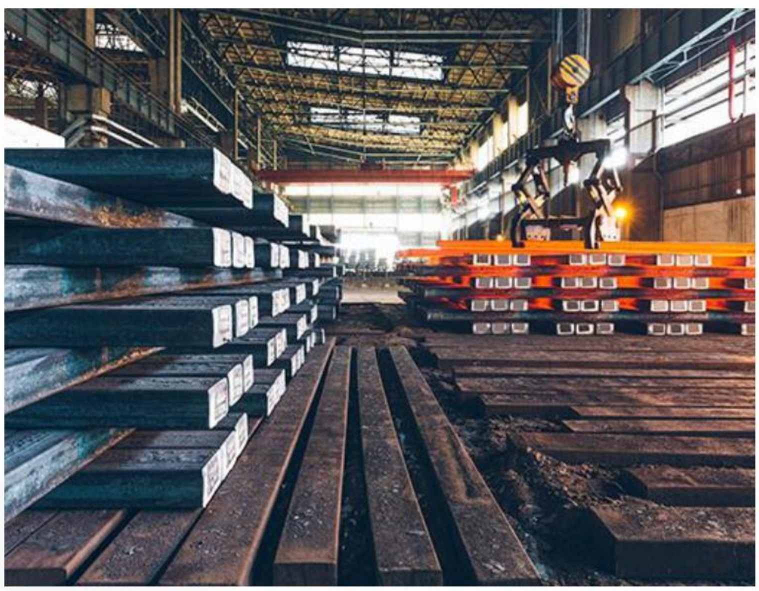
FINAL REPORT

Resource Efficiency Scoping Assessment in the Iron and Steel sector in Indonesia
A Guide to Implementing Low Carbon Initiative



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NOTICE

Preface

The report "Identification of Resource Efficiency Opportunities in the Iron and Steel Industry in Indonesia: Findings and Recommendations" has been produced with the initiative and support of the United Nations Industrial Development Organization (UNIDO) within the framework of the Partnership for Action on Green Economy (PAGE).

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List of Abbreviations

BAPPENAS	National Development Planning Agency
BAU	Business As Usual
BJLAS	Aluminium-Zinc Coated Steel
BJLS	Zinc Coated Steel
BNI	Bank Negara Indonesia
BOF	Blast Oxygen Furnace
BP	Beam Plant
BPC	Better Process Control
CAGR	Compound Annual Growth Rate
CBAM	Carbon Border Adjustment Mechanism
CCUS	Carbon capture, utilisation, and storage
CEMS	Continuous Emissions Monitoring System
EAF	Electric Arc Furnace
EBT	Electronic Benefit Transfer
EM	Equipment Modification
EV	Electric Vehicles
FGD	Focus Group Discussion
FOLU	Forestry and Other Land Use
GDST	PT Gunawan Dianjaya Steel
GITA	Green Industry and Trade Assessment
GHG	Greenhouse Gas
GRP	PT Gunung Raja Paksi
HBI	Hot Briquetted Iron
ICPC	Indonesia Cleaner Production Centre
IISIA	Iron and Steel Industry Association

ILO	International Labour Organization
IMC	Input Material Change
IPPU	Industrial Processes and Product Use
KS	PT Krakatau Steel
LCA	Life Cycle Assessment
LCDI	Low Carbon Development Initiative
NGO	Long Section Mill
MSM	Medium Section Mill
NBS	Nature Based Solution
NDC	Nationally Determined Contribution
PAGE	Partnership for Action on Green Economy
PAHs	Polycyclic Aromatic Hydrocarbons
GDP	Gross Domestic Product
RECP	Resource efficiency and cleaner production
SDGs	Sustainable Development Goals
SEC	Specific energy consumption
SPINDO	PT Steel Pipe Industry of Indonesia
SR	Sustainability report
SWC	Specific water consumption
TC	Technology Change
TML	PT Tata Metal Lestari
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNIDO	United Nations Industrial Development Organization
UNITAR	United Nations Institute for Training and Research

Executive Summary

The Indonesian government recognizes the importance of iron and steel in national development and has implemented various policies and initiatives to encourage iron and steel production in an effective and sustainable manner. This includes education for iron and steel industry players to apply sustainable principles that support the achievement of decarbonization through the use of renewable energy, resource efficiency in the production process, as well as optimizing the handling of waste generated.

This study finds that the implementation of resource efficiency measures may involve the use of advanced technologies to maximize the efficiency of the iron and steel production process. This includes optimizing energy consumption, reducing water use, and minimizing raw material use. With these measures, the industry can reduce its ecological footprint and contribute to a more sustainable and responsible approach to iron and steel production.

The study found that the application of resource efficiency techniques in the iron and steel industry can boost competitiveness, reduce environmental footprint, and help the government meet climate targets. The study also found that some companies have advanced in the application of resource efficiency while others are still lagging behind.

Therefore, resource efficiency and cleaner production (RECP) integrated with a life cycle perspective towards low carbon development should be the focus of the future sustainability of the iron and steel industry in Indonesia.

Introduction

To better understand the environmental performance and resource efficiency potential in Indonesia, particularly in the iron and steel industry, the United Nations Industrial Development Organization (UNIDO) under the Partnership for Action on Green Economy (PAGE) together with the Indonesian ministries and BAPPENAS (Ministry of National Development Planning) commissioned the Indonesia Cleaner Production Centre (ICPC) to conduct a study. The study aimed to identify the potential and opportunities for resource efficiency for the iron and steel industry in Indonesia. The potential benefits of such resource efficiency strategies are documented through pilot projects in the iron and steel industry.

The initial plan focuses on energy efficiency to enable a deep dive into maximizing the potential for improved energy performance in the construction and associated sectors.

To select the two pilot industries, a two-stage selection process was conducted:

1. Resource Efficiency Questionnaire Survey

   A survey was conducted among members of the Indonesian Iron and Steel Industry Association (IISIA). Out of 193 companies registered as members of IISIA, nine iron and steel companies in Indonesia responded to the survey. Five companies expressed interest in the RECP study from this stage, 5 companies were selected, namely: PT Jatim Taman Steel Manufacturing, PT Krakatau Posco, PT Gunung Raja Paksi Tbk (GRP), PT Tata Metal Lestari (TML), and PT Sunrise Steel.

2. Detailed Questionnaire Based on RECP Industry Selection Criteria

   A more detailed questionnaire was used to select 2 pilot plants for resource efficiency demonstration and one plant was used as supporting data reference, namely: PT Gunung Raja Paksi (GRP) and PT Tata Metal Lestari (TML).

Apart from the two companies willing to serve as pilot industries, this RECP study also draws data from the Sustainability Reports published by each of the iron and steel industries in Indonesia. The companies studied based on the data disclosed through the Sustainability Report are: PT Krakatau Steel (KS), PT Gunawan Dianjaya Steel (GDST), and PT Steel Pipe Industry of Indonesia (SPINDO).

The resource efficiency assessment at the pilot plant was conducted based on four aspects:

1. Specific energy consumption (SEC), in GJ (gigajoule) /tonne of product
2. Specific greenhouse gas emissions, in kg CO_2 eq./ton of product
3. Specific water consumption, in m^3/tonne of product
4. Percentage of wastewater recycled, %.

Resource Efficiency and Cleaner Production (RECP) Profile of Iron and Steel Companies

The RECP profile of each iron and steel company varies according to the scale of operations, the type and classification of iron or steel products they manufacture, and the technological processes and equipment they use. The consumption of other resources in the iron and steel industry, such as water and energy, also varies greatly across companies. The types of iron and steel industries participating in the study are classified into two: intermediate and downstream industries.

Range of Specific Energy Consumption (SEC) and Energy Efficiency

In this analysis, the Energy Performance Indicators of each iron and steel industry are compared with the baseline period (in this case 2020). Energy consumption includes energy sources used as fuels that are equivalized to energy. Specific energy consumption is calculated using GJ per tonne of iron and steel.

a. Intermediate Industry

Based on Figure 1, it can be seen that the industry-specific energy consumption between GRP, GDST, and KS in 2020 to 2022 ranges from 2.56 to 4.07 GJ/tonne, with an average SEC value of 3.10 GJ/tonne of product for each year. Electricity units are in kilowatts per hour. To calculate the specific energy consumption, the electricity units are converted to GJ by following the conversion ratio of 0.0036 GJ/kWh.

SEC Range of Intermediate Industries in 2020-2022 = 2.56 - 4.07 GJ/tonne of product

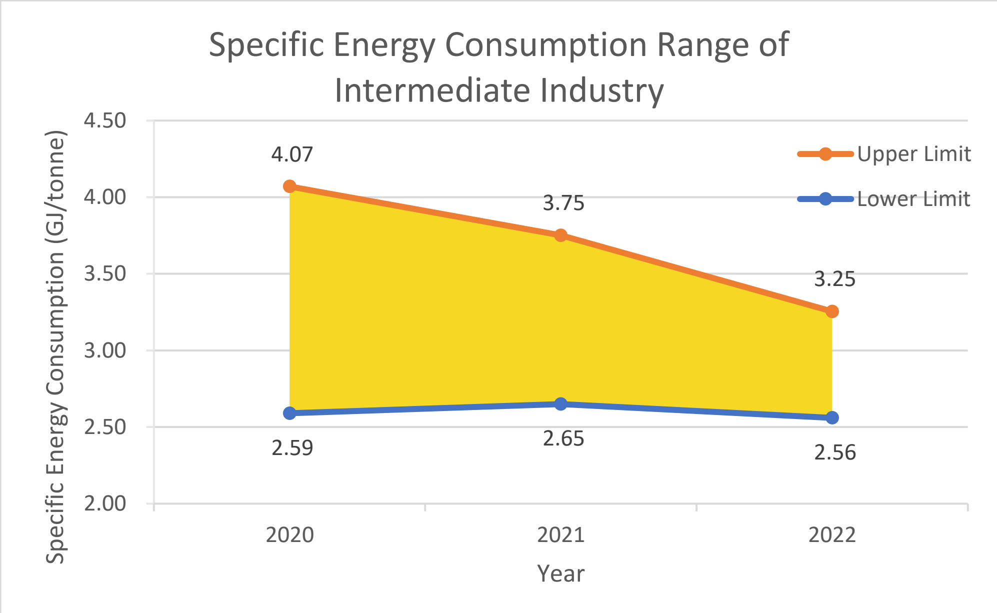

Figure 1 Range of Specific Energy Consumption and Efficiency of Intermediate Industry RECP Pilot Units

Source: RECP Pilot Unit Profile of Intermediate Industry, 2023

The percentage increase in energy efficiency of the three intermediate industrial pilot units in 2022, based on 2020 specific energy consumption data, has a range of 26%. The lowest value is -6%, while the highest value is 20%. One of the iron and steel industries experienced a 6% decrease in energy efficiency, while the other industry showed a positive increase. Overall, the average improvement in energy efficiency is 7%.

This shows that on average, the intermediate industries in 2022 experienced an increase in the percentage of energy efficiency, although one of the industries had a negative increase value or a decrease in energy efficiency. This conclusion is supported by the actual energy consumption data of the industries in 2022, which is generally lower than the projections based on the SEC in 2020. Two industries showed lower actual energy consumption than projected, while one industry showed higher consumption. The complete data can be seen in Table 6, Table 16, and Table 20.

b. Downstream Industry

The analysis can only be made for 2021 and 2022 because PT SPINDO's Sustainability Report data is only available for 2021 and 2022. Based on Figure 2, it can be seen that the specific energy consumption of the downstream industry, which includes TML and SPINDO from 2021 to 2022, is in the range of 1.37 to 20.27 GJ/ton, with an average SEC value of 6.95 GJ/ton of product for each year. The unit of electricity used is kilowatt per hour. To calculate the specific energy consumption, the electricity unit is converted to GJ by following the conversion ratio of 0.0036 GJ/kWh.

Notes: It should be noted that there is an anomaly in the value of iron and steel production in PT SPINDO's Sustainability Report, so the values included in this analysis still need to be validated.

Downstream Industry SEC range in 2021-2022 = 1.37 - 20.27 GJ/tonne of product

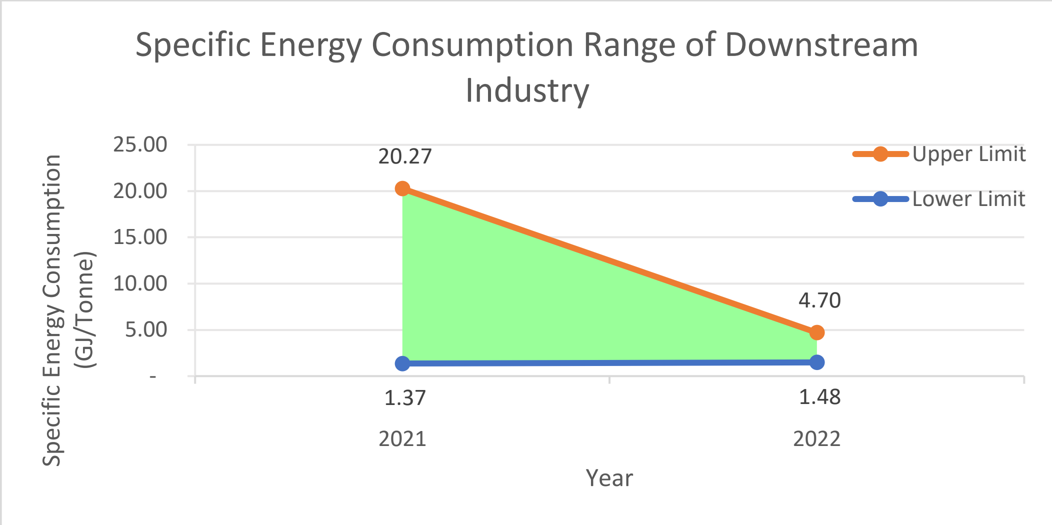

Figure 2 Range of Specific Energy Consumption and Efficiency of Downstream Industry RECP Pilot Units

Source: RECP Pilot Unit Profile of Downstream Industry, 2023

The percentage increase in energy efficiency of the two downstream industrial pilot units in 2022, based on the 2021 specific energy consumption data, has a range of 86%. The lowest value is -9%, the highest value is 77%, and the average increase is 34%. This shows that in general, the downstream industry in 2022 experienced an increase in the percentage of energy efficiency, which can be seen from the actual energy consumption data is smaller than the projected energy consumption data in 2022 with the SEC base in 2021.

The RECP study identified the energy efficiency measures that have been implemented in these units through measures such as:

- Better Process Control (BPC);
- Technology Change (TC); and
- Equipment Modification (EM).

Range of Specific CO_2e Emissions

Specific CO_2e emissions are total emissions divided by total iron and steel production. Specific details of scope 3[1] emissions are not included in the calculation of specific CO_2 e emissions. The calculation of specific CO_2 e emissions is limited to the inventory of scope 1 greenhouse gas emissions from fuel combustion and scope 2 from the use of electrical energy for production.

The method for calculating CO_2 reductions is based on absolute CO_2 reductions from CO_2 use and is not based on calculating projected reductions using a baseline. There are several different approaches used to identify the baseline of CO_2 reductions. Some of these methods include:

[1] Scope 3 emissions: There are three scopes for calculating greenhouse gas emissions under the Greenhouse Gas Protocol. Scope 3 covers all other indirect emissions that occur in an organization's upstream and downstream activities.

1. Historical data: This approach uses data from previous years to establish a baseline of current and future CO_2 emissions. This can be useful for identifying trends and patterns over time.
2. Industry average: This approach compares an organization's emissions to the industry average to establish a benchmark for CO_2 reduction.
3. Best practice: This approach looks at best practices and emissions levels from industry-leading organizations to set benchmarks for CO_2 reduction.
4. Business-as-usual scenario: This approach projects future emissions based on the assumption that an organization will continue its current practices, without changing anything to improve energy efficiency or reduce emissions.
5. Regulatory standards: This approach uses legal or regulatory standards as the basis for calculating CO_2 emissions and reductions.
6. Absolute emissions: This approach sets a benchmark based on a company's total absolute emissions.

a. Intermediate Industry

Figure 3 shows the specific CO_2e emissions found in the intermediate industries covering GRP, GDST, and KS in 2020 to 2022 are in the value range of 0.11 - 0.37 Tonnes CO_2e/tonne of product.

Range of GHG Emission Intensity of Intermediate Industry in 2020-2022 = 0.11-0.37 Tonnes CO_2 e/tonne of product

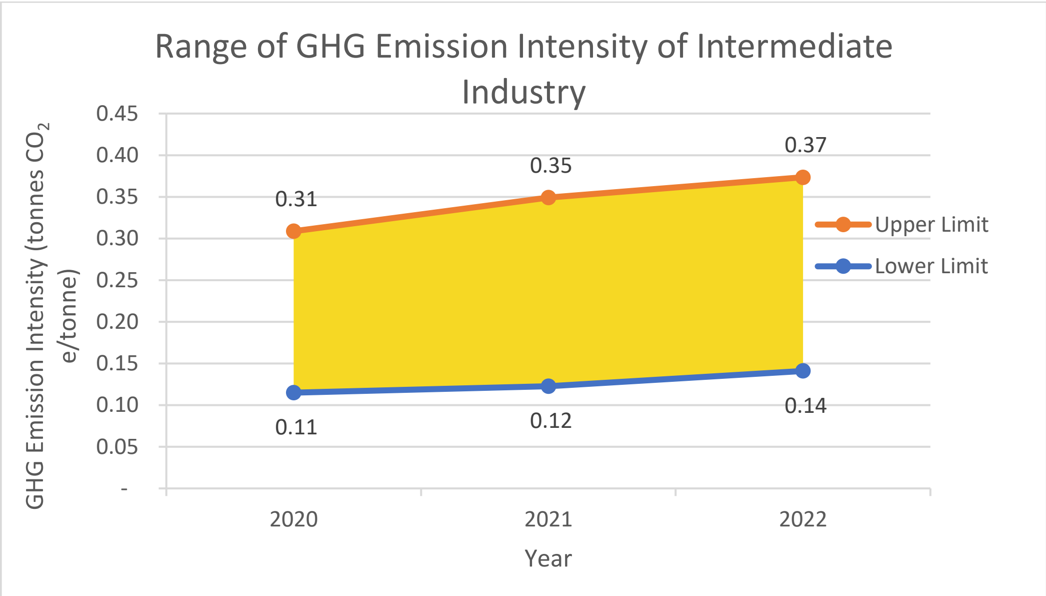

Figure 3 Range of GHG Emission Intensity of Intermediate Industry RECP Pilot Units

Source: RECP Pilot Unit Profile of Intermediate Industry, 2023

Specific CO_2e emissions in intermediate industry in 2020 - 2022 have increased every year. This is an indication that various strategies need to be implemented to achieve production efficiency.

b. Downstream Industry

In the corporate sustainability report of SPINDO, which is included in the downstream industry but is not a pilot industry, there is no CO_2 emissions data. Therefore, it is not possible to compare data for the analysis of CO_2 emissions in this downstream industry. This is because TML is the only industry in the downstream steel industry category that provides such data.

The RECP study identified the water efficiency measures that have been implemented in these units through measures such as:

- Better Process Control (BPC);
- Input Material Change (IMC); and
- Equipment Modification (EM).

SWC Range or Specific Water Consumption (SWC) and Water Efficiency

Water in the iron and steel industry is used for cleaning and cooling processes. Specific Water Consumption (SWC) is used as a water performance indicator to evaluate or measure water efficiency, where SWC is defined as the ratio of cubic meters (m^3) of water consumed to the unit weight of product produced by this water consumption, expressed in cubic meters per tonne (m^3/tonne). SWC is calculated as the ratio of water used to produce a product.

a. Intermediate Industry

Figure 4 shows the SWC in the intermediate industry covering GRP, GDST, and KS in 2020 to 2022 is in the value range of 0.60 - 2.98 m^3 /ton, with an average SWC value of 1.45 m^3 /ton of product for each year.

SWC Range of the Intermediate Industry in 2020-2022 = 0.60 - 2.98 m^3 /tonne of product

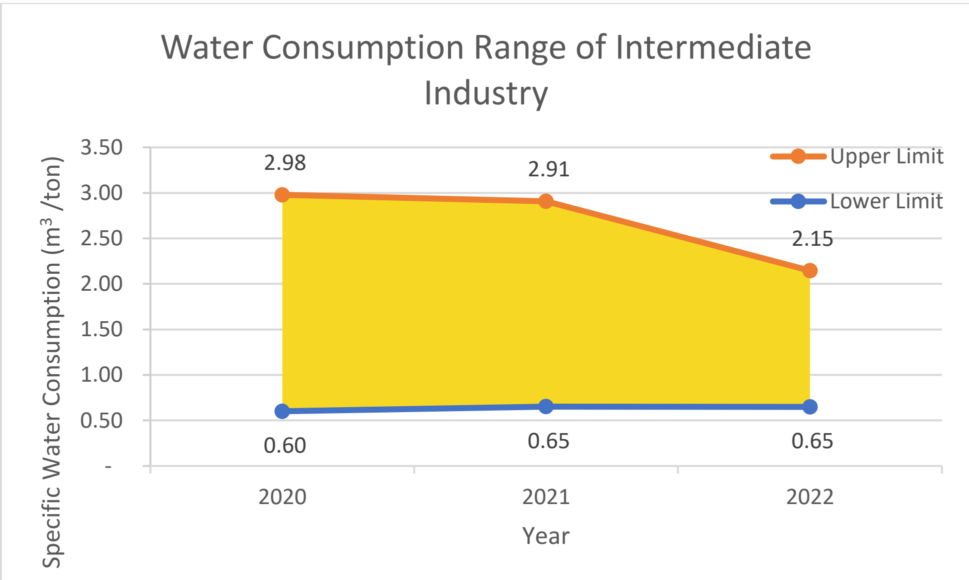

Figure 4 Specific Water Consumption Range of Intermediate Industry RECP Pilot Unit

Source: RECP Pilot Unit Profile of Intermediate Industry, 2023

From the graph, it can be seen that the range of SWC values of the intermediate industry from 2020 - 2022 is getting smaller. Therefore, the intermediary industry should continue to improve strategies to increase water use efficiency.

b. Downstream Industry

The downstream industries in this study include PT Tata Metal Lestari (TML) and PT Steel Pipe Industry of Indonesia (SPINDO). Based on the calculation of the basic data of the two downstream industries from 2021 to 2022, the SWC of the downstream industry is in the value range of 0.16 to 0.73 m^3 /ton, with an average SWC value of 0.47 m^3 /ton of product for each year.

Downstream Industry SWC Range in 2021-2022 = 0.16 - 0.73 m^3/tonne of product

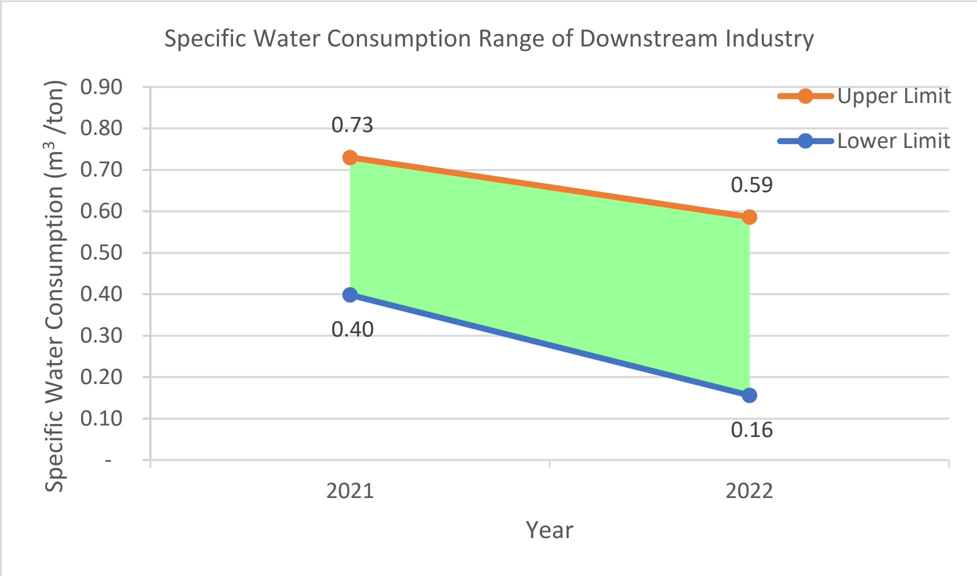

Figure 5 Range of Specific Water Consumption of Downstream Industry RECP Pilot Units

Source: RECP Pilot Unit Profile of Downstream industry, 2023

From the graph, it can be seen that the range of downstream industry SWC values from 2021 - 2022 has decreased significantly.

The RECP study identified the water efficiency measures that have been implemented in these units through measures such as:

- Better Process Control (BPC);
- Input Material Change (IMC); and
- Equipment Modification (EM).

Conclusions and Recommendations

The iron and steel industry in Indonesia had limited participation in this RECP study, with only two industries, PT Gunung Raja Paksi and PT Tata Metal Lestari, actively involved. Information from other companies was partially sourced from their published corporate sustainability reports.

Table 1 Recapitulation of Pilot Unit RECP Profile

Item	Intermediate Industry			Downstream Industry	
	Pilot Unit	SR data		Pilot Unit	SR data
	GRP	GDST	KS	TML	SPINDO*
Specific Energy Consumption (GJ/tonne)	3,13	2,56	3,25	1,48	4,70
Specific Water Consumption (**m^3** /ton)	0,95	0,65	2,15	0,59	0,16
Specific Rainwater Utilisation (**m^3** /ton)	-	-	-	0,04	-
Specific CO_2 emissions (t-CO_2 e/ton)	0,37	0,14	0,286	0,19	-

* Notes: There are anomalous values for iron and steel production in PT SPINDO's Sustainability Report, so the values included in this analysis still need to be validated. CO_2 emissions are also unknown because the substance of CO_2 was not measured in the stack and flue gas emissions measurement.

Several iron and steel companies in Indonesia have created action plans to achieve zero carbon emissions, demonstrating a commitment to sustainability initiatives. Efforts that have been made by the iron and steel industry include installing solar renewable energy technology, recycling wastewater and utilizing rainwater to maximize energy and water efficiency in the production process.

Challenges in Achieving Zero Carbon Emissions in Pilot Units

In achieving zero carbon emissions, the iron and steel industry also experiences various obstacles. Based on the results of discussions during the field visit, several obstacles faced by the pilot unit that led to low environmental performance improvement were identified, including:

a. Lack of infrastructure and availability of raw materials for iron/steel recycling (scrap).
b. Large technology investment
c. Limited land for installation of renewable energy sources
d. Consideration of product quality and technical customization

Since the replacement of industrial technology requires large investments, companies must allocate the necessary time and funds for research and analysis to select the right technology investment, so the transformation of the iron and steel industry to low carbon technology cannot be achieved in the short run.

Despite the challenges, three out of five pilot companies in the iron and steel industry have achieved efficiencies in energy and water use.

- The intermediate industry pilot resulted in savings in energy efficiency at a cost of $31,791,404 and savings in water efficiency at a cost of $2,958,545.
- The downstream industry pilot resulted in savings in energy efficiency at a cost of $925,410,747 and savings in water efficiency at a cost of $1,665,506.

However, only one in five companies managed to obtain cost savings for the economic value of carbon. The savings generated are also still relatively minimal when compared to the other three variables. This shows that the iron and steel industry in Indonesia still faces major challenges in reducing greenhouse gas emissions.

Following a series of studies, a number of recommendations have been developed to support the company's commitment to improve efficiency and reduce operational emissions. These recommendations include:

a. Environmental Management Recommendations

- Utilizing scrap materials to reduce the need for raw materials will lead to a more environmentally friendly and efficient production process, and contribute to the circular economy principle where waste reduction is prioritized;
- Improving environmental sustainability and energy efficiency through the adoption of energy-saving or energy-recycling technologies, such as advanced furnaces and *waste heat* recovery systems to optimize combustion, thereby saving fossil fuel consumption;
- Utilize new and renewable energy (EBT) such as the use of energy-efficient lamps or LED lights and the installation of solar panels to reduce carbon emissions and reduce dependence on fossil fuels;
- Implement more efficient water treatment technologies and processes, such as water recycling systems, rainwater harvesting, and wastewater treatment, to optimize water use, reduce impact on water resources, and reduce operational costs;
- Installation of CEMS (Continuous Emissions Monitoring System) as an emission monitoring tool to monitor and record emission data continuously;
- Replace damaged or obsolete engines to reduce emissions;
- Conduct routine machine maintenance and calibrate equipment according to the specified period so as to minimize the intensity of emissions produced;
- Implement metering and sub-metering of energy, water and emissions use/discharge points to monitor and manage resource use more effectively and efficiently.

b. Policy Recommendations

- Develop government programmes that incentivize informal scrap collectors through subsidies, training, and access to health and social services;
- Implement regulations that recognize and integrate the informal sector into the formal waste management system, by providing legal status and protection;
- Encourage public-private partnerships where businesses in the iron and steel industry collaborate with scrap metal collectors, offering fair prices and stable demand;

- Implement a transparent and open digitalization of the scrap and steel market for all sectors, both formal and informal, to encourage the availability of scrap in the Indonesian local market;
- Offer training to informal scrap metal collectors on safe handling, sorting and processing of scrap materials to improve the quality of scrap metal collected;
- Educate on health and safety practices to minimize risks associated with handling potentially hazardous materials;
- Facilitate the establishment of community-based collection centers where informal collectors can sell their scrap directly to formal intermediaries or industry representatives;
- Invest in a local sorting and processing facility that can serve as a hub for the informal sector, equipped with equipment to improve the quality of used goods;
- Introduce microfinance programmes to provide informal waste collectors with the capital needed to invest in equipment, transport or personal protective equipment;
- Make small-scale and affordable recycling technologies accessible to the informal sector to improve the overall efficiency and quality of used materials;
- Recognize the role of the informal sector in the iron and steel industry supply chain and create mechanisms for stable supply and demand dynamics;
- Encourage formal contracts between businesses and informal sector representatives to provide stable income and formalize trade;
- Conduct an assessment to ensure that the collection and processing of scrap by the informal sector does not negatively impact the environment;
- Engage in community development initiatives that improve the living conditions of informal sector workers, which in turn improves their productivity and efficiency;
- Import Duty Waivers for Sustainable Practices;
- Assistance in Scope 3 GHG Calculation;
- Green Industry Standard (SIH) in stages;
- Incentives for green steel production;
- Green taxonomy for iron and steel;
- Data synchronization/data management across ministries;
- Assistance in implementing circular economy for iron and steel industry.

c. Management Recommendation

In implementing production processes in the iron and steel industry, some management recommendations that can improve resource efficiency (environmental and social) include;

- Implementation of energy management systems and audits
- Employee training and development related to environmental management
- Implementation of environmental management systems across the iron and steel industry
- Implementation of heat/steam recovery systems across the iron and steel industry
- Comprehensive and integrated data collection system.

d. Financial Recommendations

- Long-term technology replacement options require substantial funding, so a long-term corporate strategy is needed. Synergies are needed with financial institutions regarding sustainable funding mechanisms to accelerate the implementation of resource efficiency and cleaner production that can reduce significant greenhouse gas emissions in the iron and steel industry in Indonesia.
- The funding mechanism can be synergized with the roadmap for sustainable finance phase II (2021 - 2025) issued by OJK. Some examples of sustainable finance implementation include financing for new and renewable energy projects (financing electricity sourced from hydro, geothermal, solar energy, biogas, biomass, and other renewable energy sources, energy efficiency, etc.) - Green Taxonomy.

e. Life Cycle Assessment (LCA) Recommendations

The iron and steel industry can expand the boundary system from Gate-to-Gate to Cradle-to-Grave. For example:

- LCA provides a comprehensive analysis of the environmental impacts of iron and steel products throughout their life cycle, from raw material extraction to product disposal. This helps companies understand where the greatest environmental impacts occur and identify opportunities for improvement.
- By identifying the life cycle phases that generate the most carbon emissions, companies can design strategies to reduce these emissions, for example by optimizing production processes, using renewable energy or improving energy efficiency.
- Develop more sustainable products by considering eco-design, the use of more environmentally friendly raw materials, or more efficient production technologies.
- Improve efficiency in industry through appropriate production technology, efficient use of raw materials, and optimal waste management so that resources are used in accordance with production needs, at the right time and place to reduce waste and environmental impact.

I. Background.

Iron and Steel Industry in Indonesia

The iron and steel industry is an important part of the base metal industry that belongs to the upstream industry sector. As one of the strategic industries in Indonesia, this sector plays a role in supplying vital raw materials for the development of various fields. Starting from the provision of infrastructure such as buildings, roads, bridges, electricity and telecommunications networks, to the production of capital goods such as factory machinery and spare parts, transportation equipment such as ships, trains, and automotive, as well as weaponry (Ministry of Industry, 2014).

However, the iron and steel industry is also one of the major contributors to greenhouse gas (GHG) emissions in the world. Iron and steel production processes that use fossil fuels, such as coal, produce high carbon dioxide (CO_2) emissions, which contribute significantly to global climate change. Iron and steel production is highly energy intensive, and is therefore strongly associated with resource conservation, energy efficiency and emission reduction (Olmez et al., 2015). In addition, iron and steel production consumes large amounts of resources and generates large amounts of liquid, solid waste and greenhouse gas emissions (Melo, 2016).

The Importance of Decarbonisation

As a major contributor to greenhouse gas (GHG) emissions and a significant waste generator, decarbonization efforts are imperative. Decarbonization is the process of reducing carbon emissions through the implementation of cleaner and more efficient technologies and practices. The implementation of decarbonization in the sector is critical to help reduce GHG emissions, improve production efficiency, reduce operational costs, and improve competitiveness in the global market.

Resource Efficiency and Cleaner Production (RECP)

One approach that can support decarbonization in this sector is Resource Efficiency and Cleaner Production (RECP). RECP is an approach that aims to improve resource use efficiency and reduce environmental impacts in the production process. By implementing RECP, the iron and steel industry can adopt clean technologies, use more environmentally friendly raw materials, and improve efficiency. This not only minimizes environmental impacts, but also contributes to the establishment of a sustainable green economy and supports a circular economy by encouraging production practices that prioritize recycling, recovery and reuse of materials.

Benefits of RECP Implementation

Through the implementation of clean technologies and efficient production practices, the iron and steel industry can reduce its carbon footprint and contribute to a greener and more sustainable future. The RECP study in the iron and steel industry sector was conducted to support the Ministry of National Development Planning/BAPPENAS in implementing low-carbon development policies and green economy in the context of industry. This activity focuses on energy efficiency to improve the energy performance of the iron and steel sector and analyze the greenhouse gas emission profile.

PAGE and GITA Framework

Under the PAGE framework, UNIDO developed the Green Industry and Trade Assessment (GITA) report in 2019 to strengthen the implementation of the low carbon development initiative (LCDI). The report measures the environmental performance of industry in terms of air and water pollution, industrial waste, resource efficiency (energy, water, and materials), and the application of clean technologies in industrial production. GITA found that industry is the largest energy consumer in Indonesia. GITA's case studies in the cement, fertilizer, pulp and paper, and food and beverage sectors recommend resource efficiency demonstrations to identify potential cost savings by introducing resource efficiency measures.

Based on the framework and studies that have been conducted, the implementation of RECP in the iron and steel industry is a key strategy to achieve environmental sustainability while maintaining economic growth. By identifying and implementing more efficient and environmentally friendly processes, the iron and steel industry can meet emission reduction targets, improve resource efficiency, and contribute to a more sustainable green economy.

1.1 Purpose of the Study

This project aims to:

1. Assess the scope of resource efficiency in the iron and steel sector and identify opportunities for RECP implementation.
2. Determine strategies to reduce emissions from industrial production.
3. Improve economic competitiveness.
4. Develop resource efficiency guidelines for implementing Low Carbon Development Initiatives (LCDI).

By adopting the RECP approach, it is expected that the iron and steel industry in Indonesia can more efficiently use resources, reduce carbon emissions, and improve overall environmental performance. This will support broader low-carbon development initiatives and promote sustainable economic growth.

II. Resource Efficient and Cleaner Production (RECP)

Resource Efficiency and Cleaner Production (RECP) was introduced in 2009 by the United Nations Industrial Development Organization (UNIDO) and the United Nations Environment Programme (UNEP). RECP is an umbrella term that combines various practices that have proven effective in the past and show good synergies, including Cleaner Production, Environmental Efficiency, Waste Minimization, Green Productivity, Pollution Prevention, and Reduced Use of Hazardous and Toxic Substances.

RECP is closely related to sustainable consumption and production, green industry, sustainable tourism development, industrial energy efficiency, innovation and competitiveness. These goals are aligned with the Sustainable Development Goals (SDGs) 2030, particularly SDG 12 (Ensure sustainable consumption and production patterns), SDG 9 (Build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation), and SDG 8 (Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all).

The sustainable processes applied in the RECP aim to improve the efficiency of natural resource utilization (including materials, water and energy). This increased efficiency enables more productive utilization of natural resources, reducing waste and air emissions. In addition, this approach is expected to contribute to improving the quality of occupational health and safety in the industrial environment, including workers, consumers, and local communities. RECP objectives can be achieved through:

1. **Resource Efficiency:** Optimizing the use of raw materials, water and energy to maximize productivity and reduce production costs.
2. **Pollution Prevention:** Reducing or eliminating hazardous waste and emissions at source through changes in production processes, use of alternative raw materials, and cleaner technologies.
3. **Green Productivity:** Improving a company's environmental performance while maintaining or increasing productivity and competitiveness.

By implementing RECP, companies can achieve economic benefits through reduced operational costs and improved efficiency, while fulfilling their environmental and social responsibilities.

Figure 6 Resource Efficient & Cleaner Production (Source: UNIDO RECP Programme)

Since 2015, UNIDO together with the Ministry of Environment and Forestry implemented the RECP Programme in Indonesia, and based on the results of the implementation of RECP activities in pilot factories, several benefits of RECP implementation were identified as follows[2] :

- Improve resource efficiency
- Reduced environmental footprint
- Improve Company branding
- Increase awareness of the work environment and Occupational Health and Safety (OHS)
- Better understanding of production processes and waste
- Increased capacity to manage and minimize resource consumption, waste and pollution

In the RECP methodology, there are eight key practices that can be applied to improve resource efficiency, increase competitiveness in the global market, and reduce environmental impacts. The following is an explanation of each practice according to the figure provided:

1. **Good Housekeeping:** Simple practices that involve no-cost or low-cost actions, such as creating and implementing Standard Operating Procedures (SOPs), switching off equipment when not in use, keeping work areas clean, and ensuring regular maintenance.
2. **Input Material Change:** Changes in input materials to reduce environmental impact. Examples include converting fossil fuels into renewable energy, replacing hazardous chemicals with safer alternatives, and using more efficient raw materials.
3. **Better Process Control:** Optimizing process control to improve efficiency and reduce emissions. This can involve implementing automated controls, monitoring and regulating processes more closely to ensure operations are running optimally and minimizing waste.
4. **Equipment Modification:** Modification of equipment to improve performance and efficiency. Examples of this practice include improving insulation, repairing leaks, and replacing obsolete equipment parts with more efficient technologies.
5. **Technology Change:** Change to cleaner and more efficient technology. This includes replacing old technologies with new, more efficient ones, such as replacing old compressors with new, more efficient compressors or adopting the latest green technologies.
6. **Onsite Reuse & Recycling:** Reuse and recycling of materials at the production site. Examples of this practice include water reuse, heat recovery from industrial processes for reuse in the same or different processes at the same site.
7. **Production of Useful Byproduct:** Production of useful by-products from waste. For example, utilizing waste heat for a neighboring company or using waste materials as raw materials for another company.
8. **Product Modification:** Product modification to improve sustainability. This includes increasing the life of the product, making the product recyclable, or reducing the materials used in the product without compromising on quality.

[2] Publication of RECP success stories, ICPC (ppbn.or.id)

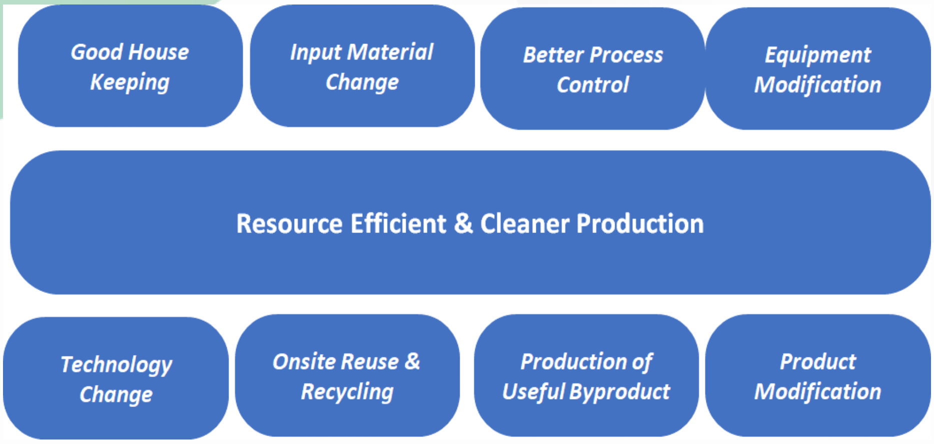

Figure 7 Eight elements of RECP Implementation (Source: UNIDO RECP Programme)

III. Research Methodology

This study aims to demonstrate the application of Resource Efficiency and Cleaner Production (RECP) in pilot unit mill level. The methodology used includes literature review, survey, statistical analysis, desktop study, and calculation. The following are the steps and approaches of the applied study methodology:

1. **Literature Review:**
    - Collect and analyze published materials, scientific articles, research papers and case studies related to RECP.
    - Ensure a comprehensive understanding of best practices and latest innovations in RECP.
2. **Survey:**
    - Distributed questionnaires to all iron and steel companies of the Indonesian Iron and Steel Industry Association (IISIA) members who attended the RECP Kick-off Meeting.
    - Of the nine companies that responded to the survey, five expressed interests in participating in the RECP, but only two companies could be used as pilot units based on the completeness of the data provided.
3. **Statistics:**
    - Utilize statistical data to understand the condition of the industry and sector being studied.
    - Analyze data to identify trends, patterns and opportunities for improved resource efficiency.
4. **Desktop Study:**
    - Conduct research, analyses and data collection using available resources such as sustainability reports, databases, national and international standards as benchmarks.
    - Identify best practices and improvement opportunities through comparative analysis.
5. **Calculation Using RECP Methodology:**
    - Apply the RECP methodology using existing frameworks and tools to calculate the potential resource savings, emission reductions, and economic benefits of implementing cleaner production practices.
    - Conduct in-depth analysis to measure the impact of RECP implementation in pilot units.
6. **Online Meeting with Pilot Companies and Stakeholders:**
    - Engage relevant stakeholders to gather inputs, share information, and build consensus on RECP initiatives.
    - Conduct online discussions and consultations to identify challenges and opportunities for RECP implementation.

7. **Demonstration of RECP at the Pilot Unit Mill:**

    - Establish pilot unit mills or small-scale facilities to implement and test resource efficiency and cleaner production practices.
    - Conduct visits to pilot unit mills to discuss and consult on resource efficiency options that can be implemented in short- and long-term planning.
    - RECP options include energy, material, water savings and operational optimization to generate attractive and cost-effective improvement opportunities.

8. **Report:**

    - Prepare a final report and policy executive summary that includes key findings, recommendations, and implementation measures.

IV. Profile of the Iron and Steel Industry in Indonesia

Figure 8 Iron and Steel Industry Profile of IISIA members.

Industry Association (IISIA) is a forum that houses iron and steel producers from the upstream industry to the downstream industry in Indonesia. As of the end of November 2023, there were 193 companies incorporated in IISIA, with a total production capacity of 18 million tonnes per year (mtpa) and a total investment value of 12 billion US dollars or equivalent to approximately 180 trillion rupiah.

In 2021, iron and steel production in Indonesia reached 14 million tonnes, and increased to 15 million tonnes in 2022 (IISIA, 2023).

The steel industry profile presented in this chapter is the result of IISIA's presentation at the Green and Circular Economy Implementation Policy Dialogue for Green Industry Development in Indonesia on 30 November 2023.

4.1 Iron and Steel Industry Classification

The iron and steel industry in Indonesia based on the process flow and the relationship between raw materials and products is divided into three types:

- **Upstream Industry:**

  Process raw materials into semi-finished products ready for use in the next production process.

- **Intermediate Industry:**

  Processing semi-finished products from upstream industries into products that are further processed in downstream industries.

- **Downstream Industry:**

  Produce end products that will be manufactured by user industries into finished goods according to the needs of various sectors, such as automotive, construction, electronic goods, household appliances, medical devices, and food packaging.

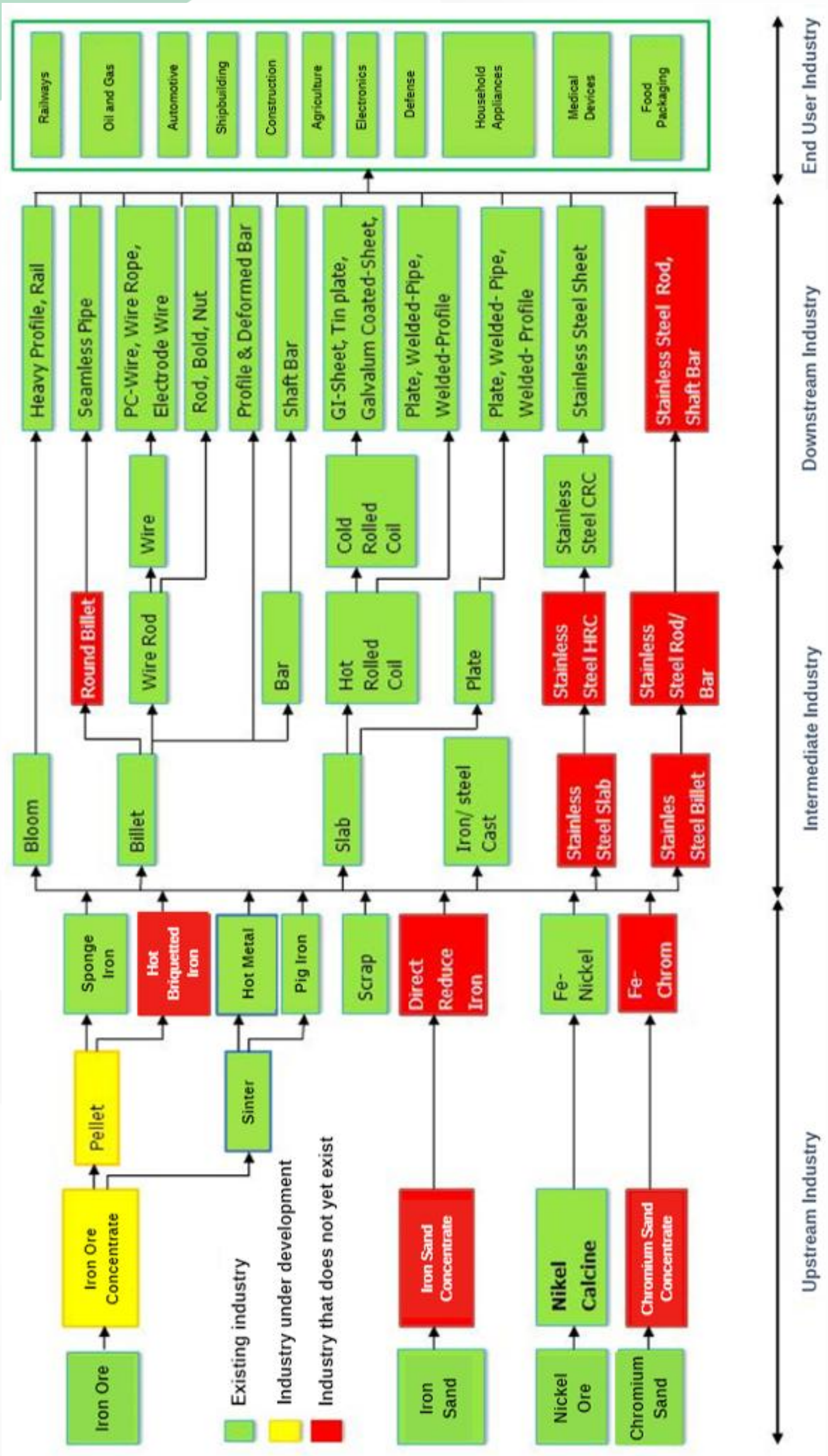

Figure 9 Iron and steel industry classification (Ministry of Industry, 2014)

4.2 Projected Global Iron and Steel Demand Trends

Based on projections calculated by the World Steel Association and Posco Research Institute, global iron and steel demand increased from 2015 to 2035, with an average increase per 10 years of 1.7%. However, although demand increased during the COVID-19 pandemic, the increase did not match previous projections.

This increase in iron and steel demand is a combination of various sectors such as Construction, Transport, Energy, Shipbuilding, and other sectors.

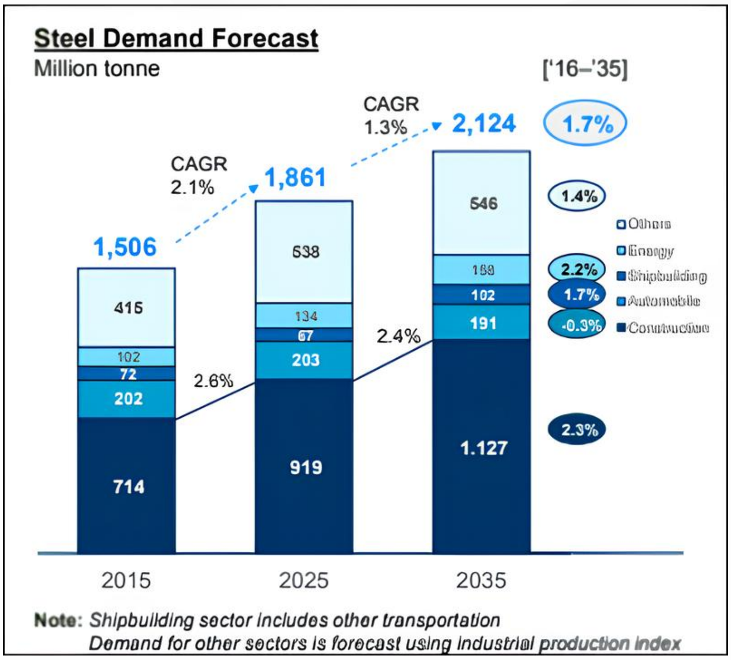

Figure 10 *Global iron and steel demand trends (IISIA, 2023).*

This growing demand from various sectors demonstrates the importance of the iron and steel industry in supporting infrastructure development and global economic growth. Despite the COVID-19 pandemic affecting initial projections, the iron and steel industry continues to show resilience and capacity to continue growing in the long term.

4.3 Iron and Steel Industry Decarbonization Commitments and Technologies

Carbon Emission Reduction Initiative in the Iron and Steel Industry

Automotive manufacturers are setting ambitious carbon emission reduction targets throughout the product lifecycle. The main focus is on the use of steel, aluminum and batteries. Due to support from national and local governments in developed countries for environmentally-friendly public procurement, construction companies are required to use low-carbon materials. As a result, iron and steel producers are starting to shift and invest in low-carbon technologies, such as:

- Steelmaking with hydrogen
- Carbon Capture, Utilization, and Storage (CCUS)
- Technology switch from Blast Oxygen Furnace (BOF) to Electric Arc Furnace (EAF) which is more environmentally friendly

Equipment and technology suppliers to iron and steel producers play an important role in the industry's decarbonization efforts. Here are some technologies that have the potential to reduce CO_2 emissions, although some are still on a trial scale:

- **Technologies with a mix of renewable electricity:** Has great potential to reduce carbon emissions, but its application is still limited to the pilot stage.
- **Electric Arc Furnace (EAF) based on scrap metal:** This technology can already be applied, but the limitation lies in the availability of scrap metal.

Although the technology with the greatest potential to reduce carbon emissions has yet to be widely implemented by industry (it is still on a trial scale), the switch to scrap metal-based EAF could be a first step towards reducing carbon emissions. However, the success of this technology still depends on the availability of sufficient scrap metal.

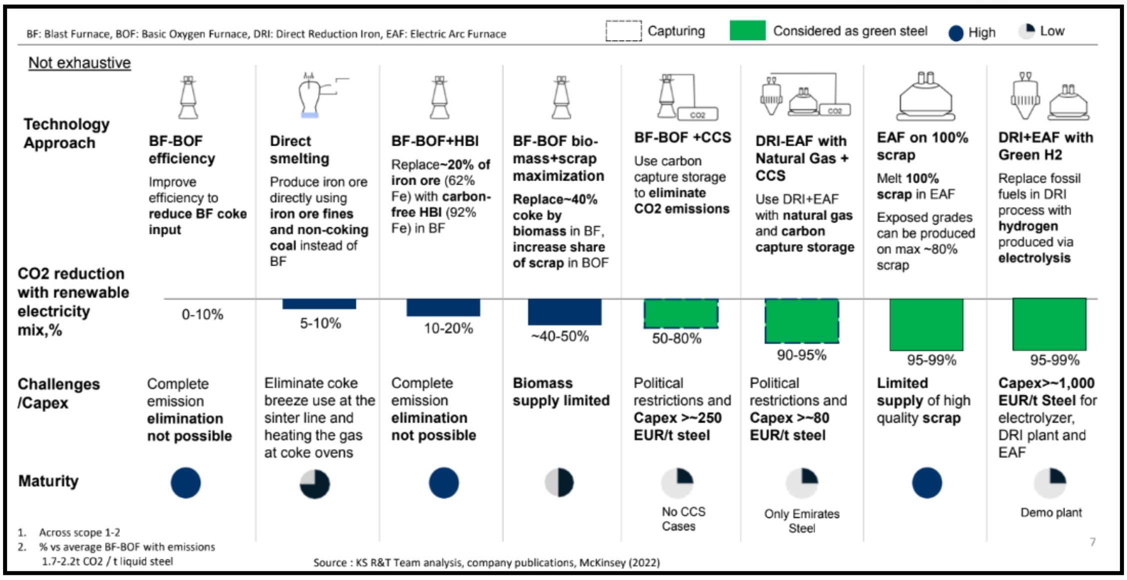

Figure 11 Categorisation of CO_2-reducing technologies (IISIA, 2023).

4.4 Potential Impact of Rising CO_2 Costs on Traditional Steelmaking Technologies

As governments and global automotive manufacturers commit to decarbonization in the iron and steel industry, the potential for policies to increase the cost of CO_2 management and treatment must be anticipated. This potential could cause unsustainable cost pressures for traditional steelmaking technologies, such as Blast Furnace - Basic Oxygen Furnace (BF-BOF) and natural gas-based lines.

Conversely, this will drive increased demand for renewable energy-based technologies as well as zero emission technologies whose use can reduce the cost of CO_2 management and treatment.

As such, the transition to cleaner and more efficient technologies can support global decarbonization goals and provide long-term economic benefits to steel producers. Technologies such as hydrogen steelmaking, the use of Electric Arc Furnace (EAF), and the implementation of Carbon Capture, Utilization, and Storage (CCUS) will become increasingly relevant and attractive to producers amid policies that encourage the reduction of carbon emissions.

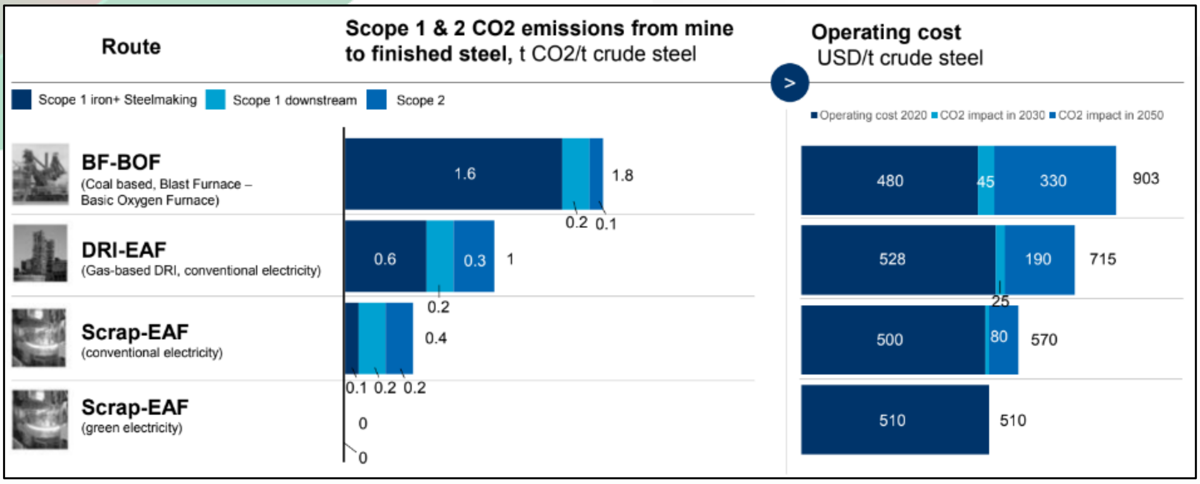

Figure 12 CO_2 *operating costs of various lines and technologies in the iron and steel industry (IISIA, 2023).*

4.5 National Iron and Steel Industry Development 2015 - 2024

Based on data from IISIA in 2023 on the development of the national steel industry 2015 - 2024, throughout the period 2015 - 2022, national steel consumption grew at a Compound Annual Growth Rate (CAGR) or consolidated annual growth rate of 5.5%.

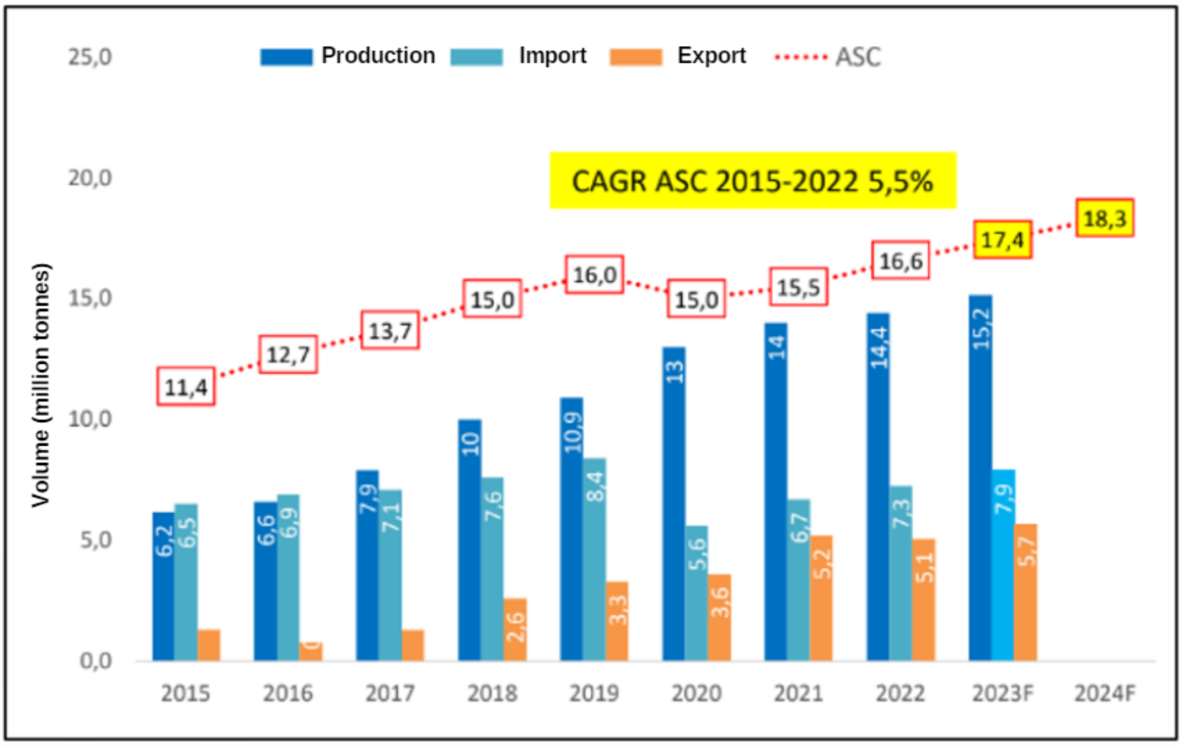

Figure 13 Development of the national steel industry 2015 - 2024 (IISIA, 2023).

Based on this data, it can be concluded that:

- Over the period 2015-2023, national steel consumption grew at a CAGR of 5.5%, from 11.4 million tonnes in 2015 to 16.6 million tonnes in 2022.
- It is estimated that steel consumption will continue to grow by around 5% to 17.9 million tonnes in 2023 and 18.3 million tonnes in 2024.
- Production and exports continued to grow, even during the COVID-19 pandemic in 2020.
- Imports have tended to increase steadily, only to decline during COVID-19 and then increase again, although not yet reaching pre-COVID levels.
- During COVID-19, imports dropped dramatically but national production increased significantly, proving the ability of the National Steel Industry to replace imported products.

4.6 Indonesia's Iron and Steel Industry Framework: Production, Consumption and Emissions

In general, the iron and steel industry in Indonesia is divided into 3 types of products, namely:

- Carbon steel
- Stainless steel, and
- Alloy steel

Based on the target market, carbon steel products have a domestic target market and are the most widely used products at more than 95%, followed by stainless steel at around 2-3% with the target market being industry. Investment drivers for carbon steel are the growth of domestic market potential and capacity limitation/reduction in China, while investment drivers for stainless steel are the ban on nickel ore exports and the availability of nickel ore and coal raw materials.

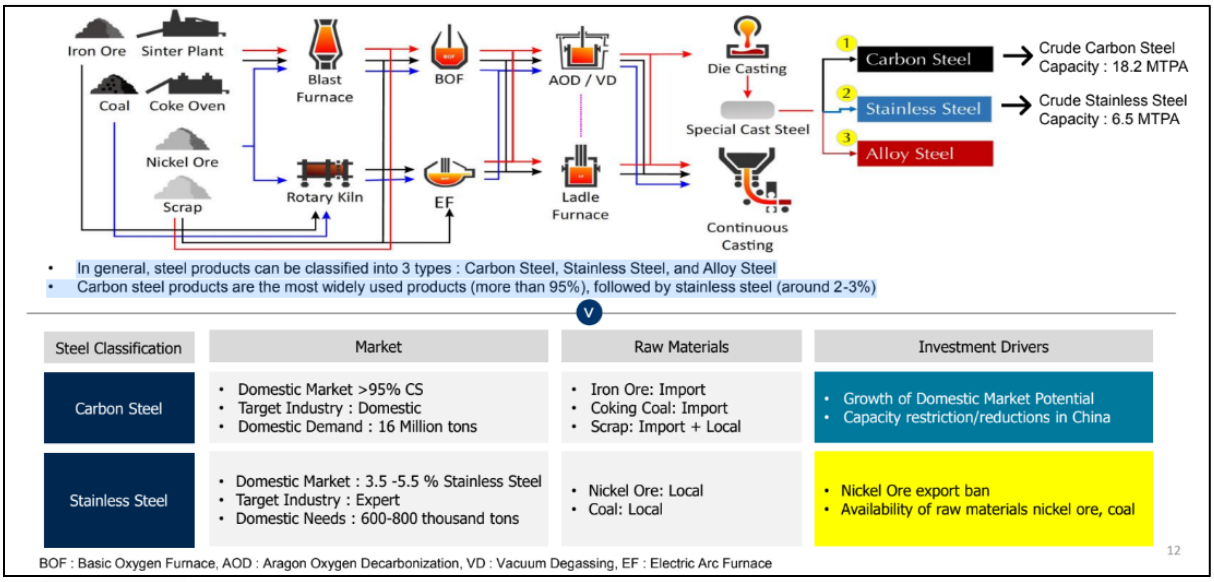

Figure 14 Classification and production lines of the steel industry.

4.7 Indonesia's Commitment to Greenhouse Gas (GHG) Emission Reduction

Indonesia has a target to reduce greenhouse gas (GHG) emissions by 31.89% by 2030 and achieve Net Zero Emissions by 2060. To achieve this, Indonesia submitted an updated National Determined Contribution (NDC) with Business as Usual 1 (BAU1) production targets and emission reductions from each sector as follows:

- **Energy Sector:** 12.5% reduction from BAU total
- **Waste Sector:** 1.4% reduction from BAU total
- **IPPU sector:** 0.2% reduction from BAU total
- **Agriculture sector:** 0.3% reduction from BAU
- **FOLU sector:** 17.4% reduction from BAU

Indonesia has also developed regulations to encourage the implementation of decarbonization initiatives, such as Presidential Regulation No. 98 of 2021, Minister of Environment and Forestry Regulation No. 21 of 2022, Ministry of Energy and Mineral Resources Regulation No. 16 of 2022, Presidential Regulation No. 55 of 2019, and other relevant regulations.

4.8 Economic and Steel Demand Projections

According to Pricewaterhouse Cooper (PwC) projections, Indonesia will become the world's fourth largest economy with a Gross Domestic Product (GDP) of $10,502 billion (GDP per capita $32,600) by 2050. Based on experience in various countries, GDP growth will be followed by an increase in demand for steel.

Indonesia is currently experiencing a rapid increase in steel consumption with a per capita GDP of around $10,000. This growth is expected to continue and stabilize in the GDP per capita range of $10,000 to $30,000. The main sectors that have an important role to play in domestic steel demand are:

- Construction: ~75%
- Manufacturing: ~20%
- Mining, Oil and Gas, Agricultural Industries, and Transport Services: ~5%

These sectors play a role in Indonesia's national development and economic growth towards a developed country. Therefore, Indonesia needs a huge additional steel industry capacity (>100 million tonnes) to meet domestic demand by 2050.

Figure 15 Projected Steel Consumption in Indonesia for 2021 - 2050 (IISIA, 2023).

With a strong commitment to decarbonization and increased steel production capacity, Indonesia can meet growing domestic demand, achieve GHG emission reduction targets, support sustainable economic growth, and ensure sustainable national development.

4.9 Zero Carbon Emissions Roadmap for Iron and Steel Companies in Indonesia

The Iron and Steel Industry and the Energy and Emissions Challenge

Activities in the iron and steel industry require a lot of energy that has the potential to produce emissions. Based on data from the World Steel Association (2023), the iron and steel industry consumes 8% of total global energy consumption, making it the largest energy consumer after the chemical sector. Total CO_2 emissions from the iron and steel industry are 7% of total global emissions, or around 2.6 Giga Tonnes CO_2 equivalent.

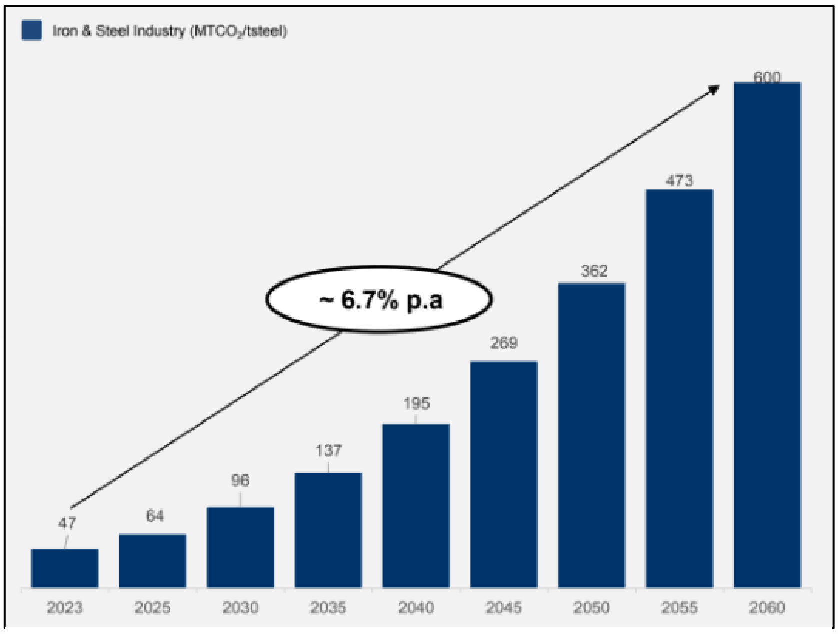

Figure 16 Indonesia Iron and Steel Industry Emissions Projections (million tonnes of CO2 per tonne of steel) (IISIA, 2023).

With the projected increase in steel demand in Indonesia, total CO_2 emissions are also expected to increase. Indonesia's steel demand is projected to reach around 207 million tonnes per year by 2060, which will result in around 600 million tonnes of CO_2 emissions.

Circular Economy and Life Cycle Thinking Approach

To address the issue of steel production growth and resulting emissions, the iron and steel industry needs to adopt a circular economy approach. This approach includes the process of reusing, repairing, remanufacturing and recycling steel products to conserve natural resources and critical raw materials. In addition, Life Cycle Thinking is key to achieving sustainability. All stakeholders must prioritize sustainability in all activities and conduct life cycle assessments, both for environmental aspects and those that include social (Social Life Cycle Assessment) and economic aspects (Life Cycle Costing).

Decarbonization Technology and Programmes

To achieve resource efficiency and cleaner production in a circular economy, some initiatives that can be undertaken by the iron and steel industry in Indonesia in order to achieve the zero-carbon emission target by 2060 include:

- Identify and implement environmentally friendly and efficient technologies.
- Increase the use of renewable energy in the production process.
- Optimize material recycling and reuse.
- Adopt CCUS and hydrogen technology to reduce carbon emissions.
- Develop an electric vehicle ecosystem and supporting infrastructure.

V. Assessment of Resource Efficiency and Cleaner Production (RECP) in the Iron and Steel Industry Sector

In the course of this study, RECP Pilot Units for the iron and steel industry sector were selected based on the following selection criteria:

1. The company has a commitment that is reflected by sending answers to the questionnaire sent via Google Form.
2. Submit monthly water, energy and yield consumption baseline data from 2020 to December 2022.
3. Industries that keep in touch either through email or other forms of communication.
4. Commit to follow-up actions such as receiving site visits, data collection and discussions.

In conducting this study, an initial survey was circulated to members of the Indonesian Iron and Steel Industry Association (IISIA). Out of 193 companies registered as members of IISIA, nine iron and steel companies in Indonesia responded to the survey. Five companies expressed interest in the RECP study.

Table 2 List of Industries Responding to the Survey

No.	Industry Name	Industry Classification	Interested in RECP
1	PT Kayafit Metal Industries	Intermediate	No
2	PT Inter World Steel Mills Indonesia	Intermediate	No
3	PT Krakatau Baja Konstruksi	Intermediate	No
4	PT Tunggal Jaya Steel	Intermediate	No
5	PT Jatim Taman Steel Mfg	Intermediate	Yes
6	PT Krakatau Posco	Intermediate	Yes
7	PT Gunung Raja Paksi Tbk	Intermediate	Yes
8	PT Tata Metal Lestari	Downstream	Yes
9	PT Sunrise Steel	Downstream	Yes

After further evaluation, two companies were willing to be used as pilot/demonstration units for the assessment of resource efficiency and cleaner production (RECP). The two companies are shown in Industries that are RECP Pilot Units Table 3.

Table 3 Industries that are RECP Pilot Units

Company	Location	Industry Classification
PT Gunung Raja Paksi	Cikarang, West Java	Intermediate Industry
PT Tata Metal Lestari	Cikarang, West Java	Downstream Industry

Apart from the two companies willing to serve as pilot units, this RECP study also draws data from the Sustainability Reports published by each of the iron and steel industries in Indonesia. Sustainability Reports are reports on the performance and commitment to sustainability of companies, especially listed companies. It discloses environmental, social and governance performance, including information on production, energy consumption, water and greenhouse gas emissions. In addition, this report usually also discloses strategies and/or actions taken by the company to reduce emissions.

Since the Sustainability Report is a formal report prepared by the company, the information obtained is primary data that can be used as a benchmark to evaluate the efficiency and net production performance of the iron and steel industry in Indonesia.

The companies reviewed based on the data disclosed through the Sustainability Report are:

- PT Krakatau Steel (KS)
- PT Gunawan Dianjaya Steel (GDST), and
- PT Steel Pipe Industry of Indonesia (SPINDO).

Representativeness of RECP Pilot Data

Based on total production in 2022, the assessed Pilot Unit represents 14% of the steel production market share in Indonesia. When combined with the units assessed using the Sustainability Report data, the total representation of the units assessed is 28%.

Table 4 Representativeness of RECP Pilot Data

Company	Industry Classification	Total Production Year 2022 (tonnes)
PT Gunung Raja Paksi	Intermediate Industry	1,973,400
PT Tata Metal Lestari	Downstream Industry	126,228
	Total Pilot Unit Production	**2.099.628**
	Representation of Pilot Units to Total Production (2022)	**14%**
PT Krakatau Steel*	Intermediate Industry	1,880,560
PT Gunawan Dianjaya Steel*	Intermediate Industry	177,944
PT Steel Pipe Industry of Indonesia*	Downstream Industry	
	Total Production of Units Under Review	**4.158.132**
	Representation of Units Under Review to Total Production (2022)	**28%**

*Data source: Company Sustainability Report.

5.1. Resource Efficient and Cleaner Production (RECP) Pilot Unit Profile

Each iron and steel company has a different RECP profile depending on the capacity and classification of iron and steel products produced. This also applies to the consumption of other resources, such as energy and water. There are three aspects analyzed in the RECP study, namely energy, water and greenhouse gas emissions. Each aspect is analyzed for its total consumption and intensity, or in the Ministry of Industry's green industry standard referred to as water consumption or specific energy consumption. This specific value or intensity is the total consumption divided by the total production in that year. Chapter 5 discusses in detail the RECP profile of the company selected as the pilot unit in this study.

5.1.1 PT Gunung Raja Paksi (Intermediate Industry)

PT Gunung Raja Paksi Tbk (GRP) is a member of Gunung Steel Group, one of the largest private steel companies in Indonesia. Established in 1970 in Medan, North Sumatra, GRP started business by producing hot steel and gradually expanded production to steel beams and sheets. In 1991, PT Gunung Naga Mas transitioned into PT Gunung Raja Paksi (GRP).

PT Gunung Raja Paksi Tbk (GRP) produces semi-finished and finished products such as **Hot Rolled Coil, H-Beam Wide Flange, Spiral Pipe, and Welded Beam**. GRP is located in West Cikarang, West Java Province, Indonesia, with an area of more than 200 hectares and has approximately 5,400 employees.

With more than 50 years of experience in the steel industry, PT Gunung Raja Paksi Tbk (GRP) produces 1,200,000 tonnes of high-quality steel annually that is certified by local and international certification organizations.

Commitment to Decarbonization

Based on the results of GHG inventory calculations and Life Cycle Assessment (LCA) studies conducted by the company, it is known that the main sources of GRP emissions come from the use of electricity from the grid and fuel combustion (natural gas and coal). GRP actively seeks clean energy alternatives to reduce its dependence on fossil fuels and move towards carbon neutral in its operations.

As part of its commitment towards decarbonization, GRP developed a decarbonization roadmap towards carbon neutral through five pillars:

- **Pillar 1 Fuel Switching:** Replace fossil fuels with cleaner alternatives.
- **Pillar 2 Production Improvements and Resource Efficiency Improvements:** Improve the efficiency of production processes and resource utilization.
- **Pillar 3 Green Power Sourcing:** Adopt more environmentally friendly sources of electrical energy.
- **Pillar 4 Carbon Offsetting:** Through project investment or purchase of carbon credits to offset emissions.
- **Pillar 5 Collaboration and Partnerships:** Working together with various parties to support decarbonization efforts and achieve common goals.

These steps demonstrate PT Gunung Raja Paksi Tbk's (GRP) commitment to contribute to the reduction of carbon emissions so that the carbon neutral target can be achieved.

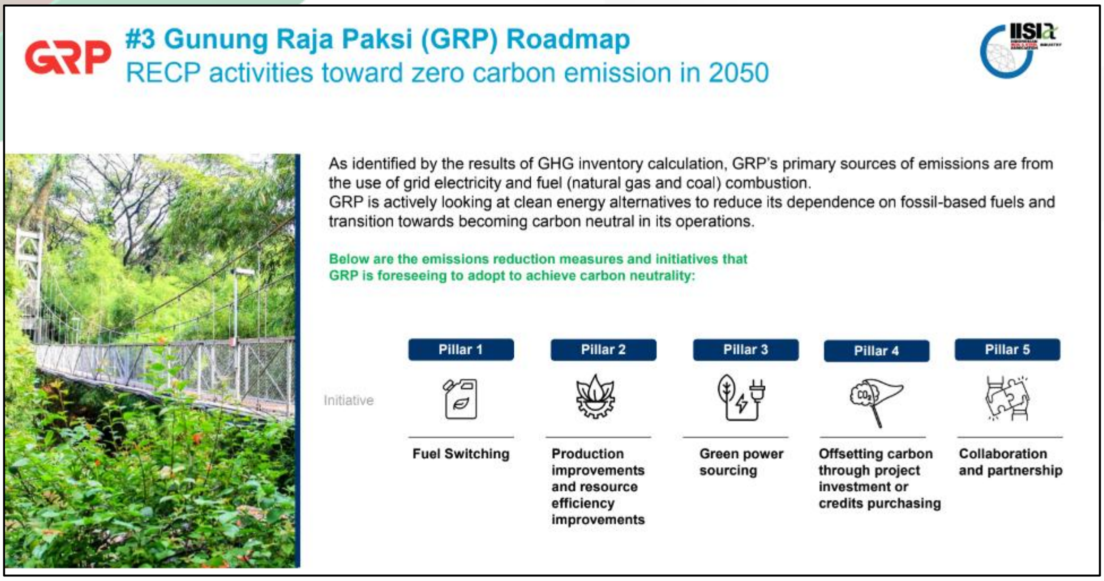

Figure 17 PT Gunung Raja Paksi Roadmap (IISIA, 2023).

Table 5 displays the RECP pilot study conducted at PT Gunung Raja Paksi.

Table 5 Total Iron and Steel Production vs Energy and Water Consumption of PT Gunung Raja Paksi.

Item	2020	2021	2022	Unit
Iron and Steel Production	1.561.000	1.523.200	1.973.400	Tons
Energy Consumption	4.628.544	4.457.469	6.184.398	GJ
Water Consumption	2.053.771	1.305.251	1.878.086	m^3
CO_2 emissions	481.959	531.769	737.113	t-CO_2e
Specific Energy Consumption	2,97	2,93	3,13	GJ/tonne
Specific Water Consumption	1,32	0,86	0,95	m /ton^3
Specific CO_2 emissions	0,31	0,35	0,37	t-CO_2e/ton

Data Source: RECP Pilot Unit Profile, 2023

Notes: Calculation discrepancies may occur due to rounding.

Table 6 Energy Saving Potential of PT Gunung Raja Paksi

GRP	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Energy use	5.860.998	6.184.398	-323.400	-6%	GJ
Energy costs	153.323.708	161.783.852	-8.460.144	-6%	US$

Note: energy cost ≈ US$ 26.16/GJ

Table 7 Water Saving Potential of PT Gunung Raja Paksi

GRP	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Water usage	2.596.356	1.878.086	718.270	28%	m^3
Water costs	3.375.263	2.441.512	933.751	28%	US$

Note: water cost ≈ US$ 1.3/m^3

Table 8 Potential Savings in Economic Value of Carbon PT Gunung Raja Paksi

GRP	2020 Actual	2022 Actual	Savings	Percentage (%)	Unit
GHG Emissions	481.959	737.113	-255.154	-53%	t-CO_2e
GHG emission costs	4.819.590	7.371.130	-2.551.540	-53%	US$

Note: GHG emission cost ≈ US$ 10/ t-CO_2e

From the comparison of the 2020 baseline with the 2022 reporting period, it can be concluded that:

- **Increased Energy Intensity:** Energy intensity increased from 2.97 GJ/tonne of iron and steel in 2020 to 3.13 GJ/tonne of iron and steel in 2022, representing a 6% decrease in energy efficiency.
- **Decrease in Water Intensity:** Water intensity decreased from 1.32 m³/tonne of iron and steel in 2020 to 0.95 m³/tonne of iron and steel in 2022, or about 0.37 m³/tonne of iron and steel (28.03%).
- **Increased CO_2 emissions:** The CO_2 emissions intensity increased from 0.31 t-CO_2e/tonne of iron and steel in 2020 to 0.37 t-CO_2e/tonne of iron and steel in 2022, or about -0.06 t-CO_2 e/tonne of iron and steel (-19.35%).

Findings from RECP Results

From the RECP results, an increase in energy intensity and CO_2 emissions at GRP was found. However, this decrease in efficiency is not unknown to GRP. Some of the factors causing the decrease in efficiency at GRP include:

- **Difficulty Finding Scrap Raw Materials:** In 2022, GRP had difficulty sourcing scrap raw materials and used HBI (Hot Briquetted Iron) as a substitute. This substitution resulted in an increase in the energy intensity of the production process.
- **Long Section Mill (LSM) Technology:** The LSM technology has just been updated and is still in the process of trials and fine tuning to obtain new sizes. Currently, the LSM production capacity accounts for only 30% of the total production capacity and has not been utilized to its full potential, leading to inefficient energy consumption.
- **Beam Plant (BP) Mill Technology:** The BP Mill technology used by GRP is from 1980-1990s and is a contributor to the inefficiency of the production process. GRP plans to replace the BP Mill technology with a Medium Section Mill (MSM), but this plan still requires further research and consideration due to the potential for product diversification and high investment.

Initiatives to Improve Efficiency

GRP has planned various initiatives in its roadmap to improve the efficiency of the production process (Figure 17). However, these efforts require large investments, so improvements cannot be achieved in the near future. Some of the initiatives that have been undertaken include:

- **Solar Renewable Energy Installation:** Since April 2023, GRP has been installing and operating solar renewable energy. Solar renewable energy capacity continues to be expanded with a target total capacity of 33 MWp.
- **Sustainability-Linked Loan:** In December 2022, GRP secured a Sustainability-Linked Loan from Bank Negara Indonesia (BNI) of USD 32 million (IDR 500 billion) in recognition of its sustainability initiatives in Southeast Asia.

In practice, PT Gunung Raja Paksi has implemented efforts to increase energy efficiency, reduce greenhouse gas (GHG) emissions, and increase water use efficiency. Details of the strategies undertaken and their implementation status can be seen in Table 9.

Table 9 Implementation of PT Gunung Raja Paksi Efficiency Strategy

No.	Action Scenario	Efficiency Category	Status
Better Process Control (BPC)			
1	Procurement of energy conversion and storage systems	Energy	Proposed
2	Documentation of environmental aspects of environmental parameters such as waste quality and quantity	GHG Emissions	Ongoing
3	Reuse of production water from cooling tower for production process	Water	Implemented
4	Recycling of clear water and treated wastewater	Water	Proposed
Good Housekeeping (GHK)			
1	Perform routine machine maintenance and calibrate tools according to the specified period.	GHG Emissions	Proposed
2	Implement the 5R system (Ringkas, Rapi, Resik, Rawat, Rajin) and good spatial layout to prevent spills and leaks.	Water	Proposed
Input Material Change (IMC)			
1	Using low-carbon raw materials to reduce emissions	GHG Emissions	Implemented
Technology Change (TC)			
1	Using solar panels and energy-efficient lighting to minimize energy use	Energy	Implemented
2	Changing the rolling mill beam plant technology to medium section mill	Energy and GHG Emissions	Planned
3	Using water power generation technology	Energy	Planned
4	The use of Electric Arc Furnace (EAF) technology is due to the use of electrodes and minimal emissions produced.	GHG Emissions	Implemented
5	Elimination of Blast Furnace technology flow due to high CO_2 emissions generated	GHG Emissions	Implemented

No.	Action Scenario	Efficiency Category	Status
6	Reduction of CO_2 emissions with the establishment of the Long Section Mill (LSM) production process	GHG Emissions	Implemented
Equipment Modification (EM)			
1	Procurement of scrubbers and dust collectors to treat air emissions	GHG Emissions	Implemented
2	Documentation of environmental aspects of environmental parameters such as waste quality and quantity	GHG Emissions	Ongoing
3	Installation of CEMS (Continuous Emissions Monitoring System) as an emission monitoring tool	GHG Emissions	Proposed

With these efforts and initiatives, PT Gunung Raja Paksi Tbk (GRP) demonstrates its commitment to improving energy and water efficiency, reducing emissions, and supporting the sustainability of the iron and steel industry in Indonesia.

5.1.2 PT Tata Metal Lestari (Downstream Industry)

PT Tata Metal Lestari is a member of Tatalogam Group, one of the largest metal roof tile and mild steel companies in Indonesia. The company was established in 1994 with the aim of replacing corrugated iron roofs that rusted easily. Tatalogam Lestari started its business from a garage as a place to cut zinc rolls for sale, then expanded to produce stone coated metal roof tiles in a simple factory in Cibitung, Bekasi.

PT Tata Metal Lestari is a manufacturing industry engaged in the production of zinc-aluminum coated steel, which is used as raw material for metal roof tiles and mild steel. The plant produces Aluminum-Zinc Coated Steel (BJLAS) and Zinc Coated Steel (BJLS). Located in Delta Silicon Industrial Estate, South Cikarang, West Java Province, Indonesia, PT Tata Metal Lestari has an annual production capacity of 225,000 tonnes and is supported by approximately 221 employees.

Commitment to Sustainability

By 2020, Tata Steel Group has set a roadmap to reduce emissions based on data provided to the North Sea Canal Area Environment Agency. The data from the report was used to determine the baseline value of emissions. As part of the Tata Steel Group, PT Tata Metal Lestari continues to be committed to supporting sustainability by adopting environmentally friendly practices in its operations.

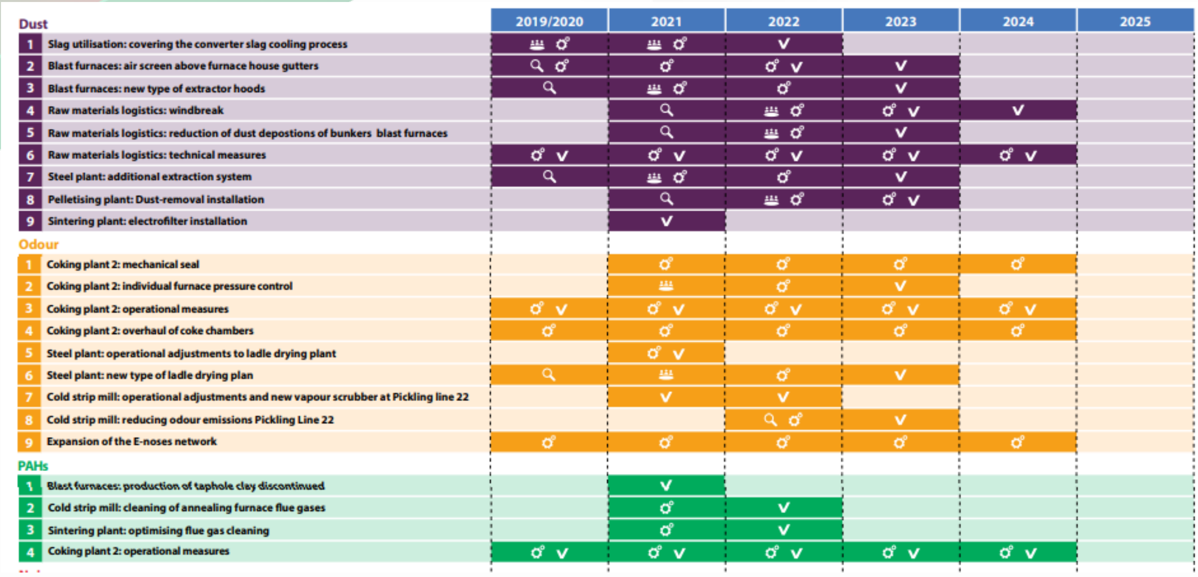

Figure 18 Tata Steel Group Roadmap (Source: Tata Steel Group Sustainability Report, 2023).

Table 10 displays the RECP pilot study conducted at PT Tata Metal Lestari

Table 10 Total Iron and Steel Production vs Energy and Water Consumption of PT Tata Metal Lestari

Item	2020	2021	2022	Unit
Iron and Steel Production	99.682	152.525	126.228	Tons
Energy Consumption	150.601	208.233	187.192	GJ
Water Consumption	25.529	60.749	74.005	m^3
Rainwater Utilization	-	7.177	5.029	m^3
CO_2 emissions	19.522	26.120	24.299	t-CO_2e
Specific Energy Consumption	1,51	1,37	1,48	GJ/tonne
Specific Water Consumption	0,26	0,40	0,59	m /ton^3
Specific Rainwater Utilization	-	0,05	0,04	m /ton^3
Specific CO_2 emissions	0,20	0,17	0,19	t-CO_2e/ton

Data Source: RECP Pilot Unit Profile, 2023

Notes: Calculation discrepancies may occur due to rounding.

Table 11 Energy Saving Potential of PT Tata Metal Lestari

TML	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Energy use	172.332	187.192	-14.861	-9%	GJ
Energy costs	4.508.198	4.896.952	-388.754	-9%	US$

Note: energy cost ≈ US$ 26.16/GJ

Table 12 Water Saving Potential of PT Tata Metal Lestari

TML	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Water usage	50.275	74.005	-23.730	-47%	m^3
Water costs	65.358	96.207	-30.849	-47%	US$

Note: water cost ≈ US$ 1.3/m^3

Table 13 Potential Savings in Economic Value of Carbon PT Tata Metal Lestari

TML	2020 Actual	2022 Actual	Savings	Percentage (%)	Unit
GHG Emissions	19.522	24.299	-4.777	-24%	t-CO e_2
GHG emission costs	195.220	242.991	-47.769	-24%	US$

Note: GHG emission cost ≈ US$ 10/ t-CO_2e

From the comparison of the 2020 baseline with the 2022 reporting period, the following conclusions can be drawn:

- **Decrease in Energy Intensity:** Energy intensity decreased from 1.51 GJ/tonne of iron and steel in 2020 to 1.48 GJ/tonne of iron and steel in 2022, representing a 1.99% improvement in energy efficiency.
- **Increased Water Intensity:** Water intensity increased from 0.26 m^3/tonne of iron and steel in 2020 to 0.59 m^3/tonne of iron and steel in 2022, or about -0.33 m^3/tonne of iron and steel (-126.92%). The significant increase in water consumption in 2022 compared to 2020 is because in 2020, TML was still in the early stages of being established and starting operations. In 2020-2021, there was a significant increase for the adaptation of a stable amount of production and water consumption.
- **Reduction of CO Emissions$_2$:** CO_2 emission intensity decreased from 0.20 t-CO_2 e/tonne of iron and steel in 2020 to 0.19 t-CO_2 e/tonne of iron and steel in 2022, or about 0.01 t-CO_2 e/tonne of iron and steel (5%).

PT Tata Metal Lestari Sustainability Initiatives

- **Rainwater Collection and Utilization:** Since March 2021, PT Tata Metal Lestari has been collecting, treating and utilizing rainwater as one of the water sources in the production process to improve water use efficiency. However, the utilization of rainwater is highly dependent on rainfall in the area so the intensity fluctuates every year.
- **Solar Renewable Energy Installation:** Since April 2022, PT Tata Metal Lestari has initiated the use of solar renewable energy. However, due to limited area at the Cikarang plant, only one transformer could be installed. In the future, these solar panels will also be used for Tata Metal's factory in Sadang Purwakarta.

Tata Steel Group's Improvement Focus

1. **Dust Indicator*:***
   - It is targeted to achieve a reduction in visible dust (solid particles) of about 65% by 2024.
   - The dust generated comes from the slag material.
   - Mitigation or reduction strategy: planned installation of large wind dampers around the storage facility in the blast furnace bunker.

2. **Odor Indicator:**
    - Local residents may experience unpleasant odors.
    - It is targeted to reduce by 85% of the total hours by the end of 2023.
3. **Polycyclic Aromatic Hydrocarbons (PAHs) indicator:**
    - Measures to reduce PAHs in the roadmap have been implemented to achieve PAHs emissions of around 50% by 2022.
    - The nitrogen oxide emission indicator is targeted to be reduced by about 30% by 2025.

Initiatives to Improve Efficiency

In practice, PT Tata Metal Lestari has implemented efforts to increase energy efficiency, reduce greenhouse gas (GHG) emissions, and increase water use efficiency. Details of the strategies carried out and the status of their implementation can be seen in the following Table 14.

Table 14 Implementation of PT Tata Metal Lestari Efficiency Strategy

No.	Action Scenario	Efficiency Category	Status
Better Process Control (BPC)			
1	Furnace efficiency monitoring	Energy	Implemented
2	Documentation of environmental aspects of environmental parameters such as waste quality and quantity	GHG Emissions	Ongoing
3	Reuse of production water from cooling tower for production process	Water	Implemented
4	Rainwater collection and vapor condensate recovery	Water	Implemented
5	Use of polyelectrolytes in wastewater treatment	Water	Implemented
6	Recycling of clear water and treated wastewater	Water	Proposed
7	Improve the efficiency of the water-cooling system	Water	Proposed
Good Housekeeping (GHK)			
1	Perform routine machine maintenance and calibrate tools according to the specified period.	GHG Emissions	Proposed
2	Implement the 5R system (Ringkas, Rapi, Resik, Rawat, Rajin) and good spatial layout to prevent spills and leaks.	Water	Proposed
3	Regular preventive maintenance of the machine and repair of all leakage points	Water	Proposed

No.	Action Scenario	Efficiency Category	Status
Input Material Change (IMC)			
1	Using low-carbon raw materials to reduce emissions	GHG Emissions	Implemented
2	Use of high-quality materials to reduce cleaning cycle	Water	Implemented
Technology Change (TC)			
1	Using solar panels and energy-efficient lighting to minimize energy use	Energy	Implemented
Equipment Modification (EM)			
1	Metering and sub-metering at key electricity use points	Energy	Implemented
2	Use a recuperator or heat exchanger to utilize hot air as a source of energy from other equipment.	Energy	Implemented
3	Use of automatic switch interlock system on pump system	Energy	Proposed
4	Implementing TV Zone System for combustion optimization to save natural gas consumption	Energy	Implemented
5	Installation of flue gas emission control devices in combustion chimneys	Energy and GHG Emissions	Proposed
6	Installation of CEMS (Continuous Emissions Monitoring System) as an emission monitoring tool	GHG Emissions	Proposed
7	Using a fume scrubber as a means of separating alkaline vapor into water vapor	Water	Implemented
8	Metering and sub-metering at the main point of use of water discharge	Water	Proposed

With these efforts and initiatives, PT Tata Metal Lestari (TML) demonstrates its commitment to improving energy and water efficiency, reducing emissions, and supporting the sustainability of the iron and steel industry in Indonesia.

5.2. RECP Pilot Data from Sustainability Report

In this study, resource consumption includes energy and water use, as well as production output. The data is taken from the Sustainability Report of the iron and steel industry with the following details:

5.2.1 PT Krakatau Steel (Intermediate Industry)

PT Krakatau Steel (KS) Roadmap

KS and its affiliates have a programme to reduce CO_2 emissions by 33% by 2030 and achieve carbon neutrality by 2060 by implementing Hydrogen Based Technology in Iron and Steel Manufacturing Facilities. By implementing energy conservation as one of the strategies in RECP, KS managed to reduce emissions by 8.3 kilo tonnes of CO_2 per year or equivalent to cost savings of up to IDR 67 billion per year in 2019 - 2023.

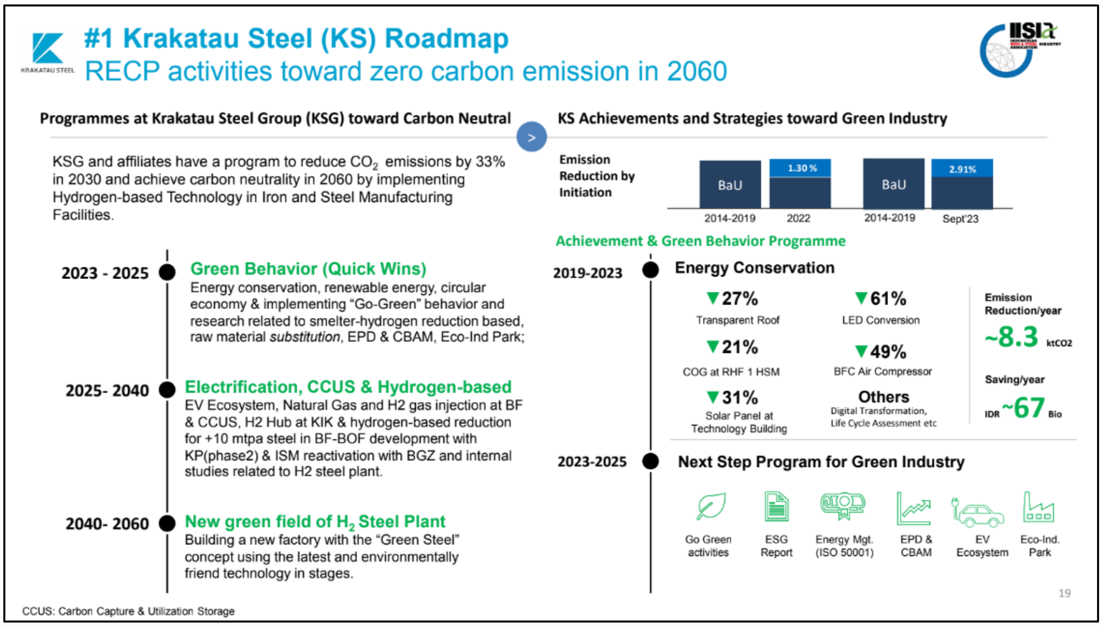

Figure 19 PT Krakatau Steel Roadmap (IISIA, 2023).

As part of its commitment towards decarbonization, KS developed a decarbonization roadmap towards carbon neutral through programme planning that is divided into three main phases:

- **Phase in 2023 - 2025: Green Behaviour (Quick Wins)**

  This phase focuses on energy conservation, use of renewable energy, circular economy, and implementation of "Go-Green" behavior. Measures taken include research and application of hydrogen-based smelter reduction technology, raw material substitution, EPD & CBAM, and development of an Eco-Ind Park.

- **Phase in 2023 - 2040: Electrification, CCUS & Hydrogen-based**

  Developing an ecosystem of electric vehicles (EVs), natural gas and hydrogen utilization in Blast Furnace (BF) and Carbon Capture, Utilization and Storage (CCUS) processes. The programme also includes the development of hydrogen-based BF-BOF with KP phase 2 and production ramp-up with ISM reactivation with BGZ, as well as internal studies on hydrogen technology.

- **Phase in 2040 - 2060: New Green H_2 Steel Plant**

The final phase involves the gradual construction of a new plant with the concept of "Green Steel" that uses the latest technology and is environmentally friendly.

PT Krakatau Posco (KP) Roadmap

KP has an emissions reduction target of 20% by 2030. The target includes reducing direct emissions from production sites and avoiding emissions that occur in the value chain, especially from the use of by-products. The company continues to strive to reduce greenhouse gas emissions through the provision of energy-efficient steel products and recycling of steel by-products.

Figure 20 PT Krakatau Posco Roadmap (IISIA, 2023).

The following is the *roadmap* that has been developed until 2050:

- **Up to 2030 (20% emission reduction target):** improved energy efficiency, use of alternative low-carbon raw materials (e.g. scrap, pellets, etc.)
- **Up to 2040 (50% emission reduction target):** Process redesign. Injection of natural gas and H2-containing gas into the BF, new EAF, and CCR1.
- **Up to 2050 (100% emission reduction target):** Commercialization of HyREX (Fluidised-bed reduction with green H2) + EAF using renewable energy sources

PT Krakatau Steel Sustainability Performance

Table 15 *Total Iron and Steel Production vs Energy and Water Consumption of PT Krakatau Steel*

Item	2020	2021	2022	Unit
Iron and Steel Production	1.593.083	1.968.221	1.880.560	Tons
Energy Consumption	6.483.848	7.382.168	6.120.493	GJ
Water Consumption	4.744.880	5.720.876	4.034.306	m^3
CO_2 emissions	-	576.919	538.401	t-CO_2e
Specific Energy Consumption	4,07	3,75	3,25	GJ/tonne
Specific Water Consumption	2,98	2,91	2,15	m /ton^3
Specific CO_2 emissions	-	0,293	0,286	t-CO_2e/tn

Source: Sustainability Report - PT Krakatau Steel, 2022

Notes: Calculation discrepancies may occur due to rounding.

Table 16 *Energy Saving Potential of PT Krakatau Steel*

KS	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Energy use	7.653.879	6.120.493	1.533.386	20%	GJ
Energy costs	200.225.486	160.112.097	40.113.389	20%	US$

Note: energy cost ≈ US$ 26.16/GJ

Table 17 *Water Saving Potential of PT Krakatau Steel*

KS	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Water usage	5.601.109	4.034.306	1.566.803	28%	m^3
Water costs	7.281.442	5.244.598	2.036.844	28%	US$

Note: water cost ≈ US$ 1.3/m^3

Table 18 *Potential Savings in Carbon Economic Value of PT Krakatau Steel*

KS	2021 Actual*	2022 Actual	Savings	Percentage (%)	Unit
GHG Emissions	576.919	538.401	38.518	7%	t-CO_2e
GHG emission costs	5.769.190	5.384.010	385.180	7%	US$

* Data for 2020 is not available, so values are calculated using the 2021 baseline

Note: GHG emission cost ≈ US$ 10/ t-CO_2e

From the comparison of the 2020 baseline with the 2022 reporting period, it can be concluded as follows:

- There was a decrease in energy intensity from 4.07 GJ/tonne of iron and steel in 2020 to 3.25 GJ/tonne of iron and steel in 2022, which shows an increase in energy efficiency of 20.15%.
- There was a decrease in water intensity from 2.98 m^3 /ton iron and steel in 2020 to 2.15 m^3 /ton iron and steel in 2022, or about 0.83 m^3 /ton iron and steel (27.85%).

- PT Krakatau Steel's Sustainability Report only presents CO_2 emissions in 2021 and 2022. There is a slight decrease in CO_2 emission intensity from 0.293 t-CO_2 e/ton of iron and steel in 2021 to 0.286 t-CO_2 e/ton of iron and steel in 2022 or about 0.007 t-CO_2 e/ton of iron and steel (2.39%).

5.2.2 PT Gunawan Dianjaya Steel (Intermediate Industry)

Sustainability Performance of PT Gunawan Dianjaya Steel

Table 19 Total Iron and Steel Production vs Energy and Water Consumption of PT Gunawan Dianjaya Steel

Item	2020	2021	2022	Unit
Iron and Steel Production	177.944	130.788	162.517	Tons
Energy Consumption	461.322	346.833	416.046	GJ
Water Consumption	106.915	85.225	105.679	m^3
CO_2 emissions	20.451	16.018	22.908	t-CO_2e
Specific Energy Consumption	2,59	2,65	2,56	GJ/tonne
Specific Water Consumption	0,60	0,65	0,65	m /ton^3
Specific CO_2 emissions	0,11	0,12	0,14	t-CO_2e/ton

Source: Sustainability Report - PT Gunawan Dianjaya Steel, 2022

Notes: Calculation discrepancies may occur due to rounding.

Table 20 Energy Saving Potential of PT Gunawan Dianjaya Steel

GDST	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Energy use	421.327	416.046	5.281	1%	GJ
Energy costs	11.021.923	10.883.763	138.159	1%	US$

Note: energy cost ≈ US$ 26.16/GJ

Table 21 Water Saving Potential of PT Gunawan Dianjaya Steel

GDST	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Water usage	97.646	106.915	-9.269	-8%	m^3
Water costs	126.940	138.990	-12.050	-9%	US$

Note: water cost ≈ US$ 1.3/m^3

Table 22 Potential Savings in Economic Value of Carbon PT Gunawan Dianjaya Steel

GDST	2020 Actual	2022	Savings	Percentage (%)	Unit
GHG Emissions	20.451	22.908	-2.457	-12%	t-CO_2e
GHG emission costs	204.510	229.080	-24.570	-12%	US$

Note: GHG emission cost ≈ US$ 10/ t-CO_2e

From the comparison of the 2020 baseline with the 2022 reporting period, it can be concluded as follows:

- There was a slight decrease in energy intensity from 2.59 GJ/tonne of iron and steel in 2020 to 2.56 GJ/tonne of iron and steel in 2022, indicating a 1.16% improvement in energy efficiency.

- There was an increase in water intensity from 0.60 m^3/ton iron and steel in 2020 to 0.65 m^3 /ton iron and steel in 2022 or about -0.05 m^3 /ton iron and steel (-8.33%).
- There is an increase in CO_2 emission intensity from 0.11 t-CO_2e/tonne of iron and steel in 2020 to 0.14 t-CO_2e/tonne of iron and steel in 2022 or about -0.03 t-CO_2e/tonne of iron and steel (-27.27%).

5.2.3 PT Steel Pipe Industry of Indonesia - SPINDO (Downstream Industry)

Sustainability Performance of PT Steel Pipe Industry of Indonesia - SPINDO

Table 23 Total Iron and Steel Production vs Energy and Water Consumption of PT Steel Pipe Industry of Indonesia

Item	2020	2021	2022	Unit
Iron and Steel Production	-	536.437	2.272.955*	Tons
Energy Consumption	11.259.903	10.873.574	10.682.890	GJ
Water Consumption	378.953	391.676	354.695	m^3
CO_2 emissions	-	-	-	t-CO_2e
Specific Energy Consumption	-	20,27	4,70	GJ/tonne
Specific Water Consumption	-	0,73	0,16	m /ton^3
Specific CO_2 emissions	-	-	-	t-CO_2e/ton

* Data Anomaly: 2022 production increased sharply compared to 2021, but energy and water use did not.

Source: Sustainability Report - PT Steel Pipe Industry of Indonesia, 2021-2022

Notes: Calculation discrepancies may occur due to rounding.

Table 24 Energy Saving Potential of PT Steel Pipe Industry of Indonesia

SPINDO	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Energy use	46.072.780	10.682.890	35.389.889	77%	GJ
Energy costs	1.205.263.913	279.464.412	925.799.501	77%	US$

Note: energy cost ≈ US$ 26.16/GJ

Table 25 Water Saving Potential of PT Steel Pipe Industry of Indonesia

SPINDO	2022 Projection	2022 Actual	Savings	Percentage (%)	Unit
Water usage	1.659.583	354.695	1.304.888	79%	m^3
Water costs	2.157.458	461.104	1.696.355	79%	US$

Note: water cost ≈ US$ 1.3/m^3

From the comparison of the 2020 baseline with the 2022 reporting period, it can be concluded as follows:

- PT Steel Pipe Industry of Indonesia (SPINDO) Sustainability Report only presents energy intensity in 2021 and 2022. There is a very significant decrease in energy intensity from 20.27 GJ/tonne of iron and steel in 2021 to 4.70 GJ/tonne of iron and steel in 2022, which shows an increase in energy efficiency of 76.81%.

- However, in the disclosure of this Sustainability Report, it is not known how much iron and steel production in each year. In the table above, the amount of iron and steel production is obtained using the calculation by dividing the total energy consumption (GJ) by the energy intensity (GJ/ton) so that the amount of iron and steel products is 536,437 tonnes in 2021 and 2,272,955 tonnes in 2022. There is an anomaly of a significant increase in the amount of iron and steel production, namely 323%, so further clarification is needed from PT SPINDO to ensure the Sustainability Report data.
- Using the data from the calculation of previous production quantities, a significant decrease in water intensity from 0.73m^3 /ton iron and steel in 2021 to 0.16m^3 /ton iron and steel in 2022 or about 0.57m^3 /ton iron and steel (78.08%) can be seen. However, this value still needs to be clarified due to anomalies in the previous iron and steel production quantities.
- CO_2 emissions are unknown because CO_2 substances are not measured in stack and flue gas emission measurements.

VI. Performance Analysis Based on RECP Study in Iron and Steel Industry and Implementation of Options

6.1. Energy

To achieve the goal of reducing greenhouse gas (GHG) emissions by 80-95% by 2050 compared to 1990 levels, industries must improve their energy efficiency. Improving energy efficiency is one way to reduce energy consumption and greenhouse gas (GHG) emissions.

Specific Energy Consumption (SEC) is used as an energy performance indicator to evaluate or measure energy efficiency. SEC is defined as the ratio of Giga Joules (GJ) of energy consumed to the unit weight of product produced by this energy consumption, expressed in Giga Joules per tonne (GJ/tonne). SEC is calculated as the ratio of energy used to produce a product. To calculate the specific energy consumption, the electricity unit is converted to GJ using a conversion ratio of 0.0036 GJ/kWh.

Energy efficiency improvements were calculated based on 2020 iron and steel production data. This calculation involves comparing the projected energy efficiency for 2022 based on 2020 specific energy consumption data with the actual energy efficiency in 2022. Due to the lack of specific data on energy efficiency, the calculation was carried out using the following alternative approach:

$$Energy\ Efficiency\ Improvement = projected\ data - actual\ data$$

$$Energy\ Efficiency\ Improvement\ Percentage = \frac{projected\ data - actual\ data}{actual\ energy\ data} \times 100\%$$

6.1.1 Intermediate Industry

The study covers three intermediate industries as pilots, namely PT Gunung Raja Paksi (GRP), PT Krakatau Steel (KS), and PT Gunawan Dianjaya Steel (GDST).

Range of Specific Energy Consumption (SEC)

Based on database calculations from the three pilot industries between 2020 and 2022, the SEC is in the range of 2.56 to 4.07 GJ/tonne of product. The average SEC value is 3.10 GJ/tonne of product per year. The following graph (Figure 21) shows the range of SEC values of the intermediate pilot industries.

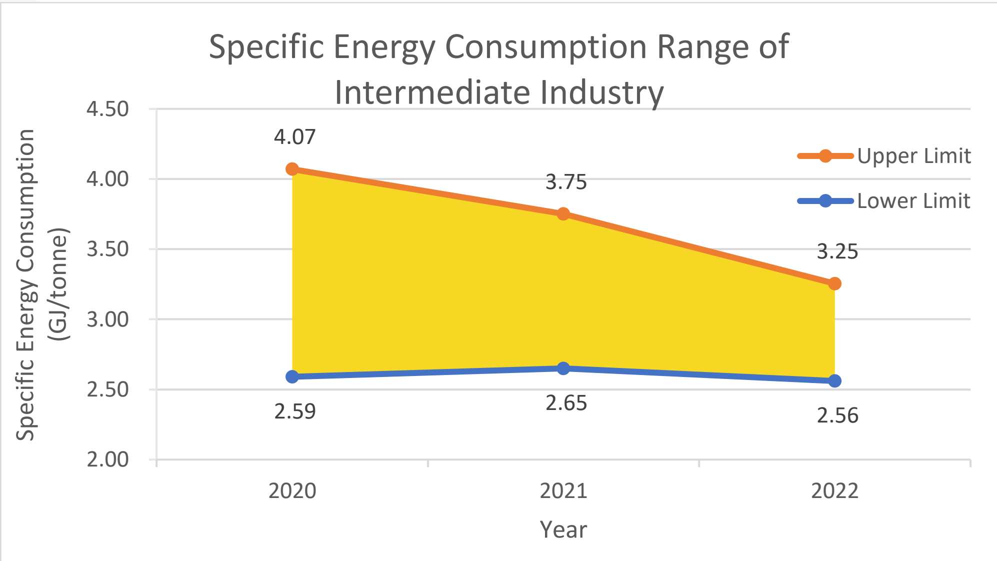

Figure 21 Range of Industry Specific Energy Consumption Between 2020-2022 (RECP Pilot Unit Profile, 2023)

The graph above displays the Specific Energy Consumption (SEC) trend of the intermediate industry pilots over the period 2020 to 2022. From the graph, it can be seen that the SEC value range of the industry between 2020 and 2022 has decreased consistently. In 2020, the SEC value range was 2.59 - 4.07 GJ/tonne. This value range decreased to 2.65 - 3.75 GJ/ton in 2021, and reached the lowest value in 2022, which was 2.56 - 3.25 GJ/ton. This decrease shows a trend of increasing energy efficiency in the intermediate industry from year to year.

Energy Efficiency

The intermediate industrial pilots subject to this study show a range of energy efficiency improvements from -6% to 20% by 2022, based on 2020 specific energy consumption data. The average efficiency improvement was 7%, with a total improvement range of 26%. While one pilot unit's intermediate iron and steel industry experienced a -6% drop in efficiency, other intermediate industries showed positive improvements. Overall, the iron and steel industry in 2022 showed an improvement in energy efficiency, as evidenced by the actual energy consumption data being lower than the 2020 projection. Complete data can be seen in Table 6, Table 16, and Table 20.

6.1.2 Downstream Industry

The study includes two downstream industries as pilots, namely PT Tata Metal Lestari (TML) and PT Steel Pipe Industry of Indonesia (SPINDO). Analyses can only be conducted for 2021 and 2022 as PT SPINDO's Sustainability Report data is only available for these two years.

Specific Energy Consumption (SEC) range

Based on the database calculations of the two downstream industry pilots for 2021 to 2022, the SEC is in the range of 1.37 to 20.27 GJ/tonne of product. The average SEC is 6.95 GJ/tonne of product. The following graph (Figure 22) shows the range of SEC values of the downstream industry pilots.

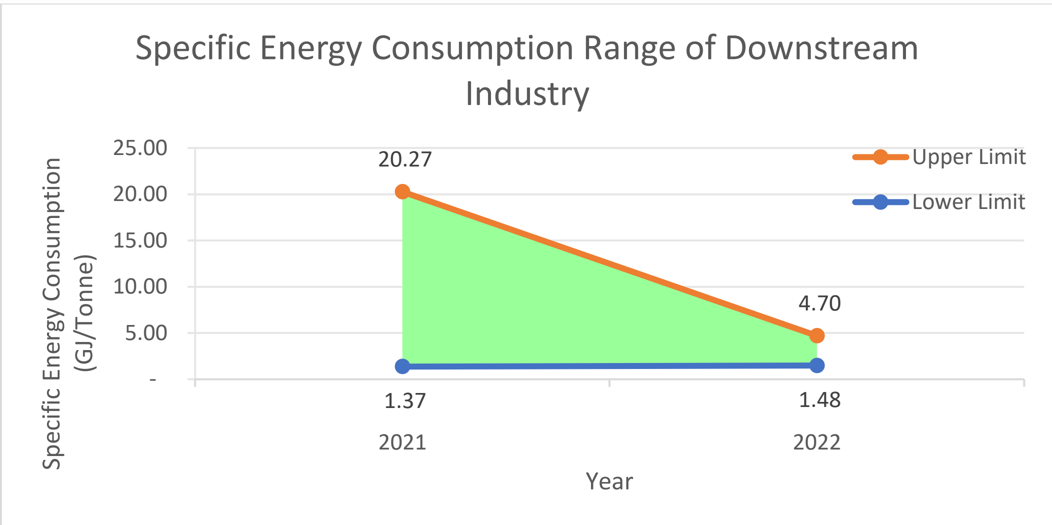

Figure 22 Specific Energy Consumption Range of Downstream Industry 2021-2022 (RECP Pilot Unit Profile, 2023)

The graph shows that the SEC value range of the downstream industry from 2021 to 2022 decreased significantly. In 2021, the downstream industry has a SEC value range of 1.37 - 20.27 GJ/ton, while in 2022 the range is 1.48 - 4.70 GJ/ton. The year 2022 is the year with the lowest SEC value compared to the previous years.

Energy Efficiency

The downstream industrial pilots that are the subject of this study show a range of energy efficiency percentage improvements from -9% to 77% in 2022, based on 2021 specific energy consumption data as the basis for data projection. The percentage increase in energy efficiency in the three intermediate pilot industries in 2022 with the 2021 data base projection is around 86%, with an average increase of 34%. This shows that the downstream industry has experienced an increase in the percentage of energy efficiency, with evidence that the actual energy consumption data is smaller than the projected energy consumption data in 2022 with the 2021 SEC base. The complete data can be seen in Table 11 and Table 24.

It should be noted that, as shown in Table 23, there are anomalies in the iron and steel production numbers in PT SPINDO's Sustainability Report, so the values used in this analysis still need to be validated.

6.2. Carbon (CO_2)

In the iron and steel industry, greenhouse gas emissions are an important aspect that needs to be carefully monitored and managed. As the industry with the second largest energy consumption, the iron and steel industry is an industry that produces a very large amount of greenhouse gas emissions. The increase in greenhouse gas emissions is largely due to the use of inefficient energy methods, and will be harmful to the environment and humanity through its negative impact on climate change. Land use change, the burning of fossil fuels in the industrial production process, as well as the inefficiency of the fuel combustion process, are the reasons for the increase in carbon emissions.

Carbon emissions, mainly in the form of carbon dioxide (CO_2), are a major contributor to the increasing greenhouse effect, and come from a variety of sources, including human and natural activities. Therefore, this study focuses on measuring CO_2 emissions, which are limited to two main aspects: first, from fuel combustion for heat energy (known as scope 1); second, from electrical energy use for production (known as scope 2).

Greenhouse gas (GHG) emissions intensity is the ratio of non-product output to one tonne of product input. The lower the emissions intensity, the less emissions produced per tonne of product, and the more efficient the production process.

6.2.1 Intermediate Industry

In the intermediate iron and steel industry pilots, namely GRP, KS, and GDST, GHG emissions in 2020-2022 are in the range of 16,018 Tonnes CO_2e - 737,113 Tonnes CO_2e. Figure 23 below compares the greenhouse gas emissions in 2020-2022 from the intermediate industries. Based on the graph, it can be seen that the range of GHG emission values continues to increase every year, in the period 2020-2022.

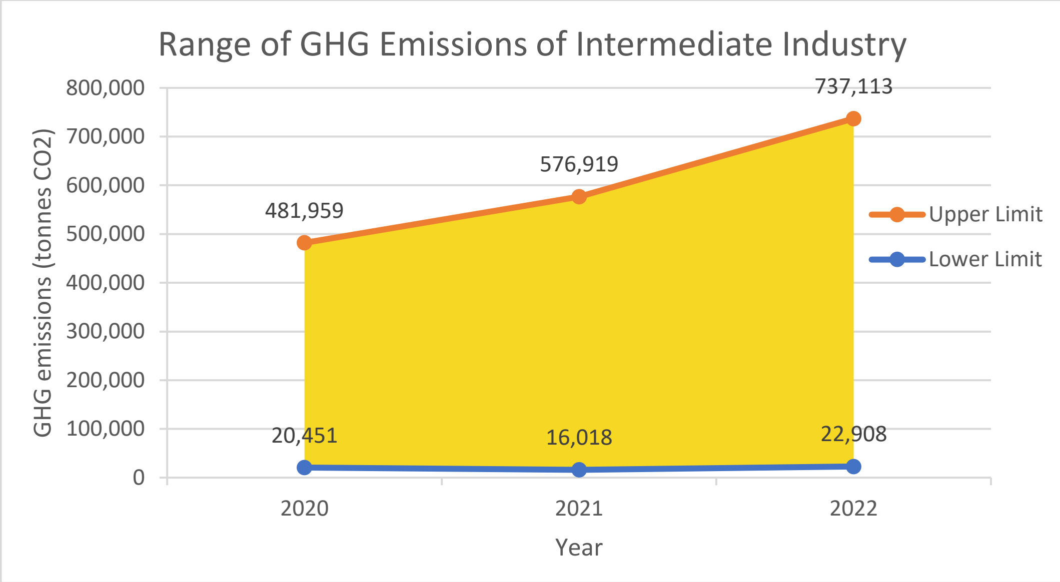

Figure 23 *Range of GHG Emissions of Intermediate Industry in 2020-2022*

Greenhouse Gas (GHG) Emission Intensity Range

To find out how much GHG emissions are produced per unit tonne of product produced, the GHG emission intensity value can be calculated. The emission intensity found in the intermediate industry in 2020 - 2022 is in the value range of 0.11 - 0.37 Tonnes CO_2e/tonne of product. Figure 24 below shows the range of emission intensity values from year to year.

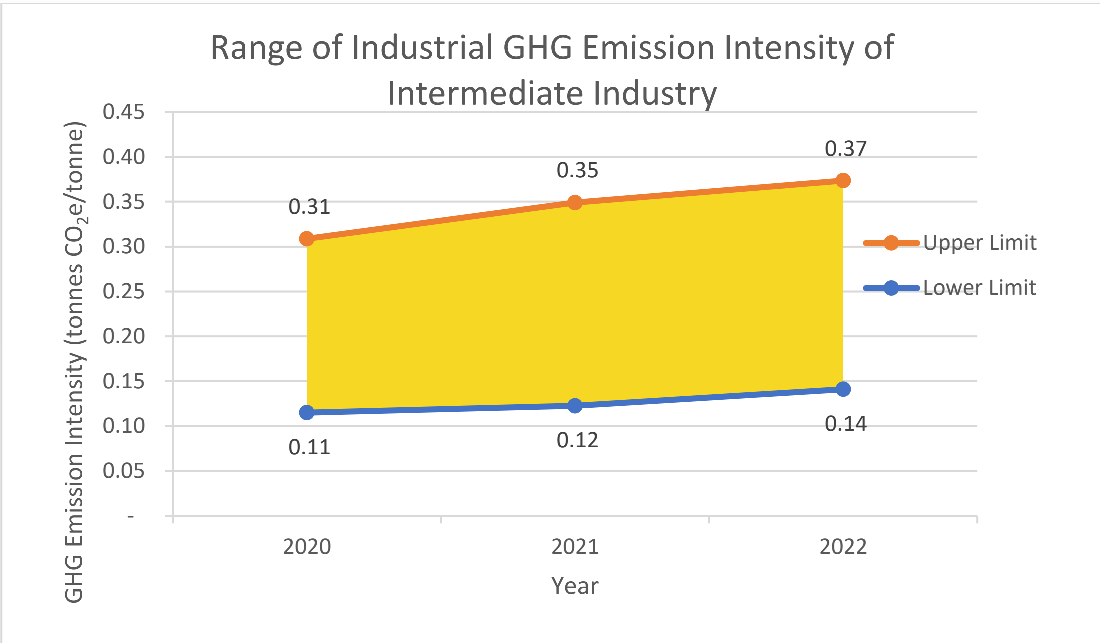

Figure 24 *Range of Industrial GHG Emission Intensity of Intermediate Industry in 2020-2022*

From the graph, it can be seen that the value of GHG emission intensity in intermediate industry during 2020 - 2022 has increased every year. This is an indication that various strategies need to be implemented to achieve more efficient production.

6.2.2 Downstream Industry

In SPINDO's downstream industry pilot, CO_2 emissions data is not included in the Company's sustainability report. Therefore, it is not possible to compare data to analyze CO_2 emissions, as TML is the only industry in the downstream steel industry category.

Unavailability of CO_2 emissions data in SPINDO's sustainability report (Table 23) makes it impossible to analyze CO_2 emissions, as TML is the only pilot industry for the downstream industry. The inequality of CO_2 emission data is due to the iron and steel industry's lack of interest in collaboration in this study, so the downstream industry RECP pilot unit only involves TML and SPINDO's sustainability report.

6.3. Water

To remedy the shortage of water and treated water, it is necessary to improve water use efficiency through optimizing the water management cycle in industry. As a first step, Specific Water Consumption (SWC) can be used as a water performance indicator to measure water use efficiency. SWC is defined as the ratio of cubic meters (m^3) of water consumed to the weight of product produced, expressed in cubic meters per tonne (m^3/tonne). SWC is calculated as the ratio of water used to produce a product.

Water efficiency improvements were calculated based on 2020 iron and steel production data. This calculation involves comparing the projected water efficiency for 2022 based on 2020 specific water consumption data with the actual water efficiency in 2022. Due to the lack of specific data on water efficiency, the calculation was carried out using the following alternative approach:

$$Water\ efficiency\ improvement = Projected\ data - actual\ data$$

$$Water\ efficiency\ improvement\ percentage = \frac{Projected\ data - actual\ data}{actual\ energy\ data} \times 100\%$$

6.3.1 Intermediate Industry

The intermediate industries in this study include PT Gunung Raja Paksi (GRP), PT Krakatau Steel (KS), and PT Gunawan Dianjaya Steel (GDST).

Specific Water Consumption (SWC) Range

Based on database calculations from the three pilot intermediate industries in 2020 to 2022, the SWC of the intermediate industry is in the value range of 0.60 to 2.98 m^3/ton with an average SWC value of 1.45 m^3/ton of product for each year. The following graph (Figure 25) shows the range of SWC values of the intermediate industry pilots.

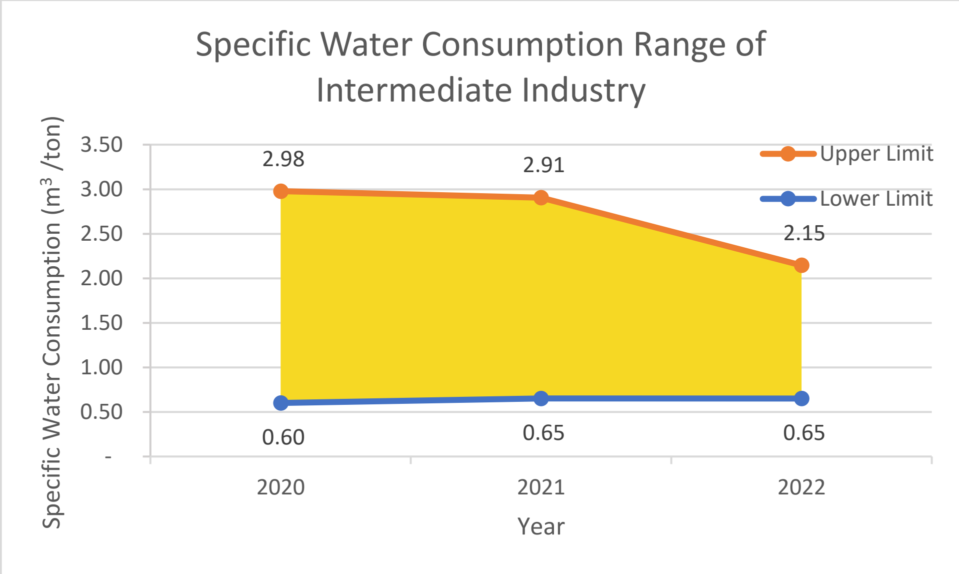

Figure 25 Specific Water Consumption Range of Intermediate industry 2020-2022

From the graph, it can be seen that the range of industry Specific Water Consumption (SWC) values between 2020 - 2022 is decreasing. In 2020, the value range was 0.60 - 2.98 m³/ton, while in 2021 it became 0.65 - 2.91 m³/ton, and in 2022, the value range shrank to 0.65 - 2.15 m³/ton. The year 2022 recorded the lowest range of SWC values in the last three years at 1.5 m³/ton, with an overall average SWC of 1.45 m³/ton. As the range of SWC values narrows, there is a decrease in water consumption in the industry, signaling an increase in water use efficiency. Therefore, it is recommended that the intermediate industries maintain and improve strategies to increase water use efficiency.

Water Efficiency

The intermediate industrial pilots subject to this study showed a range of water efficiency improvements from -8% to 28% in 2022, based on 2020 specific water consumption data. The average efficiency improvement reached 16%, with a total improvement range of 36%. Overall, the iron and steel industry in 2022 shows an improvement in water efficiency, evidenced by actual water consumption data that is lower than the 2020 projection. Complete data can be seen in Table 7,Table 17, and Table 21.

6.3.2 Downstream Industry

The study includes two downstream industries as pilots, namely PT Tata Metal Lestari (TML) and PT Steel Pipe Industry of Indonesia (SPINDO). Analyses can only be conducted for 2021 and 2022 as PT SPINDO's Sustainability Report data is only available for these two years.

Specific Water Consumption (SWC) Range

Based on database calculations from both downstream industry pilots for 2021 to 2022, SWC is in the range of 0.16 to 0.73 m³ /ton with an average SWC value of 0.47 m³ /ton of product for each year. The following graph (Figure 26) shows the range of SWC values from the downstream industry pilots.

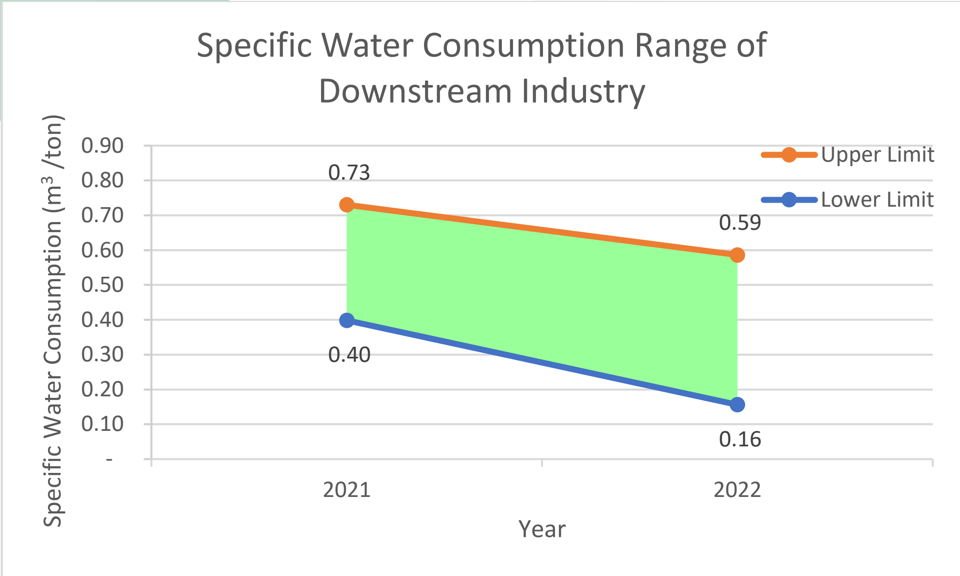

Figure 26 Specific Water Consumption Range of Downstream Industry in 2021-2022

From the graph, it can be seen that the Specific Water Consumption (SWC) value range of the downstream industry from 2021 to 2022 has decreased significantly. In 2021, the downstream industry has a SWC value range of 0.40 - 0.73 m^3/ton, while in 2022, the value range drops to 0.16 - 0.59 m^3/ton. The year 2022 recorded the lowest SWC value compared to the previous years.

Water Efficiency

The downstream industry pilots subject to this study show a range of water efficiency from -47% to 79% in 2022, based on specific water consumption data in 2021. The average efficiency improvement was 16%, with a total improvement range of 126%. Overall, the iron and steel industry in 2022 showed an improvement in water efficiency, as evidenced by the actual water consumption data being lower than the 2020 projections. Complete data can be seen in Table 12 and Table 25.

It should be noted that, as shown in Table 23, there are anomalies in the iron and steel production numbers in PT SPINDO's Sustainability Report, so the values used in this analysis still need to be validated.

6.4. Financial Benefits

Energy, water efficiency and carbon emission reduction efforts not only provide significant environmental benefits, but also have a positive impact on the financial aspects of the company. By reducing energy and water consumption, companies can save on operational costs. Meanwhile, reducing carbon emissions has the potential to generate tax incentives, lower employee health costs, and strengthen the company's figure in the eyes of increasingly environmentally conscious consumers and investors. By understanding these potentials, companies can take strategic steps to improve their financial performance.

The energy and water efficiency savings, as well as carbon emission reductions from the five-pilot intermediate (GRP, KS, GDST) and downstream (TML and SPINDO) steel industries, are measured in unit costs. These savings are calculated by comparing actual data for 2022 with projected data for the same year. Savings calculations were carried out for energy, water, and potential carbon economy savings variables, assuming the price of each variable was US$ 26.16/GJ, US$ 1.3/m^3, and US$

10/tonne CO2e, respectively. Details of savings based on energy efficiency, water, and carbon emission reductions can be found in Table 26 and Table 27.

Table 26 Financial Benefits of Energy Efficiency, Water, and Carbon Economic Value of Intermediate Industry

Category	Total Cost ($)			
	GRP	GDST	KS	Total
Energy consumption	-$8.460.144	$138.159	$40.113.389	**$31.791.404**
Water Consumption	$933.751	-$12.050	$2.036.844	**$2.958.545**
GHG Emissions	-$2.551.540	-$24.570	$385.180	**-$2.190.930**

Table 27 Financial Benefits of Energy Efficiency, Water, and Carbon Economic Value of Downstream Industry

Category	Total Cost ($)		
	TML	SPINDO	Total
Energy consumption	-$388.754	$925.799.501*	**$925.410.747**
Water Consumption	-$30.849	$1.696.355*	**$1.665.506**
GHG Emissions	-$47.769	$0**	**-$47.769**

*Data anomaly: 2022 production increased sharply compared to 2021, but energy and water use did not.

**Unavailability of data from PT. SPINDO

Overall, from the two tables above, the value of savings made in each variable and the number of companies that make savings are as follows:

1. The total energy savings generated by the intermediate industry pilot was $31,791,404, while the energy savings from the downstream industry pilot was $925,410,747. These savings show the significant benefits of energy efficiency, allowing the industry to realize greater profits. Despite the overall energy cost savings, only three out of five companies actually made savings.

2. The total water savings generated by the intermediate industry pilot was $2,958,545, while the water savings from the downstream industry pilot was $1,665,506. These savings show the significant benefits of water efficiency, so that the environmental impact of the production process can be reduced, especially in terms of water availability for the surrounding environment. In addition, the company can also reduce operational costs to treat or purchase water. Despite the overall savings in water use costs, in reality only three out of five companies actually made savings.

3. PT SPINDO could not be included in the financial analysis of carbon economic value due to limited data provided in its sustainability report. Of the four companies with GHG emissions data, three did not achieve cost savings for carbon economic value (negative cost value), while only one did achieve cost savings for carbon economic value. The savings generated are also still relatively minimal when compared to the other three variables. This shows that the iron and steel industry in Indonesia still faces major challenges in reducing greenhouse gas emissions.

The results of the savings analysis show that the Indonesian iron and steel industry still does not consider production efficiency and GHG emission reduction as a priority, so it needs internal and external encouragement. This encouragement can come from the government, for example by setting thresholds for GHG emissions intensity and SEC, and encouraging companies to attend seminars on the benefits of cleaner production to business and how it can be applied in the iron and steel industry. Meanwhile, the savings efforts that have been made need to be maintained and improved.

6.5. Analysis of Survey Results on the Iron and Steel Industry Policy Dialogue Agenda

On Thursday, 30 November 2023, the Green and Circular Implementation Policy Dialogue for Green Industry Development in Indonesia was held. In session III, there was a Focus Group Discussion involving the iron and steel industry. A total of 4 companies from the sector participated in the discussion and survey, namely PT Tata Metal Lestari, PT Gunung Raja Paksi, PT Krakatau Steel Tbk, and PT Sunrise Steel. The following are the results of the policy survey in the iron and steel industry:

a. Iron and Steel Industry Profile

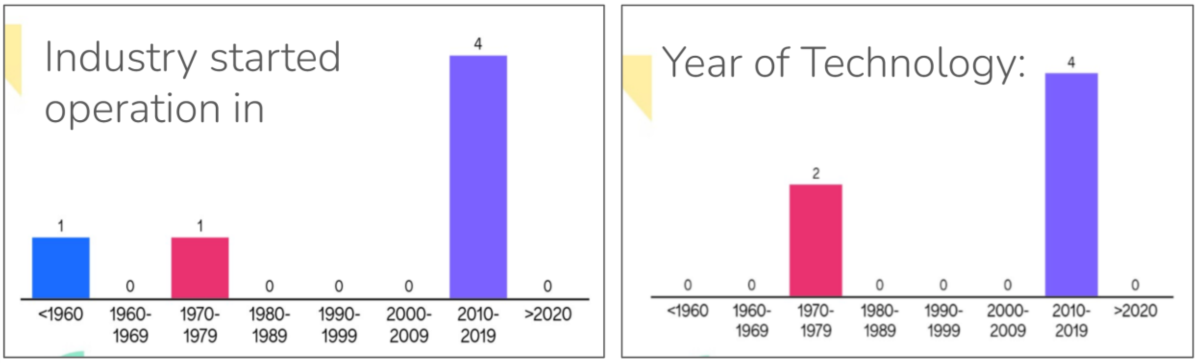

Figure 27 Iron and Steel Industry Profile Survey Results

Based on the results of the discussion, the majority of the iron and steel industries present, have been established and began operating the technology used in 2010 - 2019, there is only one industry that was established in 1970 - 1979. Revitalization of technology to the latest technology has not yet been carried out by all iron and steel industries present. This could be prioritized as newer technologies generally have higher production efficiency and produce better quality products. In addition, the iron and steel industry opens a very wide door for the circular economy as all of the industry's products are recyclable. Currently, the iron and steel industry has implemented the concept of recycling and the recycled content of products has reached 20%.

b. **Technology Innovation to Support a Better Circular Economy**

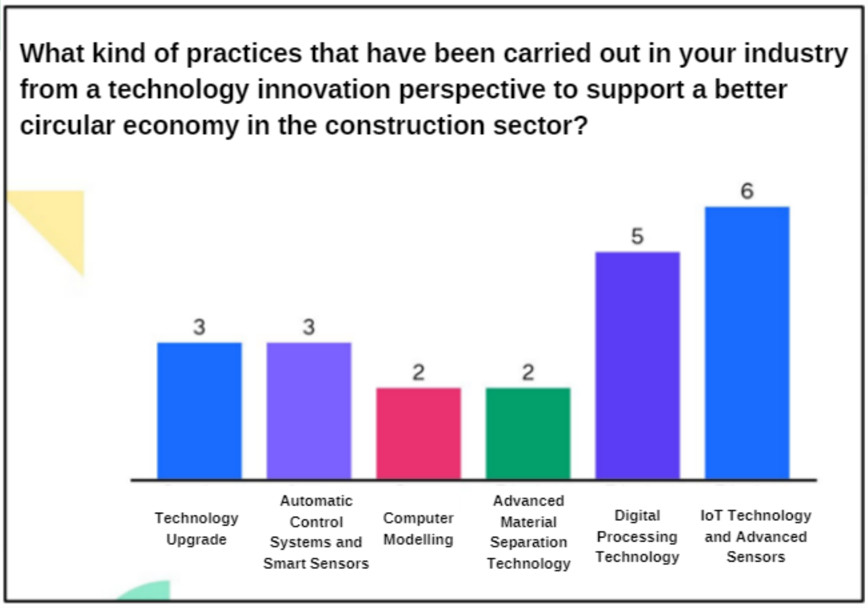

Figure 28 Survey Results of Technological Innovation in the Iron and Steel Industry

Technological innovations used in the iron and steel industry include plant revitalization, automatic control systems and smart sensors, computer modelling processes, material separation technologies, digital processing technologies, IoT (Internet of Things) technologies and sensors. Of the six innovations, the iron and steel industry is already using digital processing technology and IoT technology with the latest sensors to improve a better circular economy, where by using digital processing technology and IoT with the latest sensors, the production process can be carried out optimally, because automatic control systems connected to advanced sensors can monitor performance in real-time and can help in regulating temperature, pressure, and other parameters efficiently.

c. **Improving Energy Efficiency to Support a Better Circular Economy**

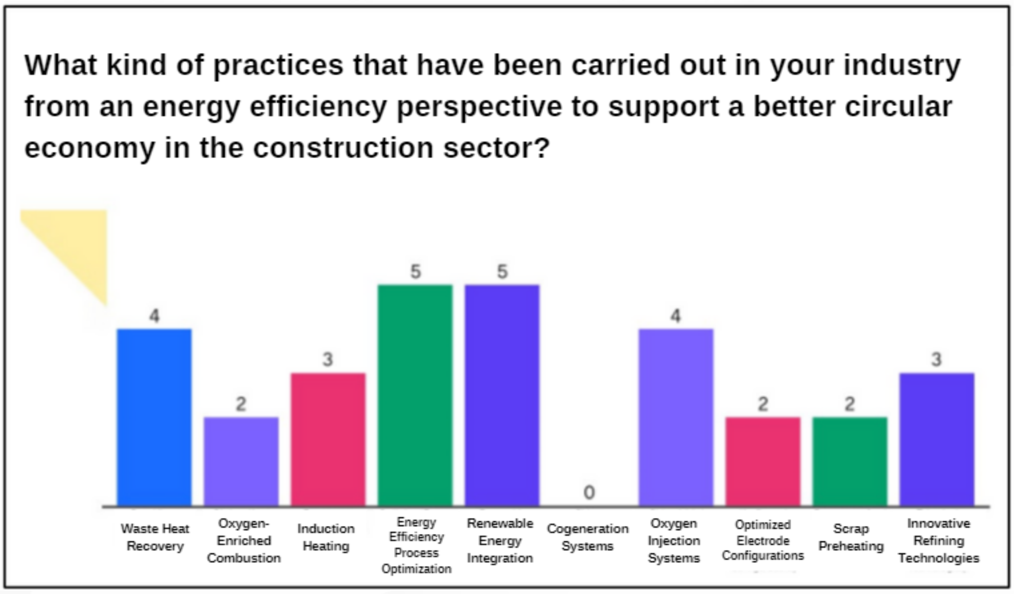

Figure 29 Survey Results of Energy Efficiency Improvement Efforts in the Iron and Steel Industry

Energy efficiency improvement efforts that have been made by the iron and steel industry include:

- Waste Heat Recycling
- Oxygen Rich Combustion
- Induction Heating
- Energy Process Optimization
- Renewable Energy Integration
- Oxygen Injection System
- Electrode Configuration Optimization
- Scrap Preheating
- Innovative Refining Technology

Of these nine measures, the majority of the iron and steel industry applies energy process optimization, renewable energy utilization, heat recovery systems, and oxygen injection systems in practice.

By improving energy efficiency and adopting sustainable practices, the industry can optimize the use of raw materials and minimize waste generation. Using renewable energy helps the iron and steel industry to reduce carbon emissions. Non-product outputs, such as heat, are used by the iron and steel industry for recycling to minimize the additional energy and materials needed to generate heat energy for the process. By implementing heat recycling and oxygen injection systems, the industry can optimize the use of raw materials and minimize waste. Waste generated from the production process can be reused in the production cycle, creating a circular economy, where existing materials are continually reused.

VII. Findings and Recommendations

7.1. Findings

The iron and steel industry in Indonesia had limited participation in this RECP study, with only two industries, PT Gunung Raja Paksi and PT Tata Metal Lestari, actively involved. The information obtained from the other companies is partly derived from the published information of the company's sustainability report.

Table 28 Recapitulation of RECP Profile of Pilot Unit and Pilot SR Data in 2022

Item	Intermediate Industry			Downstream Industry	
	Pilot Unit	SR data		Pilot Unit	SR data
	GRP	GDST	KS	TML	SPINDO*
Specific Energy Consumption (GJ/tonne)	3,13	2,56	3,25	1,48	4,70
Specific Water Consumption (**m³** /ton)	0,95	0,65	2,15	0,59	0,16
Specific Rainwater Utilisation (**m³** /ton)	-	-	-	0,04	-
Specific CO_2 emissions (t-CO_2e/ton)	0,37	0,14	0,286	0,19	-

* Notes: There are anomalies in the values of iron and steel production in PT SPINDO's Sustainability Report, so the values included in this analysis still need to be validated. CO_2 emissions are also unknown because the substance of CO_2 was not measured in the stack and flue gas emissions measurement.

Several iron and steel companies in Indonesia have created action plans to achieve zero carbon emissions, demonstrating a commitment to sustainability initiatives. Efforts that have been made by the iron and steel industry include installing solar renewable energy technology, recycling water and utilizing rainwater to maximize energy and water efficiency in the production process.

In achieving zero carbon emissions, the iron and steel industry also experiences various obstacles. Based on the results of discussions during the field visit, several obstacles faced by the pilot unit that led to low environmental performance improvement were identified, including:

a. **Lack of Scrap Recycling Infrastructure**

The iron and steel industry in Indonesia faces serious environmental challenges due to the lack of an undeveloped recycling infrastructure. This shortage results in the scarcity of scrap, which is a critical component in the manufacture of environmentally friendly iron and steel. The limited availability of scrap is an obstacle in meeting production demands for more sustainable steel options. To overcome this, companies are forced to look for alternative raw materials, such as Hot Briquetted Iron (HBI). However, the use of HBI as a substitute for scrap creates another problem in terms of increased energy use intensity in the iron and steel production process.

b. Expensive Technology Investment

Investments in modern technologies such as milling technology, which is one of the highest emitters in the steel industry, or the adoption of renewable energy sources such as solar power, are considered important steps to improve efficiency in the iron and steel industry. However, high initial costs for installation, operation, and maintenance are often the main barriers to adopting such technologies.

c. Limited Land for Installation of Renewable Energy Sources

Limited land for the installation of renewable energy sources is also a challenge for iron and steel companies in improving their energy efficiency.

d. Product Quality Considerations and Technical Adjustments

In addition to the cost aspect, the replacement of new technologies, especially key technologies such as milling, also requires thorough consideration as it can affect the quality of the products produced. The technical adjustment in operating the new technology is also a challenge for iron and steel companies in achieving efficiency in their operations, both in terms of the environment, as well as in terms of production capacity and quality.

e. Lack of Expertise in Environmental Management

The lack of knowledge and understanding of the principles, concepts, and technical calculations regarding environmental sustainability in the iron and steel industry results in inappropriate decision-making in managing the company's environment. Therefore, human resource training on environmental sustainability needs to be carried out to improve knowledge and ability to make the right decisions in managing the company's environment.

As the replacement of industrial technology requires large investments, companies have to allocate the necessary time and funds for research and analysis to choose the right technology investment, so the improvement of the iron and steel industry cannot be achieved in the near future.

Despite the challenges, three of the five pilot companies in the iron and steel industry have achieved efficiencies in energy and water use. Assuming an electrical energy cost of US$26.16/GJ and a water cost of US$1.3/$m^3$, energy efficiency in the intermediate industry pilot resulted in cost savings of $31,791,404, while in the downstream industry pilot it reached $925,410,747. Cost savings for water efficiency in the intermediate pilots totaled $2,958,545, and in the downstream pilots $1,665,506. However, only one in five companies achieved cost savings for carbon economics. The savings generated are also still relatively minimal when compared to the other three variables. This shows that the iron and steel industry in Indonesia still faces a big challenge in reducing greenhouse gas emissions.

7.2. Recommendations Management of Environmental Aspects

The steel and iron industry prioritizes environmental sustainability as an integral part of its operations. They demonstrate awareness of the importance of environmentally and economically sound strategies and technologies to improve environmental performance, reflecting a proactive approach to sustainability. These measures include:

a. Scrap Material

The iron and steel industry can improve sustainability by effectively utilizing scrap materials. The use of scrap not only reduces the need for raw materials and carbon emissions in the production process, but also supports circular economy principles by reducing waste. With effective scrap management and utilization strategies, the industry can become more environmentally friendly and efficient.

b. Energy Efficiency

The iron and steel industry has significant opportunities to improve environmental sustainability, particularly through improved energy efficiency. The enormous and intensive use of energy, especially in the steel smelting and grinding processes, marks the industry as one of the major energy users. Active efforts to improve the energy efficiency of the technologies used are a key focus, with the adoption of energy-efficient technologies such as advanced furnaces and waste heat recovery systems. This not only supports the achievement of global sustainability goals, but also provides significant economic benefits through reduced operating costs. While achieving energy efficiency in the industry can be challenging, the potential for improvement is vast and largely dependent on the investments made.

In an effort to improve energy efficiency in the industry, a number of concrete steps can be taken to reduce energy consumption including:

- Increase the use of renewable energy, such as the use of energy-efficient or LED lighting in all operational areas.
- Installation of solar panels that can be useful for energy efficiency.
- Using selective waste gas recirculation (SWGR) in the sintering process to reduce energy consumption.
- Use of automatic switch interlock systems on engines and pumps.
- Sub-metering of electricity at key points of use.
- Boiler efficiency monitoring.
- Implement TV Zone System for combustion optimization to save natural gas consumption.
- Implement a continuous line system in the use of machines so as not to drain large amounts of energy.
- Use of a recuperator or heat exchanger to recover heat for recycling.
- Switch to renewable energy sources such as solar, wind or biomass to reduce your carbon footprint. This can be done by investing in renewable energy projects or purchasing green energy from the grid.

c. New and Renewable Energy

The iron and steel industry is well positioned to improve its environmental sustainability by utilizing new and renewable energy. This move has great potential in reducing carbon emissions and is in line with global efforts to tackle climate change. While it requires significant initial investment for technologies such as solar panels, the benefits include reduced energy costs and smaller environmental impacts over time. The adoption of renewable energy also offers opportunities to reduce dependence on fossil fuels and strengthen the industry's sustainability figure. With appropriate policy support and incentives, the iron and steel industry can utilize renewable energy in its operational processes.

d. Water Efficiency

The iron and steel industry has a great opportunity to improve water use efficiency, an important step towards environmental sustainability. Optimizing water use not only reduces consumption and waste, but also reduces operating costs. By implementing more efficient technologies and processes, such as water recycling systems, rainwater harvesting, and wastewater treatment, the steel industry can minimize its usage and reduce its impact on local water resources.

In an effort to improve water efficiency in the industry, a number of concrete steps can be taken to reduce water consumption including:

- Reuse of production water from the cooling tower for the production process.
- Metering and sub-metering of water use/discharge points and establishment of work indicators.
- Regular preventive maintenance of the machine and repair of all leakage points.
- Recycling of clear water and treated wastewater.
- Reduced cleaning cycle with the use of high-quality materials.
- Use of polyelectrolytes in wastewater treatment.
- Rainwater collection and vapor condensate recovery.
- Improve the efficiency of the water-cooling system.
- Implement the 5R system (Ringkas, Rapi, Resik, Rawat, Rajin) and good spatial planning to prevent spills and leaks.

e. Reduction of Greenhouse Gas (GHG) Emissions

The iron and steel industry has a great responsibility in reducing greenhouse gas emissions, especially CO_2 emissions, resulting from its production processes. Emission reduction efforts can be carried out through various steps including:

- Conduct a reforestation programme to address carbon offsets;
- Installation of CEMS (Continuous Emissions Monitoring System) as an emission monitoring tool to monitor and record emission data continuously;
- Replace damaged or obsolete engines to reduce emissions;
- Conduct routine machine maintenance and calibrate equipment according to the specified period so as to minimize the intensity of emissions produced;
- Boiler efficiency monitoring.

7.3. Policy Recommendations

7.3.1 Informal Sector Policy Recommendations

The iron and steel industry is one of the crucial sectors that contribute significantly to economic and industrial development. On the other hand, the informal sector in this industry faces various challenges, including limited access to clean technology, lack of policy support, and constraints in implementing RECP. To address these challenges and promote increased sustainability, comprehensive and targeted policies are needed. The following are some policy recommendations that aim to strengthen the informal sector in the iron and steel industry:

a. Policy Integration and Formalisation

- Create an Incentive Programme: Develop a government programme that incentivizes informal scrap collectors through subsidies, training, and access to health and social services.
- Establish a Legal Framework: Implement regulations that recognize and integrate the informal sector into the formal waste management system, by providing legal status and protection.
- Partnerships with the Private Sector: Encourage public-private partnerships where businesses in the iron and steel industry collaborate with scrap metal collectors, offering fair prices and stable demand.
- Scrap Market Formalization and Digitalization: Implement a transparent and open scrap and steel market digitalization for all sectors both formal and informal to boost *scrap* availability in Indonesia's local market.

b. Capacity Building and Training

- Provide Training and Education: Offer training to informal scrap metal collectors on safe handling, sorting, and processing of scrap materials to improve the quality of scrap metal collected.
- Health and Safety Standards: Educate on health and safety practices to minimize risks associated with handling potentially hazardous materials.

c. Infrastructure Development

- Develop Collection Centers: Facilitate the establishment of community-based collection centers where informal collectors can sell their scrap directly to formal intermediaries or industry representatives.
- Improve Sorting and Processing Facilities: Invest in local sorting and processing facilities that can serve as hubs for the informal sector, equipped with equipment to improve the quality of used goods.

d. Financial and Technical Support

- Microfinance and Credit Schemes: Introduce microfinance programmes to provide informal waste collectors with the capital needed to invest in equipment, transport or personal protective equipment.
- Access to Recycling Technologies: Make small-scale and affordable recycling technologies accessible to the informal sector to improve the overall efficiency and quality of used materials.

e. Integration into the Supply Chain

- Supply Chain Recognition: Recognize the role of the informal sector in the iron and steel industry supply chain and create mechanisms for stable supply and demand dynamics.
- Contracts and Agreements: Encourage formal contracts between businesses and informal sector representatives to provide stable income and formalize trade.

f. Environmental and Social Considerations

- Environmental Impact Assessment: Conduct an assessment to ensure that the collection and processing of scrap by the informal sector does not negatively impact the environment.
- Community Development Initiatives: Engage in community development initiatives that improve the living conditions of informal sector workers, which in turn can improve their productivity and efficiency.

7.3.3 Other Policy Recommendations

a. Duty Waivers for Sustainable Practices

- Incentivizing Sustainable Imports: Implement duty waivers for the iron and steel industry to import machinery and technologies that improve resource efficiency and reduce environmental impact.
- Support for Local Recycling: Offer duty exemptions for imports of high-quality scrap metal to encourage recycling in the industry, where local supply is insufficient.
- Boosting Technology Upgrades: Provide tax incentives to import advanced equipment that reduces emissions and energy consumption, as part of a commitment to low-carbon development.
- Facilitating Compliance: Implement a tiered duty waivers system that rewards industries based on their level of compliance with environmental standards, which encourages continuous improvement.
- Capacity Building: Ensure that duty waivers are accompanied by technical assistance programmes to help the industry make effective use of the imported technology.

b. Assistance in Scope 3 GHG Calculation

c. Green Industry Standard (SIH) in stages

d. Incentives for green steel production

e. Green taxonomy for iron and steel

f. Data synchronization/data management across ministries

g. Assistance in implementing circular economy for iron and steel industry

7.4. Management Recommendations

In implementing production processes in the iron and steel industry, some management recommendations that can improve resource efficiency (environmental and social) include; Implementation of energy management systems and audits, employee training and development related to environmental management, implementation of environmental management systems throughout the iron and steel industry, implementation of heat/steam recovery systems throughout the iron and steel industry, and comprehensive and integrated data collection systems.

7.5. Financial Recommendations

1. Long-term technology replacement options require substantial funding, hence the need for long-term corporate strategies. Synergies are needed with financial institutions regarding sustainable funding mechanisms to accelerate the implementation of resource efficiency and cleaner production that can reduce significant greenhouse gas emissions in the iron and steel industry (stakeholders: BAPPENAS, Ministry of Industry, Ministry of Energy and Mineral Resources, Ministry of Environment and Forestry) .
2. The funding mechanism can be synergized with the roadmap for sustainable finance phase II (2021 - 2025) issued by OJK. Some examples of sustainable finance implementation include financing for new and renewable energy projects (financing of electricity sourced from hydro, geothermal, solar energy, biogas, biomass, and other renewable energy sources, energy efficiency, etc.) - Green Taxonomy.

7.6. LCA Recommendations

RECP studies in the iron and steel industry can be enhanced through Life Cycle Assessment (LCA) studies. The RECP study with system boundary from gate-to-gate can be extended to cradle to grave. This study is conducted with the following objectives:

1. LCA provides a comprehensive analysis of the environmental impacts of iron and steel products throughout their life cycle, from raw material extraction to product disposal. This helps companies understand where the greatest environmental impacts occur and identify opportunities for improvement.
2. By identifying the life cycle phases that generate the most carbon emissions, companies can design strategies to reduce these emissions, for example by optimizing production processes, using renewable energy or improving energy efficiency.
3. Developing more sustainable products. This could include designs that allow for easier recycling, the use of greener raw materials, or more efficient production technologies.
4. Improve efficiency in the industry through appropriate production technology, efficient use of raw materials, and optimal waste management to ensure that resources are used in accordance with production needs, at the right time, and in the right place to minimize waste and environmental impact.

7.7. RECP Study Challenges

The implementation of RECP studies in the iron and steel industry faces various challenges. Despite the potential benefits, including emission reductions, higher energy efficiency, and production cost savings, the implementation of RECP studies requires addressing various obstacles faced, both internal and external to the iron and steel industry. Here are some of the challenges of RECP studies in the iron and steel industry:

1. This RECP study has been communicated to IISIA and its 169 members. However, the incentives/facilities provided by the Indonesian government through technical assistance in this study were not fully utilized, with only two (2) companies willing to participate in the pilot.
2. There are questions about the industry's commitment to improving efficiency, such as government incentives for the sector are not being utilized.
3. The government needs to communicate the incentives mechanism to the stakeholders. This will broaden understanding and accessibility to government assistance.

7.8. Recommendations for the Study: Value Creation

Given the multiple challenges in implementing the RECP strategy in the iron and steel industry, a multidimensional value-creation approach is required to enable the industry to optimally capture the potential benefits of the RECP study. The following recommendations can be followed for value creation:

1. **Economic Value of Technical Assistance**

   Provide a clear economic valuation of technical assistance so that industries can see the real benefits and competitive advantages they can gain.

2. **Awareness of Competitive Advantage**

   While competitive advantages gained from government support of any kind do not necessarily need to be publicized, they should be identified as areas of internal improvement.

3. **Perception of the Role of Government**

   There is a fear of industry being penalized as a polluter rather than seeing the government as a source of help or guide. Therefore, more work is needed to modify the perception of the governance.

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