption was on a downward trend, but that the consumption of oil, a new energy resource, had risen. Meanwhile, the use of renewable energy increased by 75 GJ (18.84%). The total emissions in the year 2023 were lower than in 2022, with a 259,888-ton CO_2eq (45.75%) difference. Despite this decline in total emissions, Scope 3 emission, which included activities from third-party assets which affect its value chain, increased slightly to 109 tons CO2eq. Scope 1 emissions, which included emissions from owned resources, decreased by 199,196 tons CO2eq (61.33%) while Scope 2 emissions, referring to indirect emissions from purchased energy, decreased by 60,801 tons CO2eq (24,99%)[85].

Table 5-2. Krakatau Steel production, energy, and emission[86]

Description	Unit	2022	2023
Production			
Production Volume	Ton	1.880.560	834.368
Energy			
Energy from PLN	GJ	1.485.149	815.893
Oil	GJ	-	149.294
Natural Gas	GJ	4.634.946	2.238.843
Renewable Energy	GJ	398	473
Total	GJ	6.12.493	3.204.503

[85] Krakatau Steel, “Annual Report 2023”, https://www.krakatausteel.com/pdf/Krakatau_Steel_AR_SR_2023_1.pdf, 29th October 2024.
[86] Krakatau Steel, “Annual Report 2023”, https://www.krakatausteel.com/pdf/Krakatau_Steel_AR_SR_2023_1.pdf, 29th October 2024.

Description	Unit	2022	2023
Emissions			
Scope 1 Emission	Ton Co2eq	324.796	125.600
Scope 2 Emission	Ton CO2eq	243.301	182.500
Scope 3 Emission	Ton Co2eq	-	109
Total	Ton Co2eq	568.097	308.209

Even though production volume is dropping, Krakatau Steel continues to pursue emission reductions and engage in decarbonization process through several programs. From 2023 until 2025, the Green Behavior program will be implemented, which will improve the conservation of energy, bolster the electric vehicle ecosystem, increase the usage of renewable energy, foster circular economy programs, and implement "Go-Green" behavior and initiate research related to hydrogen-based reduction, which is expected to reduce carbon emissions for up to 11%. In the following five years, from 2025 to 2040, Krakatau Steel will improve and implement the Electrification, Carbon Capture, Utilization, and Storage (CCUS), and Hydrogenation, which is projected to further reduce the emissions by 33%. From 2040 to 2060, Krakatau Steel is planning to build a new factory with the "Green Steel" concept using the latest and environmentally friendly technology available, in the attempt to achieve a 100% reduction in emissions.[87]

The decarbonization process has been conducted by Krakatau Steel in the period of 2019 and 2023, as it moves toward 'Green Steel'. This has greatly improved the energy efficiency levels within the company, which now uses transparent roofs, LED rather than conventional lighting, reuse coke oven gas (COG) at the Rotary Hearth Furnace (RHF), operates BFC air compressor, and employs solar panels at the technology building, among other measures. The resulting energy conservation in each sector can be seen in Figure 53, which reports a reduction of around 8.3 kt CO2 per year and saving IDR 67 billion per year. [88.] Further improvements by Krakatau Steel from 2023 to 2025 to achieve Green Steel will be grouped into several programs, such as obtaining ISO 50001 Certification on Management Energy System (SME), compiling Environmental, Social, and Government (ESG) Report, improving the Battery Charging Station, implementing Go Green initiatives around the Krakatau Steel Group premises, optimizing idle equipment at PTKBI, harvesting AC condensate water and rainwater.[89]

[87]Krakatau Steel, "Annual Report 2023", https://www.krakatausteel.com/pdf/Krakatau_Steel_AR_SR_2023_1.pdf, 29th October 2024.
[88] Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the Industry behave?", Presented at E3WG JETP Workshop.
[89]Krakatau Steel, "Annual Report 2023", https://www.krakatausteel.com/pdf/Krakatau_Steel_AR_SR_2023_1.pdf, 29th October 2024.

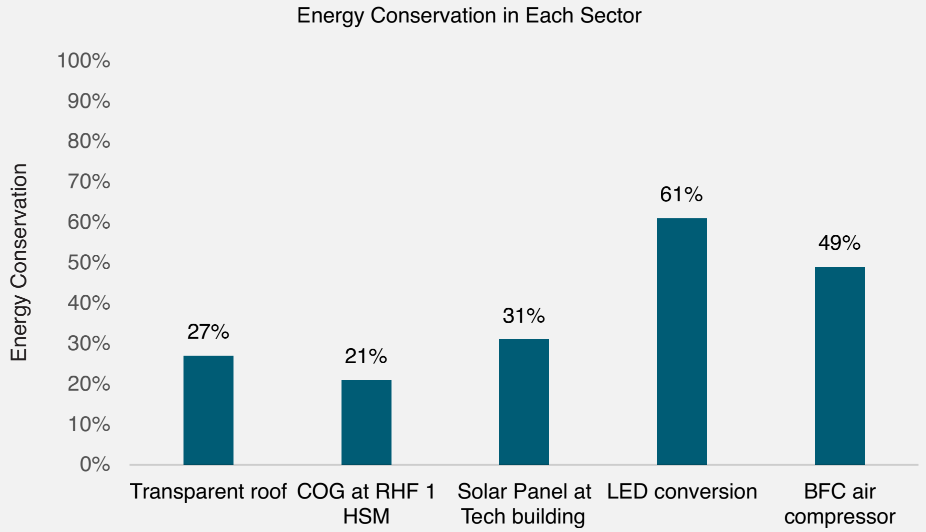

Figure 5-3. Energy Conservation in Each Sector[90]

On the other hand, Krakatau POSCO, founded in 2010 by Krakatau steel and POSCO, has adopted other approaches to achieving carbon neutrality such as by improving energy efficiency, redesigning processes, increasing by-product utilization, and implementing HyREX. By 2023, energy efficiency improvements included the use of low-carbon material alternatives, such as scrap and pellets, which reduced emissions by up to 20%. From 2030 to 2040, process redesigns - such as the injection of natural gas and H_2-containing gas into the Blast Furnace, the implementation of the Electric Arc Furnace and Carbon Capture and Reuse (CCR) technology - are expected to reduce emissions by an additional 50%. By 2050, the implementation of the HyREX (Hydrogen Reduction Ironmaking) technology and the Electric Arc Furnace powered by renewable energy resources could potentially reduce emissions by 100%.[91]

Krakatau POSCO has demonstrated efficient energy use by utilizing by-product gases and waste heat from the power plants to produce electricity and steam, reducing emissions by 1,076 $ktCO^2$ per year. Additionally, the company now has power plants with Top Recovery Technology (TRT) attached, which converts energy from high-pressure gas blast furnace into electricity, reducing emission by 112 $ktCO^2$ per year, and using steam generator from utilizing the waste heat, reducing carbon emissions by 46 $ktCO^2$ per year, resulting in generating 145 MW of electricity and reducing carbon emissions by a total of 1,200 $ktCO^2$ per[92].

[90]Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the Industry behave?", Presented at E3WG JETP Workshop.
[91] Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the Industry behave?", Presented at E3WG JETP Workshop
[92]Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the Industry behave?", Presented at E3WG JETP Workshop..

Krakatau POSCO also succeeded in reducing emissions to below the global steel production route standard with various efficiency and renewable energy initiatives, which can be seen in - . The efficiency improvement consists of reducing steam leaks, energy saving in office buildings, such as in the use of lights and air conditioners, replacing the use of LPG with natural gas, as well as optimizing fuel consumption in the rolling mill's reheating furnace, and other facilities. Other efforts include the installation of solar panels in the hot rolling plant office, making it one of the few zero-carbon offices in Indonesia, and the utilization of gas and heat waste by-products as a new energy source[93].

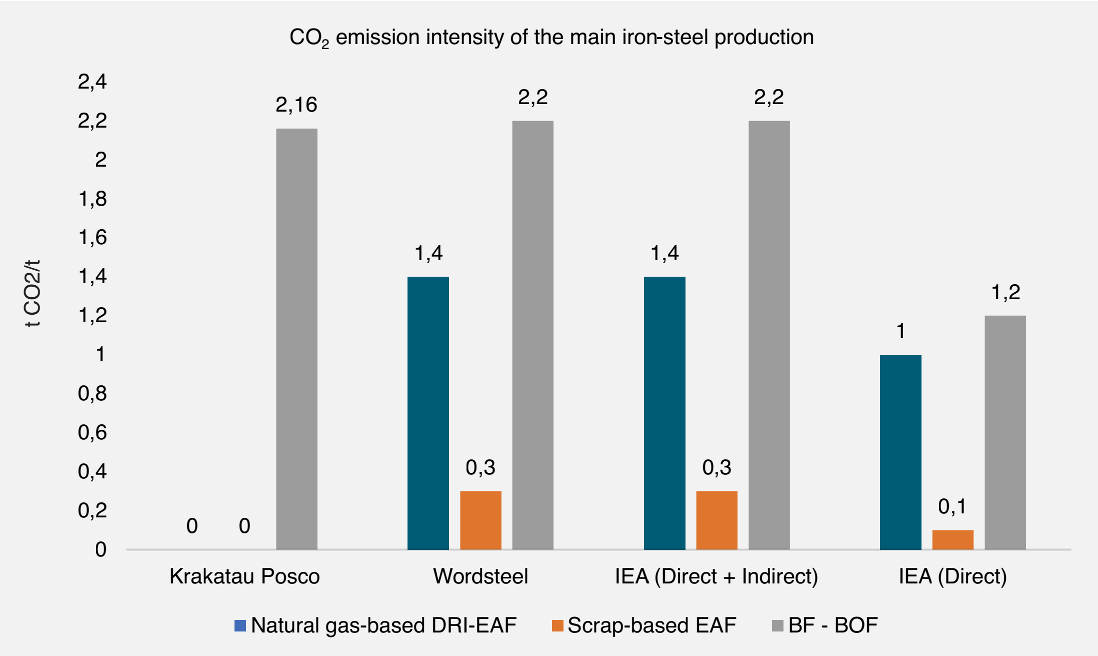

Figure 5-4. CO^2 emission intensity comparison[94].

[93]Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the Industry behave?", Presented at E3WG JETP Workshop.
[94] Krakatau Steel, "How will Decarbonization Impact the Steel Industry and How should the Industry behave?", Presented at E3WG JETP Workshop.

5.2 Identification of Bottlenecks

GRP is committed to reducing its carbon footprint by transitioning from traditional blast furnace-basic oxygen furnace (BF-BOF) technology to the more energy-efficient and low-carbon electric arc furnace (EAF) technology. This shift not only reduces reliance on coal but also significantly lowers greenhouse gas emissions. EAF technology uses electricity to melt scrap steel, which is a more sustainable approach compared to the BF-BOF method that relies heavily on burning fossil fuels.

5.2.1 Technical Challenges

During its decarbonization process and its efforts to comply with trade policies, such as CBAM, the steel industry may face several technical issues.

a. High Energy Consumption Rate For Steel Production

Indonesia's iron and steel production process is still dominated by the use of Blast Furnace – Basic Oxygen Furnace (BF-BOF) method, which requires a significant amount of energy, approximately 21 GJ per ton of steel product. BF-BOF processes in iron and steel produces 2.33 tons of Co_2 per ton of crude steel[95], hence contributing a lot of emission through this production route, and this high rate of emissions per ton of product will result in higher transaction costs when exporting steel goods to the EU or other countries adopting trade policies similar to the CBAM. The resulting higher steel price will doubtless impair the product's competitiveness. Therefore, enhancing production efficiency – through fuel injection technology, coke oven gas, biomass, EAF, and hydrogen – is critical to reducing the reliance on coal fuel for energy generation and lowering production-related emissions.

b. Incompatibility Of New Technology With Existing Infrastructure

Implementing technological advancements often require modifications to existing infrastructure, affecting its complexity and cost. These obstacles also encompass the need to modify current equipment, systems, and processes to ensure compatibility with new technology. Since the infrastructure modification process is lengthy, steel businesses must identify low carbon technologies that are cost-effective and do not impede the existing manufacturing process during the decarbonization effort.

c. Scarcity Of Scrap

Despite being a crucial raw material for the steel sector to meet its carbon neutrality targets, scrap availability remains limited. The extended lifespan of steel products leads to a shortage of scrap in developing nations like Indonesia, which have not experienced industrialization for as long as developed countries. The absence of regulations during collecting and sorting metal scrap may further exacerbate the scarcity. Therefore, it is crucial for the industry to preserve its ability to manufacture steel through two production routes during the transition phase: (1) the primary route, which utilizes iron ore as raw materials, and (2) the secondary route, which utilizes scrap as raw materials.

[95] Worldsteel Association, "Sustainability Indicators 2023 Report", https://worldsteel.org/wp-content/uploads/Sustainability-indicators-report-2023.pdf, 31st October 2024.

d. Limitation of scrap usage in BF-BOF

Each charge of the basic oxygen furnace, which refines carbon-rich pig iron into crude steel, in blast furnace (BF) steelmaking usually comprises 15%–25% scrap. Scrap serves as a source of iron units and a cooling agent, by absorbing excess heat from the exothermic decarbonization process. To reduce greenhouse gas emissions, scrap is occasionally introduced straight to the BF as a source of iron units. Because of the differing chemistry and temperature control in the oxygen-blowing process, BOFs may use a larger percentage of scrap than blast furnaces, which can only utilize 20% scrap or less. Compared to electric arc furnaces (EAFs), which can operate entirely on scrap, the quantity of scrap that may be used in a BOF is still restricted. In electric steelmaking, up to 100% of scrap is remelted using electrical energy to create new steel products[96].

e. Differences in Emission Calculation Methodologies Between CBAM And Indonesian Regulations

The emission calculation methodologies employed in CBAM and Indonesian regulations exhibit inconsistencies, particularly in the direct emission calculation formula This complicates the harmonization of the emission estimation and perhaps leads to discrepancies between the two outcomes. Another issue stems from the methodology employed in Indonesia also accounting for carbon emissions outside the production system, making it prone to overestimation. To mitigate the risk of double counting, Indonesia's employed calculation methodology must be aligned with the CBAM's emission calculation methodology.

5.2.2 Economic Challenges

From the economic perspective, there are several challenges faced by steel companies in order to decarbonize their production processes, including internal and external factors. The following are details of the economic challenges:

a. High Initial Investment of Low Carbon Technology

The initial investment required to transition to low-carbon technology is substantial. Decarbonization must be cost-effective for large-scale implementation without impairing production performance. However, the lack of established business models and limited practical experience hinders the commercial viability of these promising emission-reduction technologies. The process of scaling up various steel decarbonization technologies, which are still primarily at the pilot stage, requires progression toward commercial production, which entails a complex and costly process. A promising technology with the potential to substantially reduce emissions is hydrogen-based direct reduction, but this technology is not yet commercially viable. Industry incentives, government initiatives, and coordination among many stakeholders are essential to promoting the widespread adoption of low-carbon technologies.

In the primary production line, which uses iron ore as raw material, implementing Carbon Capture Storage (CCS) technology could potentially increase production costs by 65%–120%, while the use of green hydrogen in the Direct Reduced Iron-Electric Arc Furnace (DRI-EAF) production line may raise costs by 35–70%. On the other hand, technology switching in the

[96] World Steel Association, 2021, Fact sheet scrap use in the steel industry. https://worldsteel.org/wp-content/uploads/Fact-sheet-on-scrap_2021.pdf

secondary production line (which uses scrap) from BOF to EAF would potentially increase operational costs only by 8–13%;[97]; However, the latter is confronted with the challenge of limited scrap availability. Ultimately, product prices will reflect the increase in production costs, thereby affecting the competitiveness of Indonesian steel.

b. The Cost of Renewable Electricity Remains Comparatively Higher Than That of Fossil Fuel Sources

Renewable energy in Indonesia remains in the developmental phase. Among the steel decarbonizing technologies with high energy needs, electric arc furnaces (EAFs) require substantial electricity[98]. Additionally, Hydrogen, another fuel alternative for industry decarbonization, requires electricity for its production process. Therefore, to further reduce the carbon footprint, companies must optimize the utilization of renewable energy sources. Indonesia possesses many natural resources, many of which can be utilized for renewable energy. However, the current contribution of renewable energy is notably low. In 2023, the share of new and renewable energy in the energy mix was only 13.29%[99]. The limited usage of new and renewable energy prevents low-carbon electricity generation from achieving economies of scale, resulting in the cost of renewable electricity remaining comparatively higher than that of fossil fuel sources. Industrial decarbonization will not be optimal if the emission factor for electricity on the grid remains high. Companies have an additional alternative: captive power. However, this involves a substantial initial investment.

c. Reduction of Steel Product Convetitiveness

One of the factors impeding the industry's willingness to implement decarbonization measures is the consideration of product competitiveness. Utilizing low-carbon energy or switching technologies will unquestionably result in an increase in low-carbon steel production's cost compared to conventional production lines. Indonesian steel industry will face a significant challenge in competing with more efficient steel products from other countries, countries with less stringent decarbonization policies, or products from refuse-abundant countries (most developed countries). On the other hand, the EU's implementation of CBAM puts the domestic steel market, which is currently undergoing transition, at risk of being dominated by low-cost imported steel. Thus, it is important to implement necessary safeguards in order to protect the domestic market during the transition process.

d. Low Green Steel Demand

Another challenge faced by the steel industry is the persistently low demand for green steel. The low-carbon steel ecosystem is currently still establishing market and demand signals at the global level. This is demonstrated by the First Movers Coalition's pledge to use a minimum of 10% low-carbon steel for each member's demand. High-emission conventional steel at relatively low prices may impede the growth of low-carbon steel demand at the national level. The reduced cost of conventional steel is attributable to the absence of externality costs for the sector.

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[97]Setiadharmaji, W. (2024, July 4). *Strategi Dekarbonisasi dan Kebijakan CBAM Tantangan dan Peluang bagi Industri* [PowerPoint slides]. Indonesian Iron & Steel Industry Association (IISIA).
[98] Sukmak, P., Sukmak, G., De Silva, P., Horpibulsuk, S., Kassawat, S., & Suddeepong, A. (2023). “The potential of industrial waste: Electric arc furnace slag (EAF) as recycled road construction materials”. *Construction and Building Materials*, 368, 130393.
[99]Ministry of Energy and Mineral Resource Republic of Indonesia (2023). *Handbook of Energy & Economic Statistics of Indonesia 2023.*

Consequently, supportive measures are essential to promote the domestic market for low-carbon steel, including the implementation of carbon taxes and other carbon pricing strategies.

e. The Young Age of Steelmaking Capacity in Indonesia

Over 50% of steelmaking technology in Indonesia is under 20 years old, with approximately 40% of production capacity being around 11 years old[100]. On the other hand, the technological lifespan of BOF technology, which is predominant in Indonesia, can extend up to 60 years[101]. Studies investigating the potential for emission reductions in the steel industry indicates that conventional energy-efficiency strategies can only collectively mitigate approximately 25–40% of the average CO2 emissions per ton of crude steel produced.[102] [103] [104] [105] The decarbonization of the steel industry requires retrofitting of existing equipment or, in some cases, the complete reconstruction of facilities, which presents financial risk resulting from the mismatch in investment returns associated with Basic Oxygen Furnace (BOF) technology investment. In the short term, young, high-emission-intensive assets, such as BF-BOF, that have not yet completed their first investment cycle may not be able to undergo deep plant transformations.

5.2.3 Legal Challenges

Steel businesses are facing a range of complex legal and regulatory challenges as they strive to comply with the SIH and the CBAM. The specific legal issues faced by a company include:

a. Lack of Harmonization in Regulations

As it stands, Indonesia has multiple emission reporting frameworks under different ministries, each focusing on specific sectors.

The company must navigate a complex landscape of regulations from various ministries, each having its own specific requirements for environmental and social compliance. These requirements can overlap or contradict each other, creating a fragmented regulatory environment. For instance, the Ministry of Industry, the Ministry of Environment, and the Ministry of Trade have different standards and expectations. This fragmentation complicates the company's efforts to ensure comprehensive compliance, leading to potential legal risks if any regulatory aspect is overlooked or misunderstood. Gunung Raja Paksi, as an example, must allocate substantial resources to continuously monitor and adapt to these diverse regulatory demands to ensure that all operations align with the latest standards. This fragmentation creates difficulties in ensuring consistent and comprehensive compliance, leading to potential legal risks if any regulatory aspect is overlooked or misunderstood.

b. SIH Cannot Be Used for Exporting Goods

One of Gunung Raja Paksi's efforts to ensure the green quality of its products is carried out with the assistance of the Green Programme Council. Gunung Raja Paksi is a holder of green

[100] OECD (2024), "Steelmaking capacity by economy", *OECD Statistics on Measuring Globalisation (database)*, https://doi.org/10.1787/2ae1e9c7-en (accessed on 5 July 2024).
[101] OECD (2023), The Heterogeneity of Steel Decarbonisation Pathways, https://www.oecd.org/publications/the-heterogeneity-of-steel-decarbonisation-pathways-fab00709-en.htm (accessed on 18 July 2024).
[102] Li, Y and Zhu, L (2014). "Cost of energy saving and CO2 emissions reduction in China's iron and steel sector". *Applied Energy*, 130, 603-616.
[103] Morrow III, W. R., Hasanbeigi, A., Sathaye, J., & Xu, T. (2014). "Assessment of energy efficiency improvement and CO2 emission reduction potentials in India's cement and iron & steel industries". *Journal of Cleaner Production*, 65, 131-141.

from BWCI and IPD, among others, for publishing environmental products. IPD is a certificate used as a mandatory requirement for exporting goods. This IPD certificate is not just a single certificate, but can be a number of certificates that include Structural Steel Shapes, among others. Certification for export commodities cannot be achieved by holding only one type of certification; it must meet the standards of the export destination region or country itself. This problem arises because the criteria or standards applied in one country differ from those in other countries. To date, there has been no single certification that is universally able to cover all the required standards.

c. Ecosystem for Green Products Not Yet Established

SIH in Indonesia is currently voluntary, meaning companies that incorporate SIH into their production processes do so based on their goodwill and awareness. The government has not yet made SIH mandatory due to concerns that Indonesian industries may not be able to meet the green criteria of SIH. Making SIH mandatory could potentially burden the the country's industry. In other word, companies are not legally obligated to reduce their business emissions, and there are no sanctions for not implementing SIH.

Managing and controlling emissions from the supply chain presents significant legal challenges for Gunung Raja Paksi. The company must account for emissions from various sources, such as raw materials and electricity used in production, which can vary significantly depending on the region. For example, electricity in Indonesia has higher carbon intensity compared to the US, impacting overall emissions calculations and compliance with CBAM requirements. Ensuring accurate tracking and reporting of Scope 3 emissions, which include all indirect emissions that occur in the supply chain, involves significant legal and administrative efforts. Gunung Raja Paksi must establish robust systems to monitor these emissions and ensure that suppliers and partners align with its sustainability goals. This necessitates legal contracts and compliance monitoring throughout the supply chain to avoid potential legal risks and ensure adherence to international environmental standards.

d. No Incentives for Companies to Implement SIH

The financial implications of decarbonization are substantial, requiring significant investment. Gunung Raja Paksi points out the need for clear fiscal support and incentives to facilitate the transition to greener practices. The absence of such support could hinder their ability to comply with new regulations and maintain competitiveness. Legal challenges include negotiating and securing these incentives and ensuring that they are structured in a way that supports long-term sustainability goals. Additionally, the company advocates for a structured approach to fiscal policies that provide both incentives for compliance and penalties for non-compliance. This balanced approach is crucial to drive industry-wide adherence to sustainability standards and ensure a level playing field. For instance, the company has secured a sustainability loan from BNI, but the scale of investment needed for comprehensive decarbonization is substantial, requiring continuous support from fiscal policies.

However, other than awarding certificates to companies which have fully complied with SIH, the government has not yet released any other policies for fiscal or non-fiscal incentives, which adds uncertainty and poses a significant challenge for companies like Gunung Raja Paksi. The lack of clear governmental guidance and support can delay the necessary investments and initiatives required for effective decarbonization. To mitigate these challenges, it is imperative for the government to establish comprehensive and coherent fiscal and non-fiscal policies.

These policies should be designed not only to encourage but also mandate sustainable practices, thereby ensuring that companies have both the resources and the imperative to transition towards greener operations.

To complement its direct emission reduction efforts, GRP invests in carbon offset projects and purchases carbon credits. These initiatives help to balance out the remaining emissions that cannot be eliminated through technology and process improvements alone. By investing in projects, such as reforestation, renewable energy, and sustainable development, GRP can offset its carbon footprint and contribute to global environmental sustainability. Through these comprehensive strategies, GRP also willingly collaborates with multiple stakeholders to achieve mutual carbon emission reduction, as shown in Figure 5-2.

Krakatau POSCO has successfully reduced emissions below the global steel production route standard with various efficiency and renewable energy initiatives, which can be seen in Figure 5-4. Efficiency improvements have focused largely on minimizing steam leaks, and office buildings have seen the introduction of energy conservation guidelines relating to building lights and air conditioners. Meanwhile, natural gas has replaced LPG, and the rolling mill's reheating furnace and other facilities have gone through fuel optimization as well. The installation of solar panels at the hot rolling plant office further contributes to improving efficiency, along with the reutilization of gas and heat waste by-products as an energy resource.

CHAPTER VI

CONCLUSION AND RECOMMENDATION

6.1 Conclusion

Indonesia's steel production has grown by 20.5% annually since 2013, making it the 14th largest global producer despite accounting for just 0.89% of world output. Steel demand has also risen by 3.9% per year, outpacing the global average. Exports have increased by 21.82% annually since 2015, placing Indonesia 15th among global steel exporters in 2023, with China and the EU as key markets. Though Indonesia's EU market share remains small at 3%, exports to the EU have grown significantly, highlighting future opportunities in this market.

As Indonesia strengthens its position in the global steel market, recent policies, particularly the EU's CBAM, pose both challenges and opportunities for its economy, trade balance, and sustainability efforts. CBAM may lead to a slight decline in economic growth of 0.00013% to 0.0003% and could reduce Indonesia's trade balance by USD 29.56 million to USD 66.49 million. Furthermore, the steel export sector may see a decrease in export value of USD 6.67 million to USD15.01 million as CBAM tariffs increase.

In terms of emissions, the iron and steel industry is the third largest source of industrial emissions in Indonesia, making up to 17% of the total industrial emissions. Historically, the mainstay of steel production in Indonesia has been based on the Blast Furnace – Basic Oxygen Furnace (BF-BOF) pathway, thus resulting in a large carbon footprint due to the use of carbon coke for the iron ore reduction process. Significant emission reductions could be achieved with technology shifting, from the BF-BOF method to the DRI-EAF, with the utilization of green hydrogen and optimization usage of scrap steel in the renewables-powered EAF, which can potentially reach up to 100% with these technological advantages. It is important to consider that existing BF-BOF steel plants may still have a considerable operational lifetime. Therefore, short and intermediate term measures involving currently operating BF-BOF plants can also contribute to decarbonization. Among these measures include electrification of processes, followed by the use of renewable energy to power these processes, which would in turn accelerate RE power demand. Another alternative is to introduce the injection of reduction gas via the tuyere or directly into the shaft of the blast furnace to reduce coke consumption and its resulting CO_2 emissions.

As Indonesia advances steel industry decarbonization and CBAM implementation, challenges arise from differing emissions calculation methods. Indonesia uses the IPCC 2006 approach, which may overestimate emissions by including those generated outside the immediate production system, while CBAM uses more segmented calculations. This discrepancy complicates the alignment between Indonesian regulations and CBAM standards.

Indonesia's renewable energy regulatory framework faces implementation challenges due to the government's focus on energy security and price stability over environmental sustainability, as highlighted in Article 12 of the PP KEN. This approach reflects an energy trilemma in which energy security is prioritized, often at the expense of energy equity and sustainability, to the detriment of communities and ecosystems. In addition, the carbon tax, which is linked to the fluctuating domestic market and has a minimum rate of IDR 30/kg CO_2e, lacks stability, making it less effective. While the current carbon price in Indonesia is low compared to the EU ETS, this raises concerns about the tax's ability to drive emissions reductions and spur investment in green technologies.

Indonesia has introduced the Green Industry Standard (SIH) to promote sustainable industrial practices in 17 sectors, providing guidelines on raw materials, energy use, production processes and waste management. While adoption of the SIH is voluntary, the government plans to make it mandatory for key sectors in the future to enhance environmental sustainability and global competitiveness. However, a critical analysis of the EU's Carbon Border Adjustment Mechanism (CBAM) shows that it does not recognize SIH certifications for carbon emission calculations. This oversight means that Indonesian exporters who comply with SIH standards may struggle to meet the stringent requirements of the CBAM, potentially putting them at a disadvantage in the EU market despite their efforts to adhere to sustainability practices.

6.2 Recommendation for Goverment

6.2.1 Technical Recommendation

1. Encourage the Electrification

By transitioning from fossil fuel-reliant processes, such as the BF-BOF route, to the electric-powered method, like EAF and the heating process for rolling, the industry can significantly reduce its carbon footprint, especially when powered by renewable sources. The technological shift would come with a high initial cost, so providing further incentives could encourage the companies to invest in energy-efficient machinery and technologies that optimize resource use while lowering emissions.

2. The Importance of Energy Usage Report

By reporting the detailed usage of energy in the industry, the clarity of energy consumption in the production process will be more accurate. The reports issued by the industries can be utilized for informing future improvements, indicating which approaches will be the most beneficial for the reporting industry, whether by improving energy efficiency, material efficiency, fuel efficiency, or transitioning to new technologies.

6.2.2 Economic Recommendation

1. Providing Incentives for The Industry

Decarbonization entails significant costs, which may not always align with short-term business interests. To encourage more industries to reduce greenhouse gas (GHG) emissions and adopt green technologies, effective incentive policies are essential. These incentives may include tax reductions, subsidies for environmentally friendly technologies, or access to green financing. With sufficient incentives in place, enterprises are more likely to be motivated to actively participate in the energy transition efforts.

2. Police Response to Protectionism

With the implementation of the CBAM in the EU, there is potential for export shifts toward countries with less stringent carbon regulations, such as Indonesia. This shift could expose Indonesia's domestic market to an influx of cheaper imported steel. Therefore, policy measures are needed to limit steel imports to protect the domestic steel industry and stabilize the local market.

6.2.3 Legal Recommendation

1. Estabilishment of A National Emissions Inventory and Reporting System

Indonesia has several emissions reporting frameworks under different ministries, each focusing on specific sectors. These disparate frameworks must be integrated into a unified national system to align with international mechanisms such as CBAM, thereby streamlining the reporting process. This alignment would involve creating a centralized system for calculating, reporting, and verifying carbon emissions as well as a registry consolidating data from all relevant ministries and sectors. Such a system would facilitate standardized data collection methods, improve accuracy, and allow real-time data sharing between ministries and companies. Maintaining detailed records of emissions data and related documentation is also necessary to support compliance, as these may be subject to regulatory requirements.

By integrating all existing frameworks into a national system, Indonesia can enhance its ability to meet international reporting standards, improve data consistency across sectors, and provide a more comprehensive view of the country's emissions profile. This unified approach would also facilitate more effective policymaking and help Indonesia better track its progress towards its climate commitments, including its Nationally Determined Contributions (NDCs) under the Paris Agreement.

2. Optimization of Carbon Pricing and Carbon Tax

Despite plans to introduce a carbon tax, Indonesia has not yet implemented this policy broadly, as implementation is still limited to coal-fired power plants (PLTU). This delay hinders the country's ability to internalize the environmental costs of carbon emissions and align with global carbon pricing trends.

The government must extend the cap-and-trade and carbon tax policies to the industrial sector. By broadening the scope of the carbon tax, Indonesia can better align with international carbon pricing mechanisms, such as the EU's CBAM. This alignment can help Indonesian steel exporters mitigate potential trade barriers and increase their competitiveness in the European market.

Extending the carbon tax to the industrial sector also addresses challenges in implementing the economic value of carbon in Indonesia, such as the suboptimal application of carbon pricing mechanisms and the significant disparity between Indonesia's and the EU's carbon prices.

6.3 Recommendation for Industries

In this study, recommendations for the steel industry are formulated as guidelines, which are an integral part of this report. These guidelines will address various transition options available to the industry, options which have been structured to align with the specific conditions of the steel industry in Indonesia.

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