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Future Outlook for the Decarbonisation of the Steel Industry in Asia

Prepared by	Pacific Consultants Co., Ltd. The Institute of Energy Economics, Japan Nippon Steel Technology Co., Ltd.
With the Support of	Economic Research Institute for ASEAN and East Asia

Economic Research Institute for ASEAN and East Asia

Future Outlook for the Decarbonisation of the Steel Industry in Asia

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As we move into the next phase of the project, we look forward to continued engagement and cooperation with all stakeholders. We truly appreciate the commitment and support that have made the achievements of Phase 1 possible.

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List of Abbreviations and Acronyms

AJSI	ASEAN Japan Steel Initiative
ASEAN	Association of Southeast Asian Nations
BAT	Best Available Technology
BF-BOF	Blast Furnace-Basic Oxygen Furnace
BPS	Bureau of Philippine Standards
CBAM	Carbon Border Adjustment Mechanism
CCS	Carbon Capture and Storage
CCUS	Carbon Capture, Utilisation and Storage
CO_2	Carbon Dioxide
EAF	Electric Arc Furnace
ERIA	Economic Research Institute for ASEAN and East Asia
EU	European Union
G7	Group of Seven
GDP	Gross domestic product
GHG	Greenhouse gas
GJ	Gigajoule
Gt	Gigatonne
IEA	International Energy Agency
IEEJ	The Institute of Energy Economics, Japan
IFC	International Finance Corporation
ISA	Indian Steel Association
ISIT	Iron and Steel Institute of Thailand
ISO	International Organization for Standardization
JISF	The Japan Iron and Steel Federation
LCC	Life Cycle Cost
LeadIT	Leadership Group for Industry Transition
MJ	Megajoule
MOU	Memorandum of Understanding

Mt	Million Tonnes
OECD	Organisation for Economic Co-operation and Development
PDCA	Plan-Do-Check-Action
RHF	Reheating Furnace
SEAISI	South East Asia Iron and Steel Institute
SEI	Stockholm Environment Institute
SIMA	Sponge Iron Manufacturers Association
TCL	Technologies Customized List
TERI	The Energy and Resources Institute
UTM	University of Technology Malaysia

Executive Summary

The steel industry is highly energy-intensive, and decarbonisation of the steel industry is a key focus in the context of the global transition to carbon neutrality. This study addresses the challenges of achieving economic growth whilst reducing greenhouse gas (GHG) emissions in the steel sector. The World Steel Association (worldsteel) outlines its basic position on decarbonisation as follows: 'The production of steel remains a CO_2 and energy-intensive activity. However, the steel industry is committed to continuing to reduce the footprint from its operations and the use of its products. Our industry fully supports the aims of the Paris Agreement. There is no single solution to drastically reducing CO_2 emissions from our industry.'[1]

Without a doubt, Asia is one of the world's major steel industry clusters, and steel production occupies a key role in the region's industrial sector. The Economic Research Institute for ASEAN and East Asia (ERIA) is engaged in a wide range of research activities on energy, environment and climate change, innovation and technology, and other related areas. The current research project is part of ERIA's efforts to study the decarbonisation of the steel industry in Asia. This project aims to produce the 'Asia Steel Decarbonisation Outlook' (hereinafter referred to as the 'Outlook') outlining the overall status and future prospects of decarbonisation of Asia's steel industry, as well as the 'Towards a Net-Zero Steel Industry in Asia' Guidelines (hereinafter referred to as the 'Guidelines') for the purpose of systematic planning, implementation, evaluation, and improvement of the decarbonisation of steel plants. These outcomes will subsequently be discussed with international stakeholders to foster a common understanding of steel industry decarbonisation amongst the governments and industry representatives of the countries involved. This study will highlight key approaches for achieving decarbonisation in the steel industry in Asia and reflect on the policies and methods that are suitable for this fast-growing region with regard to decarbonisation.

During Phase 1 (2024–2025), the project began preparing the Outlook, providing a comprehensive analysis of the current state and future prospects of steel production and decarbonisation efforts in the Association of Southeast Asian Nations (ASEAN) region. The project considered crude steel production trends, energy intensity, production methods, regulatory environments, and emerging green steel initiatives, highlighting the challenges and opportunities for sustainable steel industry transformation in Asia.

Energy intensity in steel production, measured in megajoules (MJ) per tonne (t) of crude steel, varies across ASEAN countries. Viet Nam and Indonesia exhibit energy intensities close to or slightly above the global average of 21 MJ/t, in part due to their relatively

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[1] World Steel Association, *The Production of Iron and Steel*. https://worldsteel.org/climate-action/climate-change-and-the-production-of-iron-and-steel/ (accessed 5 September 2025).

recent adoption of blast furnace technology. Countries with higher shares of electric arc furnace (EAF) steel tend to have lower energy intensity; however, challenges in securing high-quality scrap limit EAF expansion. The rapid economic growth in Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam (hereafter referred to as the 'ASEAN 7') may lead to increased electrification, potentially putting stress on electricity demand and supply, as well as on renewable energy markets.

Some ASEAN countries, in particular Viet Nam and the Philippines, are notable for the significant presence of induction furnace-based steel production. These small-to-medium scale operations are less efficient and more polluting, raising environmental and safety concerns.

To analyse steel demand and production, a demand-driven modelling approach is adopted, where steel product demand determines crude steel production. The relationship between steel consumption and economic growth is nonlinear, with rapid steel demand increases during industrialisation phases and eventual saturation or decline as economies mature, as exemplified by historical data from the United States, Japan, and East Asia.

The model incorporates:

- A logistic regression to capture the effect of real gross domestic product (GDP) per capita and industrial sector value added on steel product consumption.
- Estimation of crude steel demand from steel product demand, accounting for shifts over time.
- Projection of crude steel production by method (blast furnace vs. electric furnace and others) based on economic development stages and production volume. This part is for information only.

The model is utilised for tentative analysis as part of a preliminary study aimed at understanding the fit performance of the estimation rather than as an outlook. Subsequent phases will address future steel production under decarbonisation strategies with several hypotheses.

Regarding the Guidelines, amidst the global momentum in carbon reduction, initiatives such as the Japan Iron and Steel Federation (JISF) plan to achieve carbon neutrality by publishing carbon neutrality action plans and are taking further action.

The Guidelines will be developed to consolidate insights and allow Japan's challenges and experiences to be shared and tackled together within the Asia region.

For instance, the steel industry alone can only achieve a limited impact; achieving carbon neutrality for energy sources such as electricity requires nationwide efforts.

Within this context, whilst focusing on energy-saving technologies in the steel industry in Phase 1, we will also refer to the potential of next-generation technologies, such as hydrogen-based steel production, or projects such as the CO_2 Ultimate Reduction System for Cool Earth 50 by the JISF in the next phases.

Phase 1 outlines comprehensive guidelines and research efforts aimed at achieving a net-zero steel industry in Asia, with a specific focus on Southeast Asia and India. It emphasises energy efficiency improvements as a foundational step towards decarbonisation whilst addressing the complexities of steel manufacturing processes and the need for tailored technologies and policies.

The steel sector in Asia faces the dual challenge of meeting rising steel demand whilst also reducing emissions, particularly given the new investments expected in blast furnace-basic oxygen furnace (BF-BOF) facilities in Southeast Asia and India. The Guidelines stress reducing energy consumption, adopting low-carbon energy sources such as electrification and renewables, and developing innovative technologies including hydrogen reduction and carbon capture, utilisation, and storage (CCUS). However, the improvement of energy efficiency remains the most immediate and impactful approach, with mature technologies (best available technologies, BATs) expected to account for about 70% of carbon dioxide (CO_2) emission reductions by 2050, according to the International Energy Agency's (IEA) Iron and Steel Technology Roadmap.[2]

Improving energy efficiency is complex due to the diversity of steel manufacturing processes and the long lifespans of equipment, which makes selecting effective energy-saving technologies challenging. The Guidelines promote a Plan-Do-Check-Action (PDCA) cycle for continuous energy efficiency improvement, tailored specifically to the iron and steel sector and referencing International Organization for Standardization (ISO) 50001 with additional sector-specific criteria.

A unique feature of the Guidelines is the establishment of 14 criteria to guide the selection of appropriate energy-saving equipment, emphasising factors beyond initial investment cost. These criteria include equipment specifications, installation feasibility, safety, environmental and social considerations, schedule management, life cycle cost (LCC), guaranteed performance, energy reduction potential, operational availability, durability, maintainability, post-installation support, additional benefits, and the supplier track record. This holistic approach aims to prevent suboptimal investments that could lead to operational inefficiencies or increased long-term costs.

This report provides an overview of the key features of the Guidelines supporting energy efficiency improvements and presents a methodology for updating the Technologies Customized List (TCL), which compiles BATs tailored to the needs of the target countries, with consideration of the trends in steel industry decarbonisation.

The outcomes of the Phase 1 research are summarised as follows:

- With regard to preparation of the Outlook, progress has been made in database

[2] IEA (2020), *Iron and Steel Technology Roadmap: Towards More Sustainable Steelmaking*. https://www.iea.org/reports/iron-and-steel-technology-roadmap (accessed 5 September 2025).

development and quantitative analysis of steel products, as well as crude steel production and consumption in the ASEAN region.

- The 'Towards a Net-Zero Steel Industry in Asia' Guidelines aim to be a reference document for steel plant operators to improve the energy efficiency of their plants by individually implementing the PDCA cycle. They mainly reference ISO 50001 but also integrate industry-specific considerations of the iron and steel sectors to make the Guidelines more practical. The Guidelines have been revised and refined based on feedback from the intended users, such as steel companies and other related parties involved in the iron and steel sector in Asian countries.
- The Draft TCL is a list of energy-saving and CO_2-saving technologies and environmental facilities identified as BATs that meet the needs of the target countries. The current study has updated the TCL by reviewing the technologies listed in terms of the reduction of CO_2, energy prices, and CO_2 emission factors, which forms the basis for estimating payback periods to reflect recent trends.
- As part of advocacy activities, the project members conducted the ASEAN Japan Steel Initiative (AJSI) Seminar to share and disseminate initiatives around decarbonisation in the steel sector and collect opinions from and promote collaboration in ASEAN countries. The seminar was held on 20 November 2024 in Bangkok, Thailand, as part of the South East Asia Iron and Steel Institute (SEAISI) event, '2024 ASEAN Iron and Steel Forum: Sustainable Steel and Green Construction.' Eighty-five people from nine countries/regions attended the seminar. The agenda was composed of the following three sessions:

  1. Policy Developments toward Carbon Neutrality;
  2. Activities and Challenges of Steelmakers; and
  3. Technology Developments for Energy Saving and Carbon Neutrality.

  Representatives from both the public and private sectors of ASEAN countries as well as Japan presented their policies, initiatives, and challenges.

- The 'India-Japan Public and Private Collaborative Meeting on Iron and Steel Industry' was held on 21 January 2025 with approximately 40 participants, mainly government officials and steel companies from both Japan and India. The participants engaged in lively discussions on the following three topics related to carbon neutrality in the steel industries of both countries:

  1. Policies towards Carbon Neutrality in Japan and India;
  2. Technological Trends toward Energy Conservation and Carbon Neutrality; and
  3. Climate Change-related Issues and Initiatives Faced by Steelmakers.

Chapter 1
Introduction

1. Background

To achieve decarbonised economic growth, we recognise the importance of exchanging views through dialogue and exploring policy options to enhance economic competitiveness and industrial decarbonisation, as suggested in the Asia Zero Emission Community Leaders' Joint Statement. Additionally, the prior efforts of the Group of Seven (G7) to decarbonise the global steel industry have now been integrated with the mandate of the newly established International Energy Agency (IEA)'s Working Party on Industrial Decarbonisation. Discussions have also begun amongst the World Steel Association (worldsteel) and the International Organization for Standardization (ISO) to standardise emission calculation methods. In light of these moves, it is necessary to strengthen a common approach for Asian countries, in particular members of the Association of Southeast Asian Nations (ASEAN), as well as India, to promote collaboration in the international community based on the idea of 'achieving both economic growth and decarbonisation.' Therefore, the current research aims to study the decarbonisation policies and methods suitable for the Asian steel industry with consideration of the specific regional context.

According to the 2020 IEA report on the iron and steel industries, 'among heavy industries, the iron and steel sector ranks first when it comes to carbon dioxide (CO_2) emissions, and second when it comes to energy consumption. The iron and steel sector directly accounts for 2.6 gigatonnes of carbon dioxide (Gt CO_2) emissions annually, 7% of the global total from the energy system and more than the emissions from all road freight' (IEA, 2020).

Reductions of CO_2 emissions in the iron and steel sector, therefore, have a major impact, and the development and introduction of technology to reduce CO_2 in this sector is of paramount importance. The steel industry in Asia plays a pivotal role in the global steel market, accounting for more than 70% of the world's steel production. This high level of production is accompanied by substantial carbon emissions, making the decarbonisation of the steel industry a top priority for the region.

2. Objectives of the project

To achieve decarbonisation in the steel industry in Asia, it is essential to examine, discuss, and implement policies and methods that are suitable for the fast-growing Asian region. To this end, this research project aims to develop an Outlook for the overall picture and the future prospects of decarbonisation of the Asian steel industry, as well as Guidelines for the systematic planning, implementation, evaluation, and improvement of decarbonisation of steel plants. These outcomes will be discussed with international stakeholders to foster a common understanding amongst the governments and industry representatives of the target countries.

The objectives of this study are as follows:

a) Studying, discussing, and implementing policies and methods for decarbonising the steel industry that are suitable for the rapidly growing Asian region.

b) Preparing an Outlook that outlines the overall current status and future prospects of decarbonisation of the Asian steel industry, formulating Guidelines for the systematic planning, implementation, evaluation, and improvement of energy efficiency for the purpose of decarbonisation of steel plants, and compiling a list of technologies that can contribute to energy efficiency, mitigation of environmental impacts, and future decarbonisation through conducting an expert-led survey of steel plants.

c) Sharing and disseminating the results of this research project through international workshops.

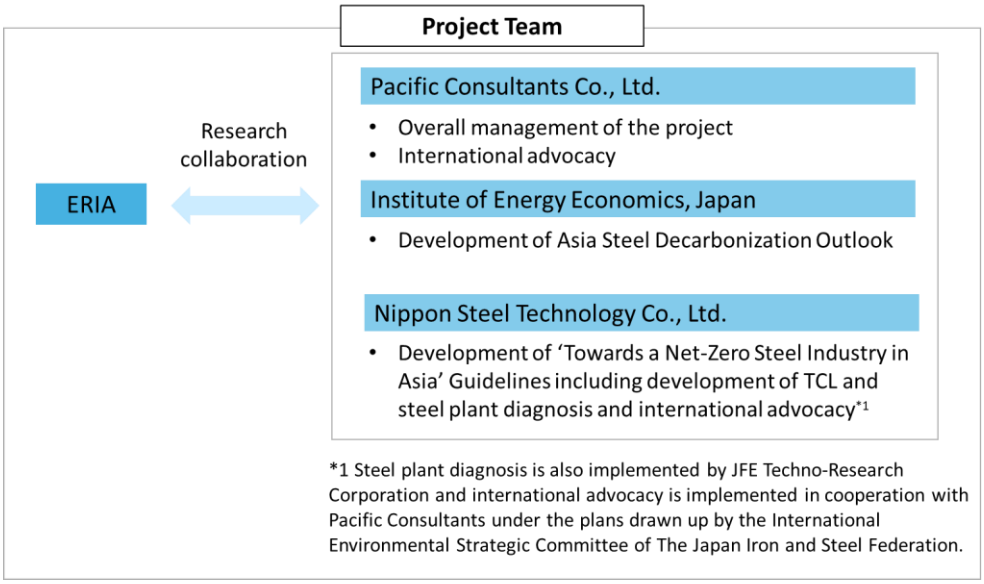
In Phase 1 of the project, the following activities have been implemented in pursuit of each objective.

(1) Outlook: Collecting and analysing socio-economic and production data on current and future indicators related to steel industry decarbonisation in Asia; reviewing previous research, including historical studies, time series data, and expertise to inform the long-term forecast for steel decarbonisation.
(2) Guidelines: Developing the draft 'Towards a Net-Zero Steel Industry in Asia' Guidelines through steel plant diagnosis; reviewing and updating the Technologies Customized List (TCL) to reflect the latest country-specific data on energy costs, CO_2 conversion factors, and coefficients related to equipment installation, as well as local needs.
(3) International advocacy: Collecting needs and opinions from ASEAN countries and other regions at the ASEAN Japan Steel Initiative (AJSI) seminar and India-Japan Public and Private Collaborative Meeting on Iron and Steel Industry.

3. Implementation structure

This project team consists of Economic Research Institute for ASEAN and East Asia (ERIA) researchers, and researchers and engineers from Pacific Consultants Co., Ltd., the Institute of Energy Economics (IEEJ), Japan, and Nippon Steel Technology Co., Ltd., as shown in Figure 1.1. Members of the International Environmental Strategic Committee of the Japan Iron and Steel Federation (JISF) also contribute to the project as observers.

Figure 1.1: Implementation Structure



Source: Authors.

Chapter 2
Research Activities

1. Draft Asia Steel Decarbonisation Outlook

To contribute to the study of steel decarbonisation in Asia, long-term trends in crude steel production will be projected. In Phase 1, a pilot model for the Association of Southeast Asian Nations (ASEAN) was built using an econometric[3] method.

This chapter offers a comprehensive overview of trends in crude steel production in ASEAN, the distinctive characteristics of the Asian market structure, and prospective developments in green steel. It subsequently analyses the relationship between apparent steel consumption and economic growth, and explores methodologies for modelling steel demand.

1.1. Database development

A database has been developed to quantitatively analyse steel product demand and crude steel production in ASEAN.[4] For steel supply and demand, the World Steel Association's (worldsteel) 'Steel Statistical Yearbook 2024' dataset was obtained. Where necessary, data on steel products, crude steel consumption, and crude steel production prior to 2003 that were not included in the dataset were supplemented from the previous years' editions of the 'Steel Statistical Yearbook.' Macroeconomic data, such as data on population, real gross domestic product (GDP), and exchange rates were compiled using the World Bank's 'World Development Indicators' and the United Nations 'National Accounts Main Aggregates Database', amongst others.

1.2. Crude steel production structures in ASEAN

1.2.1. Production development

Before proceeding to the numerical analysis, we first review the current landscape of crude steel production across major producing countries in the ASEAN region.

Of the 10 ASEAN member countries, seven countries (Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam) for which data are available were aggregated and designated as ASEAN 7 (hereafter referred to as 'ASEAN 7').

As of 2023, the total crude steel production of ASEAN 7 was 51 million tonnes, as shown

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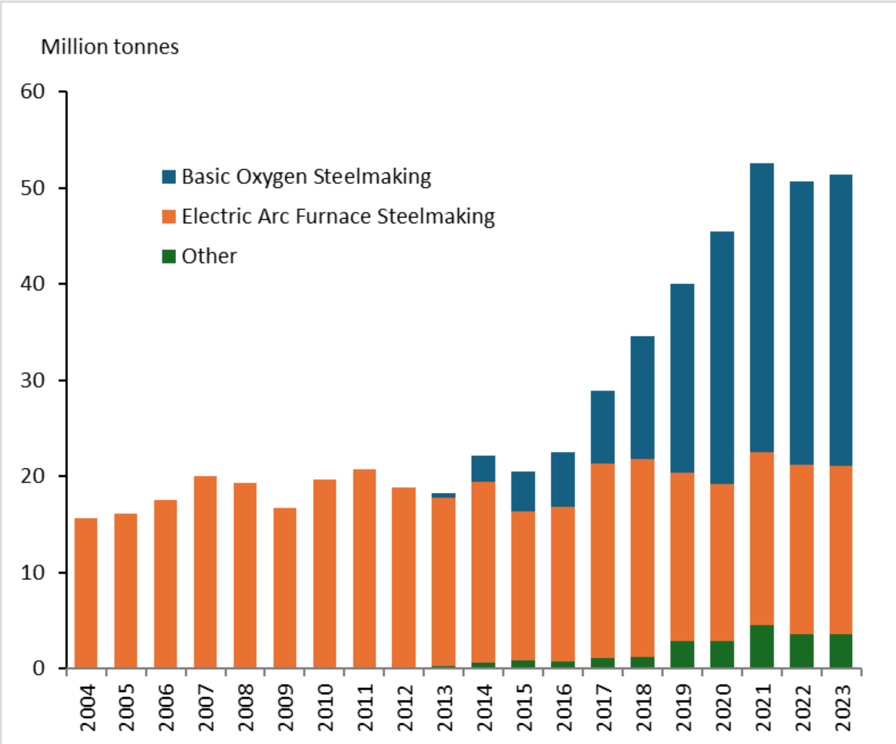
[3] 'Econometric' here is broadly defined, unlike the case in Section 1.4.

[4] ASEAN here includes Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam but does not include Brunei Darussalam, Cambodia, or Lao PDR, for which data are not available in the World Steel Association's 'Steel Statistical Yearbook.' The same applies below.

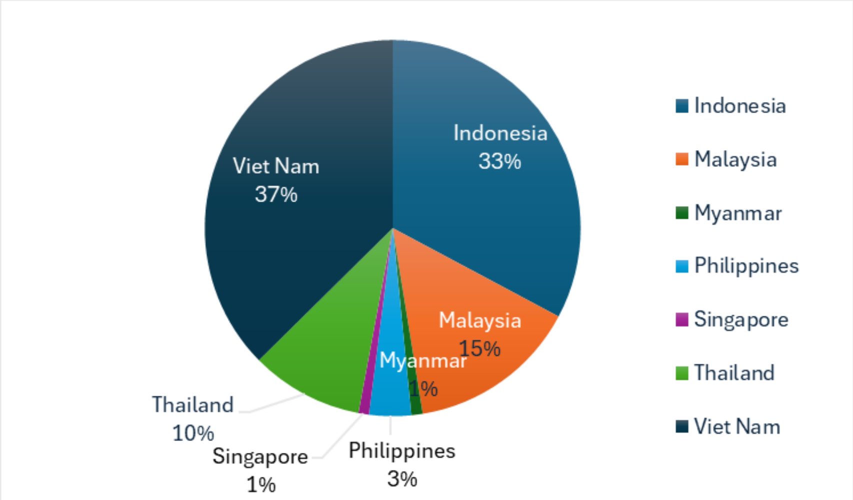
in Figure 2.1. The share of crude steel production by country is shown in Figure 2.2. Crude steel production in ASEAN 7 used to primarily employ electric furnaces, but construction of new blast furnaces has continued

Figure 2.1: Production of Crude Steel in ASEAN 7



Source: worldsteel (2024a).

Figure 2.2: Shares of Crude Steel Production in ASEAN 7, 2023



Source: worldsteel (2024a).

According to the World Steel Association (worldsteel) data, blast furnace production figures were first officially recorded in the statistics at 0.5 million tonnes in Viet Nam in 2013, followed by 1.9 million tonnes in Indonesia in 2014, and 0.5 million tonnes in Malaysia in 2016.

It is noteworthy, however, that from a historical perspective, Indonesia was the first amongst ASEAN 7 to establish a large-scale blast furnace. As reported by the South East Asia Iron and Steel Institute (SEAISI), 'Krakatau POSCO, a joint venture between PT Krakatau Steel of Indonesia and POSCO of South Korea, completed this first large-scale blast furnace and the largest steel mill in ASEAN in 2014' (SEAISI, 2024a).

As a result, the blast furnace share of ASEAN 7 has grown rapidly from 20% in 2015 to 59% as of 2023. However, this ratio is low compared to the global average of 70%, and the region remains largely characterised by electric furnaces.

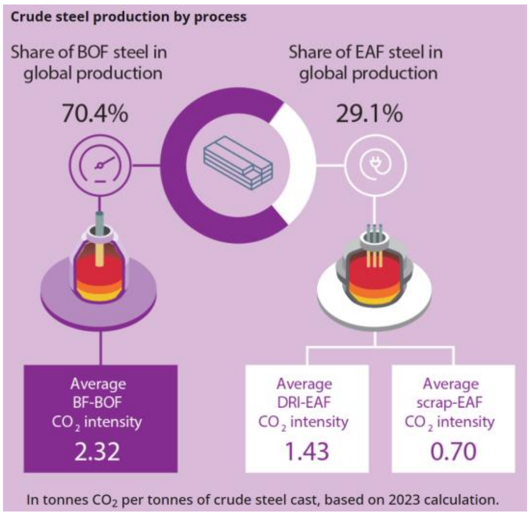
Also, strong steel demand may be creating a unique market growth path for ASEAN 7. Whereas the global average growth rate of crude steel production from 2010 to 2023 was 2.2% per annum, for ASEAN 7 it was 7.7%, indicating solid growth in steel demand due to strong economic growth.

CO_2 emission intensity

The World Steel Association (worldsteel) publishes CO_2 emission intensities by production route as a global average using data from its member companies' steel-producing sites in accordance with the international ISO 14404 standard.

Various technologies and pathways exist for decarbonising crude steel production. Representative production routes include the blast furnace-basic oxygen furnace (BF-BOF) route, electric arc furnace (EAF) production using a combination of scrap and direct reduced iron (DRI), and scrap-only EAF production, as shown in Figure 2.3.

Figure 2.3: CO_2 Intensity by Production Route, 2023



Source: worldsteel (2025).

Subsequently, these data are compared with the IEA estimation. The results indicate that, at the global average level, the values are consistent, as summarised in Table 2.1.

If adjustments were to be made for indirect emissions, the indirect emission intensities for the main production routes are calculated here using the global average CO_2 intensity of power generation for electricity imported from the grid, in line with the methodology employed by the World Steel Association (worldsteel), to facilitate comparison. Furthermore, the emissions associated with the on-site combustion of steel off-gases (applicable only to the blast furnace route) are calculated using the corresponding emission factors for coke oven gas and blast furnace gas.

Table 2.1: Comparison of CO_2 Intensity Data(t CO_2/t) between worldsteel and the IEA

Production Rotes	Blast Furnace-Basic Oxygen Furnace	Scrap-based Electric Arc Furnace	Natural Gas-based Direct Reduction Induction
IEA (direct)	1.2	0.04	1.0
IEA (direct + indirect)	2.2	0.3	1.4
worldsteel	2.2	0.3	1.4

Note: The IEA data boundary includes agglomeration and coke production, ironmaking and steelmaking, and casting. It excludes other semi-finishing and finishing processes, the use of which differs according to the specific finished steel product being produced. worldsteel reference values are adjusted to match the IEA 'crude steel boundary' described above. Differences between the IEA and worldsteel values shown here are mainly attributable to the treatment of electricity.
Source: IEA (2020).

When decarbonisation is considered within a broader systems context that accounts for energy supply-demand structures, multiple steel production routes and pathways emerge, contingent on the integration of renewable energy, hydrogen, and carbon capture and storage (CCS).

For example, in the case of hydrogen-based DRI, one option is to produce it in third countries with access to low-cost, low-emission hydrogen and import it from overseas.

1.2.2.Characteristics and trends of steel production capacity in ASEAN

This section examines trends in crude steel production capacity, primarily based on data from the Organisation for Economic Co-operation and Development (OECD) (2025) and SEAISI (2024a).

According to the latest estimates, ASEAN's crude steel production capacity stands at approximately 82.9 million tonnes (Mt), as presented in Table 2.2., showing steady growth despite being at a developing stage . Whilst ASEAN's share of global capacity is relatively small at around 3%, its capacity growth rate over the past five years (2019–2024) has been robust at 11.1%. Similar to other emerging economies, ASEAN's capacity growth rate is relatively high (OECD 2025).

Table 2.2: World Steel Production Capacity (Mt)

Region	2019	2020	2021	2022	2023	2024	Change 2019-24 %	Change 2019-24 Qty
Asia	1,630.0	1,636.1	1,632.7	1,646.2	1,643.0	1,660.6	2%	30.6
China	1,148.3	1,147.9	1,146.5	1,149.9	1,141.5	1,141.5	-1%	-6.8
India	142.2	142.3	143.9	154.0	161.2	179.5	26%	37.3
Japan + Rep.of Korea	210.1	210.1	204.0	204.0	199.4	198.6	-6%	-11.5
ASEAN	74.6	78.7	80.4	80.4	82.9	82.9	11%	8.3
Other Asia	54.8	57.2	57.9	57.9	58.0	58.1	6%	3.2
Europe	279.6	279.7	280.3	281.5	283.7	280.5	0%	1.0
European Union (27)	220.3	217.7	217.7	217.7	217.8	213.0	-3%	-7.3
Türkiye	50.7	53.4	54.0	55.2	57.4	59.0	16%	8.3
Other Europe	8.6	8.6	8.6	8.6	8.6	8.6	0%	0.0
United States, Mexico	154.2	157.5	157.7	162.8	163.3	163.3	6%	9.1
Commonwealth of Independent States and Ukraine	143.4	142.6	143.9	145.0	145.0	145.0	1%	1.6
Middle East	80.7	84.1	89.0	92.3	93.9	94.9	18%	14.2
Central and South	73.9	73.4	73.9	73.9	74.2	74.2	0%	0.3
Oceania	6.4	6.4	6.4	6.4	6.4	6.4	0%	0.0
Africa	44.6	44.7	43.5	45.8	46.9	47.3	6%	2.7
Others	0.0	0.0	0.0	0.0	0.0	0.0		0.0
World	2,412.7	2,424.4	2,427.4	2,453.8	2,456.3	2,472.1	3%	59.4
World excluding China	1,264.4	1,276.5	1,280.9	1,303.9	1,314.8	1,330.6	5%	66.1
OECD	641.9	645.3	640.0	646.3	644.4	640.4	0%	-1.5
Non-OECD	1,770.8	1,779.1	1,787.4	1,807.5	1,811.8	1,831.6	3%	60.8

Note: 'Qty' refers to the quantity in mmt.
Source: OECD (2025).

Furthermore, according to OECD (2025) estimates, if the additional 14.8 Mt (2.7 Mt under construction) to be added between 2025 and 2027 becomes operational, the total for 2027 could reach a maximum of 97.7 Mt. Even when considering only the projects currently under construction, the total is projected to reach 85.6 Mt.

Looking at the specifics, reflecting geographical conditions, investments by Chinese companies account for 78% of the total, with a significant proportion of these projects involving blast furnaces. Examples include planned investments of 20 Mt in Indonesia and 25 Mt in Malaysia, as shown in Table 2.3 (OECD, 2025).

The prevalence of state-owned blast furnaces reflects the nature of the economic markets in Malaysia and Indonesia. Expanding blast furnace capacity requires massive investment, making government support indispensable. In particular, measures such as tax benefits and support for land and infrastructure are being implemented.

Table 2.3: Main Capacity Expansion in South East Aia

Country	Firm	Ownership	Type	Capacity	Operation Year	Investment	Government support
				(Mt)		(US$ billion)	
Chinese investment							
Indonesia	Dexin Steel	Private	BOF	4.0	2020	4.0	Tax benefits
		Private	BOF	3.0	2023		
		Private	BOF	13.0	(1.0)	(1.0)	
Malaysia	Alliance Steel	Private	BOF	3.5	2018	1.6	Tax benefits
		Private	BOF	6.5	2026	1.8	
	Eastern Steel	State-owned	BOF	0.7	2015	(1.0)	
		Private	BOF	2.0	2023	1.7	
		Private	BOF	2.3	2027	(1.0)	
	Wenan Steel	Private	BOF	10.0	2025	3.3	Tax benefits, lower than market pricing related to land use and others
Philippines	Panhua	Private	BOF	12.0	2026	3.5	Tax benefits
	Baowu Steel	State-owned	BOF	3.0	(1.0)	2.0	(1)
Viet Nam	Yongjin Metal	Private	(1)	0.3	2022	0.1	Tax benefits
		Private	(1)	0.3	2025	0.1	
Subtotal				60.5		18.1	
Other country's investment							
Indonesia	Krakatau Steel	State-owned	BOF	3.0	2013	3.0	Debt instrument placements, debt forgiveness and debt restructuring
		State-owned	BOF	3.0	2027	3.5	
		State-owned	BOF	4.0	2030	(1.0)	
Viet Nam	Formosa Ha Tinh Steel	Private	BOF	7.5	2017	9.9	Tax benefits, lower than market pricing related to infrastructure and land use
Subtotal				17.5		16.4	
Total				**78.0**		**34.5**	

Notes: (1) Not available. (2) In 2015, Hiap Teck (Malaysian Private Organization) owned 55%, and Shougang (Chinese SOE) owned 40%. In early 2018, Shougang sold its stake in Eastern Steel to Beijing Jianlong, a private Chinese steelmaking company. (3) In 2013, POSCO (Korean POE) owned 70%, and Krakatau Steel (Indonesian SOE) owned 30%. In 2022, Krakatau Steel increased its share ownership to 50%.
Source: Based on OECD (2025) with modifications by the authors.

According to one analysis, concerns have been raised that ASEAN's surplus production capacity may expand significantly, as the region's steelmaking capacity is projected to grow more than twofold. A recent analysis by SEAISI (2024a) has also highlighted concerns regarding excess production capacity in the ASEAN region. Based on the latest figures, SEAISI estimates that by 2029–2030, total capacity will reach 184.5 Mt if all planned capacities are installed. This would be more than 2.3 times today's capacity of 78.1 Mt.

In 2022, ASEAN-6 (Indonesia, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam) steel demand was 75.1 Mt, with crude steel capacity of 78.1 Mt. Production was 50.5 Mt, and capacity utilisation was 64.6%, below the healthy level of 80% (SEASIS, 2024a). It should be noted that the actual figure differs by approximately 5 Mt between OECD and SEAISI data.

With regard to the respective shares of blast furnace and EAF production, SEAISI (2024a) likewise provides projections. These estimates appear to take into consideration the aforementioned construction plans, and, given the identified predominance of blast furnaces, the analysis paradoxically strengthens the case for the use of carbon dioxide capture, utilisation, and storage (CCUS) systems.

In 2011, steel production was overwhelmingly dominated by the EAF route, which accounted for approximately 95% of total installations, whereas the blast furnace route represented only about 5% as shown in Table2.4. By 2022, however, a marked structural shift had occurred: the share of blast furnaces rose to 29%, whilst that of EAFs declined to 65%. Projections for 2028 suggest that this transformation will accelerate further, with blast furnaces expected to reach 59% and EAFs to decrease to 38%, indicating a profound reconfiguration of production routes in less than two decades, as summarised in Table 2.4.

Table 2.4: Share of Steel Production Capacity by Route in ASEAN

Year	Blast Furnace	Electric Arc Furnace
2011	5%	95%
2022	29%	65%
2028	59%	38%

Source: SEAISI (2024a).

As such, ASEAN's steel industry is set to become more carbon intensive, with 'de-greening' in the future, if ASEAN governments continue to encourage such investments without CCUS.

Within the same analysis, SEAISI also sounds an alarm over the issue of overcapacity in Malaysia, as illustrated in the following statement:

'Malaysia's crude steel capacity today is about 16.1 M(t). By 2029/2030, based on the latest announced projects and industry information, total crude steel capacity will rise to 54.7 M(t), if all the projects materialise. Will the additional capacity of 38.6 M(t), while good in terms of confidence in the country, be able to support Malaysia's steel demand of 7.5 M(t)in 2022 or the region, which is also expanding in capacity?' (SEAISI, 2024a).

In the longer term, the expansion plans and forecasts for production capacity in ASEAN indicate that the global issue of overcapacity may also extend to this region. As the capacity expansion plans of emerging economies tend to be ambitious, this development warrants close monitoring in the years ahead.

1.2.3.Energy intensity of crude steel production

This section examines the energy intensity – energy consumption in the iron and steel industry per tonne of crude steel produced – in ASEAN 7, as illustrated in Figure 2.4. For this study, energy consumption data were obtained from the IEA, and total crude steel production data were sourced from the World Steel Association (worldsteel). By combining these figures with the IEA energy data, energy intensity values were estimated for each country using macro-level data.

The IEA energy balance table (IEA, 2024) includes a memorandum item titled 'Memo: Iron and steel blast furnaces and coke ovens',[5] which is separately listed. This item was adopted as the basis for energy data in this analysis. Historically, energy consumption in the steel sector has been reported under various classifications, such as final energy consumption, the energy transformation sector (e.g. blast furnaces, coke ovens, power generation using by-product gases, and own uses), and, in some countries, even as non-energy use.

However, most of these figures are now consolidated under the aforementioned memorandum item ('Memo'), which is used tentatively for the purpose of confirming the current situation in each country. Due to uncertainties regarding data boundaries and variations in the treatment of energy consumption by EAFs across countries, the reliability of this dataset for precise international comparison may be limited. The energy intensity values in Malaysia and Singapore do not cover electricity. The existence of countries facing future challenges in terms of statistics should be noted here.

Following the energy intensity values in Malaysia and Singapore does not cover electricity.[6]

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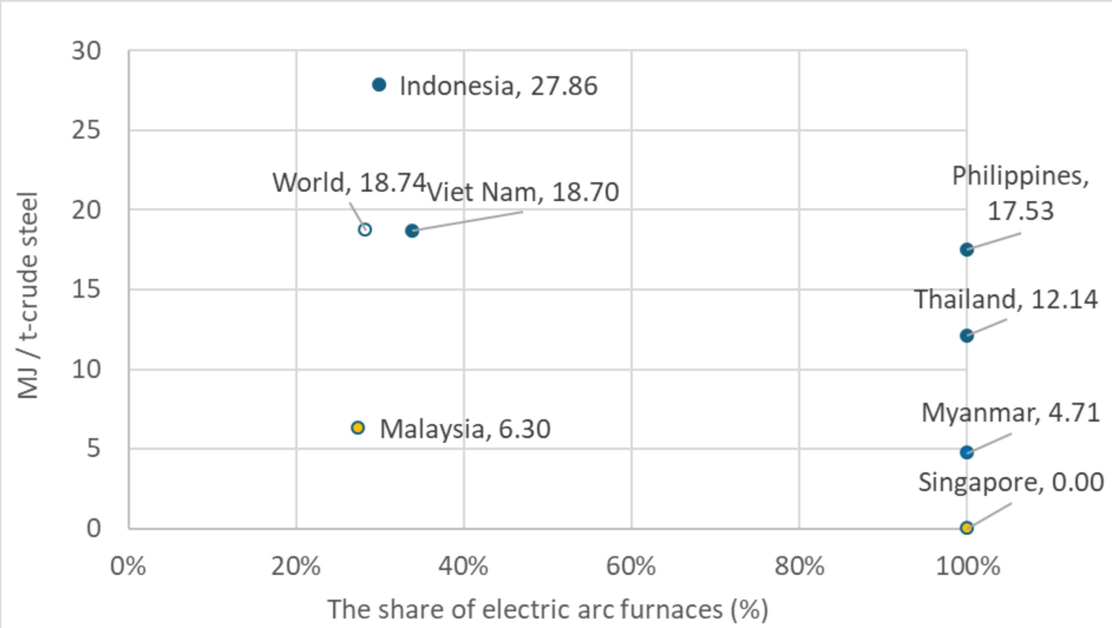
[5] This is understood as the final energy consumption minus the energy used in transformation process. The data footnote shows: IRONSTL - (TBLASTFUR + TCOKEOVS + EBLASFUR + ECOKEOVS).

[6] The entire electricity consumption by the iron and steel sectors in Malaysia and Singapore is classified under 'industry not elsewhere specified.' As a result, electricity data specific to iron and steel production are also not included in its 'Memo: Iron and steel blast furnaces and coke ovens.'

Figure 2.4: Shares of Electric Furnaces and Energy Intensity Using IEA Data (Tentative Results) in ASEAN 7, 2022



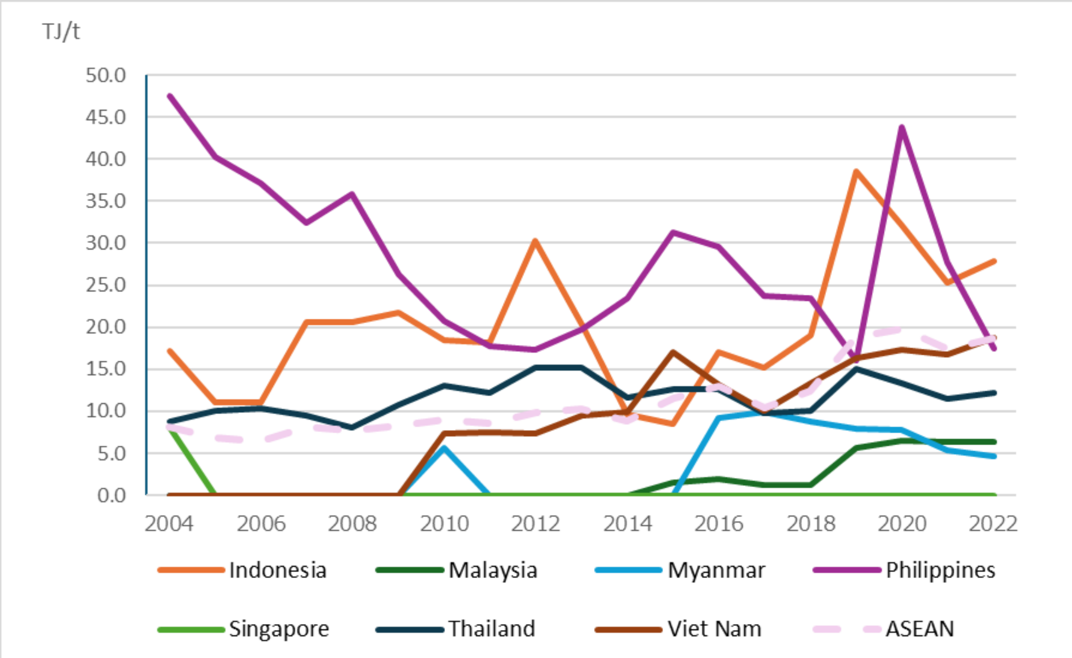
Notes: The energy intensity values for Malaysia and Singapore do not cover electricity. Due to uncertainties regarding data boundaries and treatment of energy consumption by EAFs across countries, the reliability of this dataset for precise international comparison may be limited.

Source: IEEJ estimations based on IEA Energy Balance data and world steel data.

When examining country-level trends in energy intensity in the ASEAN region, fluctuations in have been pronounced since 2019, as illustrated in Figure 2.5. The impact of reduced crude steel production in 2020 can be observed across the ASEAN region, with the exception of Indonesia. This suggests that the deterioration in energy intensity may be attributable to reduced operating rates resulting from the coronavirus disease (COVID-19) pandemic, or possibly to increasing difficulties in energy data compilation. As will be discussed later, the possibility that reduced operating rates are also attributable to excess production capacity cannot be overlooked.

To accurately capture the progress of efficiency improvements, it is becoming increasingly important to monitor changes over time.

Figure 2.5: Trends in Energy Intensity in ASEAN 7 (Tentative Analysis)



Source: IEEJ estimations based on IEA Energy Balance data and worldsteel data.

To understand the nature of estimated energy intensity, this section examines the survey conducted by the World Steel Association (worldsteel) and presents a comparison of the derived energy intensity values for 2022. The world average energy intensity value derived from the World Steel Association's (worldsteel) survey of member companies differs by 12% from the global average value calculated using the aforementioned method. According to the 2022 World Steel Association Survey, the global average energy intensity of crude steel production is 21.01 gigajoules (GJ) per tonne. In contrast, our estimation yields a value of 18.74 GJ per tonne in ASEAN 7.

The former (the World Steel Association's (worldsteel) investigation) is based on a bottom-up survey; although it is not a complete census, it is one of the most reliable datasets, ensuring boundary consistency through ISO 14404:2013 – the calculation method for CO_2 emission intensity from iron and steel production. The latter relies on macro data from the IEA, using the World Steel Association's (worldsteel) crude steel production figures.

In Viet Nam and Indonesia, where blast furnace technology has been introduced relatively recently, the energy intensity levels are close to, or slightly above, the global average. Whilst it is difficult to draw firm conclusions based on a single year of data, the findings suggest that there may still be room for additional energy efficiency improvements in the process in these countries.

Furthermore, even in countries such as the Philippines and Thailand, where all furnaces are EAFs, the efficiency of these furnaces remains relatively low, or may reflect challenges related to boundary definitions. Based on a the World Steel Association (worldsteel) survey, the global average energy intensity of electric arc furnaces is 10 GJ/t, as summarised in Table 2.5. As previously mentioned, there is significant potential for improving energy efficiency in the operations of many small and medium-sized enterprises.

Table 2.5: Global Energy Intensity, 2022 and 2023

Steelmaking Route	2022 Energy Intensity (GJ/t-crude steel)	2023 Energy Intensity (GJ/t-crude steel)
Global average	21.01	21.27
Blast furnace-basic oxygen furnace (BF-BOF)	23.98	24.20
Electric arc furnace using scrap (Scrap-EAF)	10.13	10.24
Electric arc furnace using direct reduced iron (DRI-EAF)	22.25	23.13

Source: world steel data.

In general, countries with a higher proportion of EAF steel tend to exhibit lower energy intensity and CO_2 intensity. However, as is well known, the challenge of securing sufficient quantities of high-quality scrap with clear provenance remains. Currently, more than 86% of scrap is sourced from extra-regional imports, as illustrated in

Table 2.6: (listed as 'other Asia'). According to the World Steel Association (worldsteel) data, net imports of ASEAN 7 amounted to 6.7 Mt in 2023. In particular, Viet Nam's imports reached 5.3 Mt, ranking fourth amongst the world's scrap importers. Further details of the data are provided in the Appendix.

Of particular concern is the significant constraint faced by the Asian market in securing sufficient high-quality scrap, a challenge that is expected to become increasingly important in the future.

Table 2.6: World Trade in Ferrous Scrap by Area, 2024

Million tonnes / Exporting region	European Union (27)	Other Europe	Russia & other CIS + Ukraine	North America	South America	Africa and Middle East	China	Japan	Other Asia	Oceania	Total imports	of which: extra-regional imports*
European Union (27)	25.7	3.3	0.4	0.6	0.1	0.3	-	0.0	0.0	0.0	30.5	4.8
Other Europe	12.2	2.2	0.7	4.7	0.5	0.6	-	0.0	0.2	0.0	21.1	18.9
Russia & other CIS + Ukraine	0.3	0.0	0.0	0.0	-	0.0	0.0	-	0.0	-	0.3	0.3
North America	0.3	0.1	-	7.6	0.0	0.0	-	0.0	0.0	0.0	8.0	0.4
South America	0.0	0.0	-	0.8	0.3	0.0	-	0.0	0.0	0.1	1.1	0.8
Africa	2.1	2.3	0.0	0.3	0.0	0.1	0.0	-	0.0	0.0	4.8	4.7
Middle East	0.0	0.1	0.0	0.0	0.0	0.2	-	0.0	0.0	0.1	0.5	0.3
China	0.0	0.0	0.0	0.0	0.0	0.0	-	0.1	0.1	0.0	0.2	0.2
Japan	0.0	0.0	-	0.0	0.0	0.0	0.0	-	0.0	0.0	0.1	0.1
Other Asia	2.0	1.9	0.3	8.1	1.3	2.6	0.0	6.4	3.9	2.6	29.1	25.3
Oceania	0.0	0.0	-	0.0	-	-	-	-	0.0	0.0	0.0	0.0
Total exports	42.6	9.9	1.4	22.1	2.2	3.8	0.0	6.5	4.3	2.8	95.8	55.8
of which: extra-region- al exports*	16.9	7.7	1.4	14.6	1.9	3.5	0.0	6.5	0.4	2.8	55.8	
Net exports (exports- imports)	12.1	-11.2	1.2	14.2	1.1	-1.5	-0.2	6.5	-24.9	2.8		

* Excluding intra-regional trade marked

Source: worldsteel (2025).

At the same time, within the context of global decarbonisation efforts, it is likely that companies will need to prepare to invest in energy-saving equipment, such as systems utilising by-product gas and/or adopting hydrogen-based DRI (H_2-DRI) technologies. This may place further strategic pressure on operators to pursue increasingly advanced blast furnace operations.

Additionally, a rapid transition to electric furnaces powered mainly by renewable energy, with energy efficiency (energy intensity) and CO_2 efficiency (CO_2 intensity) as the main factors, may affect future electricity supply and demand as well as economic growth in the ASEAN region. The availability of CCS is also subject to geographical conditions.

Looking ahead, we intend to consider the adoption of technologies such as CCS and the use of hydrogen as important areas for further study.

1.2.4.Continuing presence of induction furnaces in ASEAN 7

This section focuses on the distinctive characteristics of steel demand in ASEAN, with particular attention to induction furnaces. Crude steel production data referred to by the World Steel Association (worldsteel) categorises production routes into three groups:

basic oxygen furnaces, electric furnaces, and other processes ('Other').[7] This section focuses on the third category. Although India is excluded from detailed analysis due to its diverse and complex steelmaking structure, it is notable that since 2015, its output under other processes has not been recorded in the World Steel Association (worldsteel) statistics. In contrast, Viet Nam recorded 4.4 million tonnes of crude steel production under other processes in 2021, indicating a significant contribution.

This divergence suggests that the 'other processes' category largely comprises crude steel produced by small to medium-sized enterprises utilising induction furnaces, which are generally less efficient and associated with higher levels of local pollution. Consequently, such production may be subject to gradual phase-out under future environmental and pollution control regulations.

Based on various discussions introduced in the following sections, it can be inferred that induction furnace-based steel production is also likely to be present across other ASEAN 7 countries to some certain extent.[8] Whilst there is growing concern across ASEAN over the environmental and safety risks associated with induction furnace steelmaking, the regulatory stance of individual countries varies considerably.

Viet Nam

Kawabata (2023), in a study analysing the entry of Japanese firms into the Vietnamese steel market, assesses the increasingly complex dynamics of Viet Nam's steel industry. He notes that 'in the future, integrated blast furnace systems are expected to become larger and shift their focus toward steel sheet production, but the coexistence of induction furnaces and electric arc furnaces is likely to continue for the time being', suggesting the emergence of a distinctive market structure characterised by the continued coexistence of multiple production technologies.

In parallel, an affiliated body of the Government of Viet Nam has also recognised the difficulty of improving energy efficiency in this sector. It has acknowledged that 'most of them are small-scale with a capacity of under 500,000 tonnes each year and employ outdated technology and they consume a lot of energy, so they have low competitiveness and cause environmental pollution' (Agency for Innovation, Green Transition & Industry Promotion, Ministry of Industry and Trade, 2024). This statement reflects the government's intention to pursue improve the current situation.

The government is expected to formally release the 'Draft Steel Industry Development Strategy for the Period up to 2030, with a Vision to 2050', and further clarification of the state's policy direction is awaited by stakeholders.

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[7] Including open hearth furnaces.

[8] According to Kawabata and Yin (2020), 'in China, small-scale production using induction furnaces, which are small electric furnaces that utilize induction currents generated by high and medium frequencies, was actively carried out until it was completely banned in 2017. This is not reflected in the crude steel production and production capacity statistics.' Also, some countries might define it as foundry production.

Philippines

According to the Government of the Philippines (Crismund, 2025), discussions are currently underway regarding a potential ban on the use of induction furnaces by steel manufacturers at the Department of Trade and Industry, along with a review of the licensing framework governing such facilities. Due to the absence of a refining process to remove harmful elements from liquid steel, concerns have also been raised regarding the structural safety of buildings in which such steel is used.

A member of the Department of Science and Technology-Metals Industry Research and Development Center Governing Council reiterated their call for a nationwide ban on induction furnace use in steelmaking. He also pointed out that 'since China began the crackdown on steel manufacturers using induction furnaces, their operations were relocated to ASEAN countries, including the Philippines' (Crismund, 2025).

On the other hand, in practice, EAFs and induction furnaces appear to remain in operation for the foreseeable future. This reflects the complexity of reconciling diverse market and policy interests, which makes coordinating these competing technologies particularly challenging.

This position is further substantiated by a statement from a senior trade industry development specialist at the Bureau of Philippine Standards (BPS). He said, 'the BPS issues Philippine Standard (PS) licenses for those who use induction furnaces and EAFs as long as these products comply with the PNS (Philippine National Standards).'

Indonesia

In the case of Indonesia, statements originating from neighbouring ASEAN member states suggest that the country has already banned the use of induction furnaces. For example, a 2025 report by the Philippine News Agency states that 'countries like China, Japan, and Indonesia have already outlawed this technology due to concerns over steel quality' (Crismund, 2025).

However, as of 2025, no publicly available Indonesian government regulation or ministerial decree explicitly banning induction furnaces has been identified. Recent SEAISI reports continue to describe the prevalence of induction furnace-based production in Indonesia, particularly in the long product segment. According to these reports, more than 100 induction furnace mills remain operational, accounting for a substantial share of domestic rebar supply.

Drawing on the above analysis, this study highlights the complexity of regulatory coordination across ASEAN. Although this analysis is limited to a review of a few selected countries, mounting concerns across ASEAN regarding the environmental and safety risks associated with induction furnace-based steelmaking may compel individual countries to deliberate cautiously on regulatory approaches, particularly in light of the need to balance domestic supply and demand.

Furthermore, it has become evident that China's efforts to eliminate excess steel production capacity have had ramifications not only for international trade flows but also for the proliferation of low-cost steel products manufactured locally in recipient countries.

The first implication is the possibility that induction furnace production is mixed with electric furnace production statistics. Secondly, a unique issue in the ASEAN region is the presence of induction furnace steel as a further low-cost alternative to electric furnace steel.

1.2.5.Future plan for green steel in ASEAN

According to the Green Steel Tracker produced by the Leadership Group for Industry Transition (LeadIT) programme (LeadIT, 2025), the only registered project from the ASEAN region is that of Meranti Steel in Thailand. Current developments suggest that large-scale green steel projects remain relatively limited in the ASEAN region, which is predominantly characterised by the use of EAFs. From the perspective of electric furnace operators, including small and medium-sized businesses, the feasibility of such projects may be largely dependent on the availability of renewable energy, its associated costs, and the stimulation of demand for green steel.

LeadIT

LeadIT is an international initiative established in 2019 by the Prime Ministers of Sweden and India at the United Nations Climate Action Summit, with the aim of accelerating the decarbonisation of industries. Its goal is to achieve net-zero emissions in the industrial sector by 2050, supported by the World Economic Forum. The secretariat for LeadIT is hosted by the Stockholm Environment Institute (SEI) (SEI website, Green Steel World).

As part of LeadIT's efforts, the Green Steel Tracker was developed to monitor publicly announced low-carbon steel investments around the world. It supports decision-makers in government, industry, academia, and civil society by providing an overview of active and upcoming projects, visualising progress in the global steel industry's low-carbon transition (LeadIT, 2025).

The definition of green steel in the tracker's database is stringent to observe market dynamics. In this study, the trends in various countries were investigated to capture emerging projects and the momentum behind them in an appropriate and timely manner.

As a result, several pioneering market initiatives aimed at generating demand for green steel and decarbonising crude steel production have been identified. These include projects supported by financing from the International Finance Corporation (IFC), a member of the World Bank Group, but not represented in the tracker.

The following examples illustrate the initial steps being taken in Indonesia, Malaysia, and Thailand.

Indonesia

According to PT Gunung Raja Paksi, Indonesia's leading private steel manufacturer, the IFC has secured investment from the IFC to modernise its EAFs. With IFC financing, the steel manufacturer is modernising its EAF technology to reduce CO_2 emissions and increase production capacity for low-carbon steel.

The project focuses on improving energy efficiency, including through the integration of renewable energy sources and waste heat recovery systems. These efforts are designed to create a more sustainable and environmentally friendly steel production process.

Furthermore, it is reported that the modernisation efforts serve as a countermeasure to the European Union (EU)'s Carbon Border Adjustment Mechanism (CBAM), with the expectation that the low-carbon products from these planned high-efficiency EAFs will be exported to the EU.

Malaysia

According to JFE Steel Corporation (2024a, 2024b), Mycron Steel has signed a memorandum of understanding (MOU) with the JFE to establish a supply system for products utilising the mass balance approach, which is in line with the 'Green Steel Guidelines Ver. 3.1' published by the JISF. This partnership is expected to contribute to the expansion of green steel product adoption in the Southeast Asian market, with ongoing efforts to generate demand for green steel.

Furthermore, according to SEAISI (2024b), University of Technology Malaysia (UTM) has partnered with Mycron Steel to develop a sustainability monitoring system to aid in the decarbonisation of Malaysia's steel industry. UTM is also working on establishing national emissions factors for green steel production, which could support a standardised framework for sustainable steel production in the country.

These initiatives mark early efforts to promote the adoption of green steel in Malaysia, with collaboration between the industrial and academic sectors. The integration of advanced technologies and ongoing cooperation between Mycron Steel and UTM highlight the exploration of more sustainable and low-carbon steel production methods.

Similarly, SEAISI/Kallanish (2023) reported that 'Posco Group and Petros plan to form a working group to discuss details including carbon dioxide capture in the Republic of Korea to transportation in Malaysia, as well as CO_2 infrastructure facility construction and CO_2 injection and storage.' At the time of writing, the authors' research did not reveal any specific green iron projects in POSCO's news releases.

Thailand

Meranti Steel, a Singapore-based company, is the only project listed in the Green Steel Tracker for the ASEAN region. According to Meranti Green Steel (2023), 'Meranti's new green steel plant promises sustainable solutions. It will feature ENERGIRON direct reduction technology, jointly developed by Tenova and Danieli, ready for a transition to 90% hydrogen, Danieli DIGIMELTER featuring Q-ONE technology capable of processing green energy, and Danieli QSP-DUE thin slab casting and rolling technology for full flexibility in terms of width, thickness, and steel grades.'

The company's chief executive officer has highlighted future demand for green steel, driven by mechanisms such as CBAM and the growing need for high-quality iron ore. He noted that 'around 800 million tonnes/year of steel is made from scrap, and this could rise to 1.5 billion tonnes by 2050.'

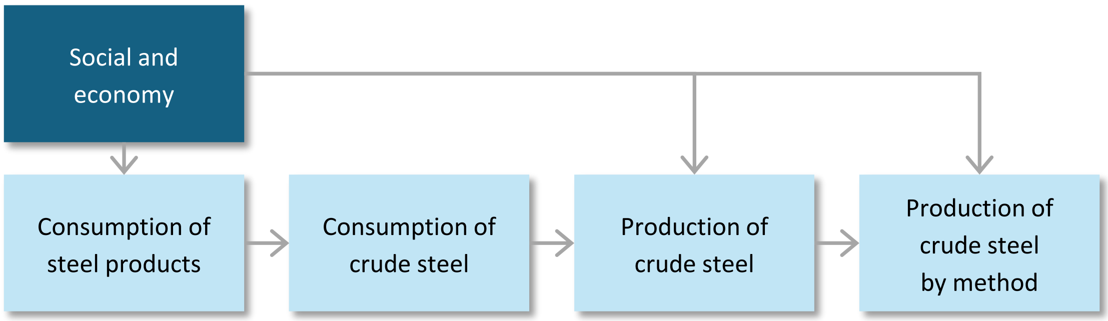
He further explained that regulations like the EU's CBAM and rising carbon taxes in Southeast Asia are pushing steelmakers to reduce emissions. For example, Singapore's carbon tax is set to rise to US$45/tonne by 2026 (Meranti Green Steel, 2025).
'One key part of green steel is direct reduced iron, which uses cleaner fuels, such as natural gas or hydrogen. DRI needs high-grade iron ore with 67%–68% iron content. Right now, DRI-based steelmaking only makes up a small share of global steel production, but demand is expected to grow quickly' (Meranti Green Steel, 2025).

1.3. Flow of the model for steel demand and production

The model constructed in this analysis is based on a demand-driven approach as a guiding principle. That is, the amount of crude steel production does not determine the level of demand for steel products, but the amount of demand for steel products largely determines the amount of crude steel production. The model flow is as shown in Figure 2.6. Therefore, the following sections first examine the relationship between steel product demand (apparent use)[9] and the economy (Section 1.4), then links crude steel demand to steel product demand (Section 1.5), and then examines the relationship between crude steel production and crude steel demand (Section 1.6). Finally, the factors that distribute total production of crude steel by production route are examined (Section 1.7).

[9] Apparent use = production + imports – exports.

Figure 2.6: Flow of the Model for Steel Demand and Production



Source: Authors.

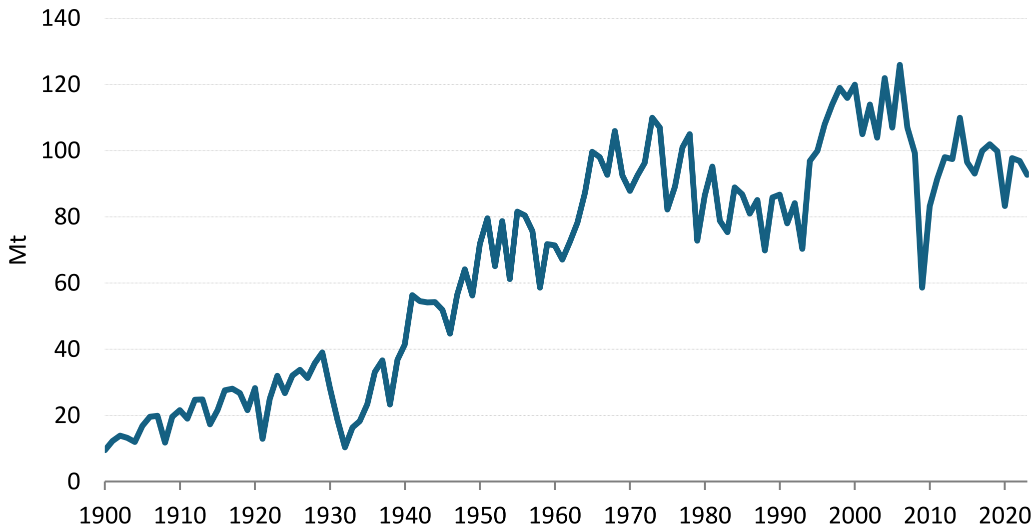
1.4. Quantitative analysis of steel product consumption in the ASEAN region

As projection methods for steel demand, the POSCO Research Institute (2018) has identified econometric approaches, intensity of use approaches, mathematical and hybrid approaches, and computational approaches, highlighting the usefulness of orthodox econometric approaches and intensity-of-use approaches in long-term outlooks. This section focuses on intensity of use and related methods that are thought to better simulate the sometimes rapid and sometimes sluggish movements of steel demand relative to economic growth.

Consumption of steel products is significantly influenced by the stage of economic development. In other words, once a certain basis for economic development is in place and industrialisation has started, the consumption of steel products rises rapidly. However, it does not increase endlessly. As the stage of economic development shifts from industrialisation to servicing, the relationship whereby economic growth significantly stimulates the consumption of steel products disappears. As the economy matures further, the consumption of steel products may show a downward trend, even in an expanding economy, as seen, for example, in the United Kingdom and the United States (Figure 2.7).

Daigo, Oki, and Goto (2016) found that in Japan, demand for steel in capital goods, which is the main demand in the early stage of economic development, peaked in 1973 and then showed a downward trend, shifting towards use in consumer goods as the economy developed further.

Figure 2.7: Apparent Consumption of Steel in the United States



Source: United States Geological Survey (2024; 2025).

Of course, this may be only a typical example. Industries that make extensive use of steel products may not emerge if the size of the country is small and large domestic demand cannot be expected. Alternatively, the service industries may take precedence over the manufacturing industry, as is the case in India, depending on the country's foundations for economic development and international industrial competitiveness. The paths followed (or that have been followed) by the diverse ASEAN countries may therefore vary. For the purposes of this initial quantitative analysis, it is assumed that the ASEAN region as a whole will industrialise, stimulating the consumption of steel products based on the trajectories observed in East Asian countries and regions with which ASEAN has strong economic ties.

In quantifying the relationship between consumption of steel products and the economy as described above, two typical and practical methods can be identified: the flow (intensity-of-use) method, which compares the consumption of steel products in each year with real GDP, and the stock method, which compares the stock of steel in use each year with real GDP. For example, Kawase (2019) states that the basic concept of both methods is the same, but that the stock method is more realistic because it is difficult to quantitatively set the stage of the intensity-of-use hypothesis in the flow method. However, Kawase also points out that there can be a wide range of saturation levels in the stock method, making it difficult to choose which pathway to take in the future for countries where steel stocks are still low. Kozawa, Hayashi, and Tsukihashi (2009) explain the usefulness of the stock-utility hypothesis, under which the share of production by electric furnaces increases if future economic growth is expected to be lower than in the past, whilst the extreme assumption of zero economic growth leads to no steel production by blast furnaces.

In the stock method, it is essential to estimate with a high degree of accuracy the quantities of steel products in use and their lifetimes to project future consumption. The data availability required for such estimation and manoeuvrability should also be carefully considered, and it should be noted that complex models do not always give good prospects.

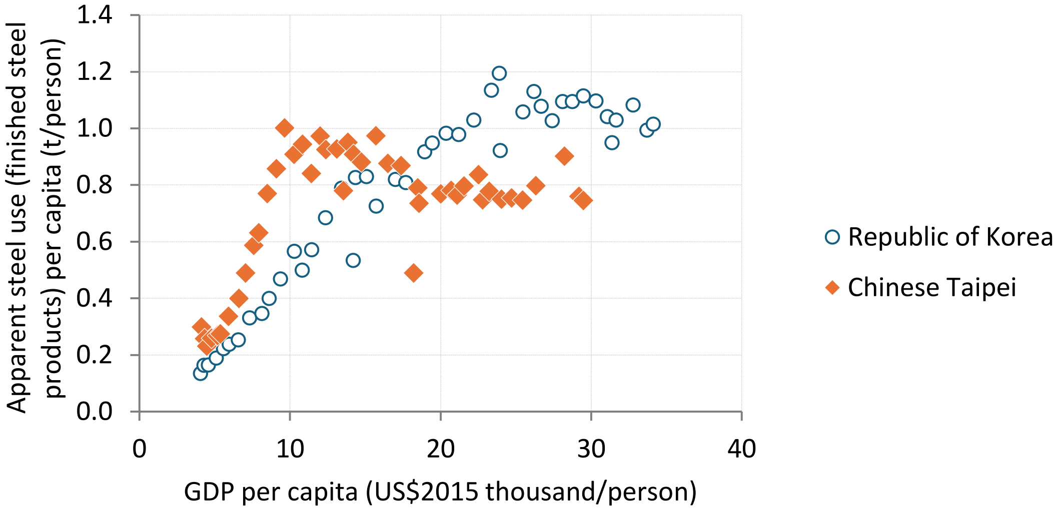
Accordingly, in this analysis, a pilot model for the quantitative analysis of steel products and crude steel consumption was developed for the ASEAN region as a whole, based on a variation of the intensity-of-use hypothesis, whilst addressing the weaknesses of the flow method (for example, Crowson (2018); Wårell (2014)).

The model structure assumes that (i) an increase in real GDP per capita leads to an increase in the apparent use of steel products per capita; (ii) the effect of an increase in the value added of the industrial sector on the demand for steel products is greater than the increase in the value added of the agriculture, forestry, fisheries, and services sectors; and (iii) once real GDP per capita exceeds a certain level, the effect of inducing consumption of steel products gradually declines. Such trends are also observed in the Republic of Korea and Chinese Taipei, neighbouring ASEAN, as shown in

Figure 2.8. Specifically, based on an analysis of the results for the world's top crude steel-producing countries (excluding ASEAN countries),[10] a logistic regression was conducted to estimate various parameters.

[10] In Phase 1, we used the world's top crude steel-producing countries (excluding ASEAN countries) as a reference, but we plan to carefully consider how to select these countries in Phase 2.

Figure 2.8: Real GDP per Capita and Consumption of Steel Products per Capita for the Republic of Korea and Chinese Taipei, 1980–2023



Sources: Compiled from International Iron and Steel Institute (1990), *Steel Statistical Yearbook 1990;* International Iron and Steel Institute (1998), *Steel Statistical Yearbook 1998;* worldsteel (2024a), *Steel Statistical Yearbook 2024;* World Bank, *World Development Indicators;* and IEEJ, *EDMC Handbook of Energy & Economic Statistics 2026* (forthcoming).

The estimated equation for steel product apparent use (finished steel products) per capita in the ASEAN pilot model is as follows:

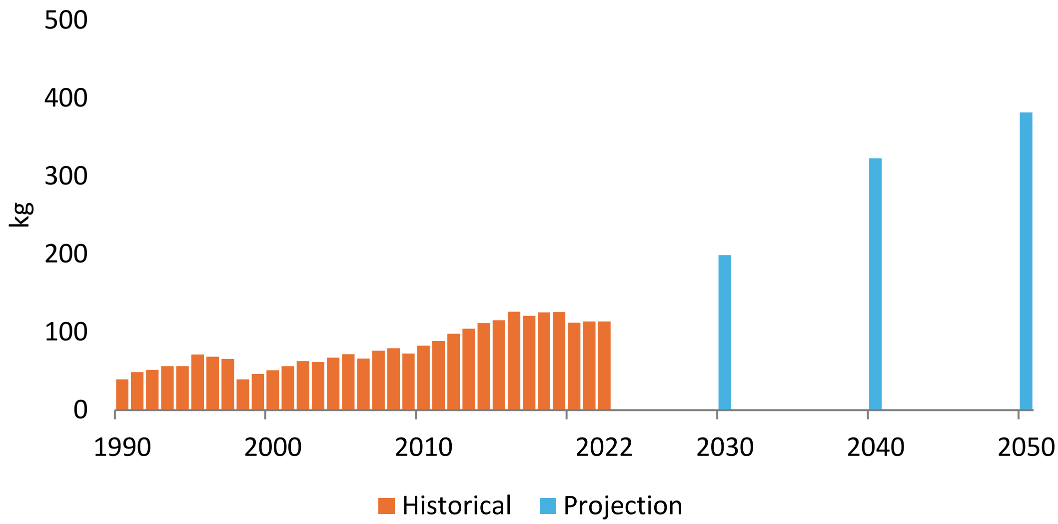
FSP_AU_P_ASEAN = exp(6.12119162)/(1+exp(3.54729−3.53596*(VAIND_ASEAN/POP_ASEAN)+1.10912*((VAAGR_ASEAN+VASER_ASEAN)/POP_ASEAN)))*(113.435/129.905)

where FSP_AU_P_ASEAN is steel apparent use (finished steel products) per capita (kg), VAIND_ASEAN is value added by secondary industry (US$2015 billion), POP_ASEAN is population (million), VAAGR_ASEAN is value added by primary industry (US$2015 billion), and VASER_ASEAN is value added by tertiary industry (US$2015 billion). The multiplier at the end is an adjustment based on 2022 values.

As mentioned earlier, the estimation referenced the historical trajectories of the world's top crude steel-producing countries,[11] resulting in a tendency towards overestimation in the future projection. However, the validity of the model structure has been confirmed. For the purposes of this trial calculation, it is tentatively assumed that real GDP will grow at an annual rate of 4.2% and that the population will increase by 0.4% per year from 2022 to 2050.

[11] The top 20 producers outside ASEAN: Austria, Brazil, Canada, China, Egypt, France, Germany, India, Iran, Italy, Japan, the Republic of Korea, Mexico, Poland, Russia, Saudi Arabia, Spain, Chinese Taipei, Türkiye, and the United States.

Figure 2.9: Tentative Results for Apparent Use of Steel Products (Finished Steel Products)
per Capita in ASEAN

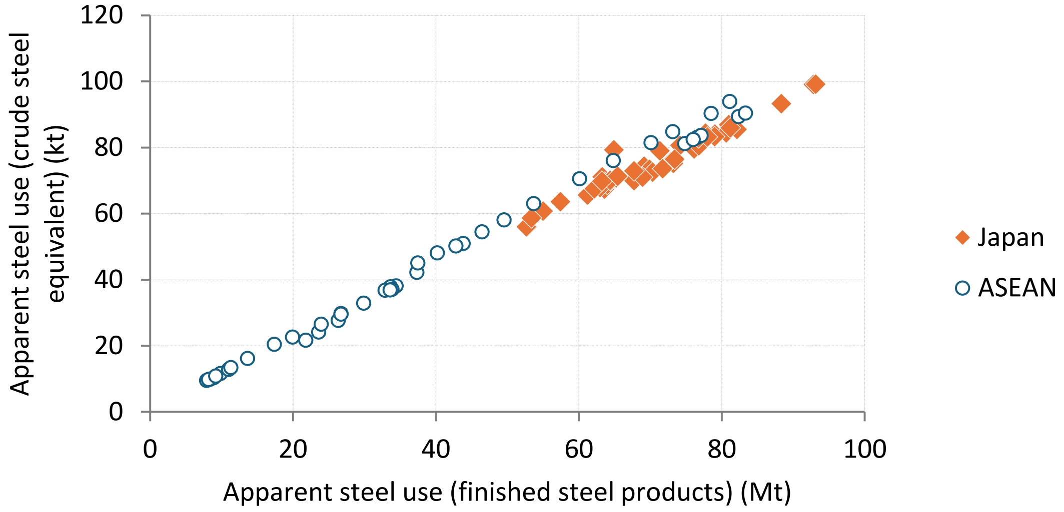


Note: Trial calculations.
Source: Authors.

1.5. Quantitative analysis of crude steel consumption in the ASEAN region

The apparent use of crude steel is estimated from the apparent use of steel products. There are no major difficulties in the formulation, as a strong and stable correlation is generally observed between the two, as shown in Figure 2.10. However, it should be noted that in ASEAN, changes in the relationship were observed before 2017 and after 2018.

Figure 2.10: Consumption of Steel Products and Crude Steel in ASEAN and Japan, 1980–2023



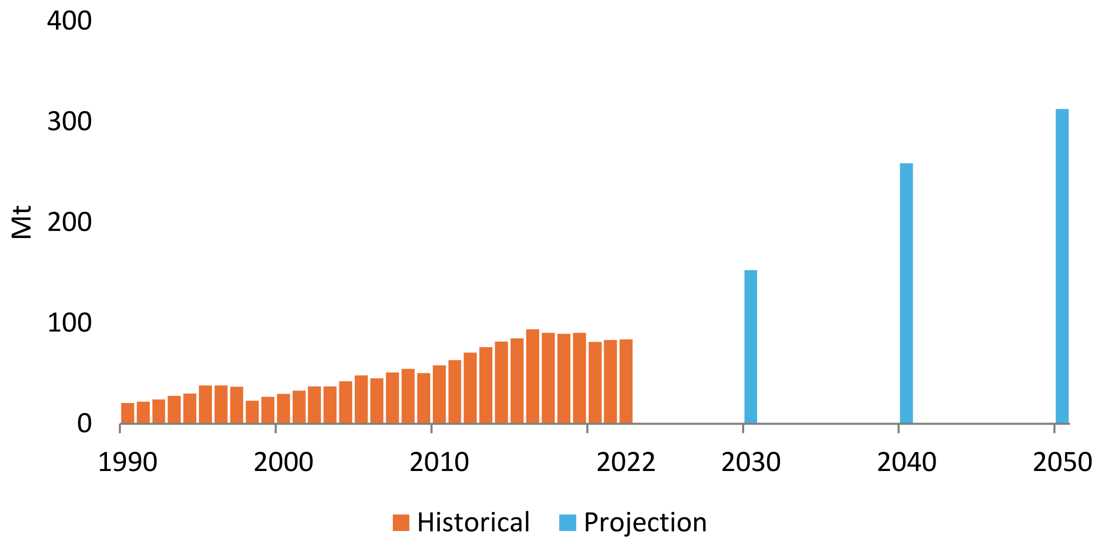
Note: ASEAN here includes Indonesia, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam but does not include Brunei Darussalam, Cambodia, and Lao PDR, for which data are not available in the World Steel Association (worldsteel) 'Steel Statistical Yearbook.'
Source: worldsteel (2024a).

The estimated equation for crude steel apparent use in the ASEAN pilot model is as follows:

log(CS_AU_ASEAN) =
0.126283+0.995004*(log(FSP_AU_ASEAN))+0.049461*(DUM(1990,2017))

where CS_AU_ASEAN is crude steel apparent use (kt), FSP_AU_ASEAN is steel apparent use (finished steel products) (kt), and DUM(1990,2017) is a dummy variable with a value of 1 for the years 1990 to 2017 and 0 for other years. Based on the values of steel product apparent use (finished steel products) per capita, shown in Figure 2.9, and population projections, the future projection for crude steel apparent use is as shown in Figure 2.11.

Figure 2.11: Tentative Results of Crude Steel Apparent Use in ASEAN



Note: Trial calculations.
Source: Authors.

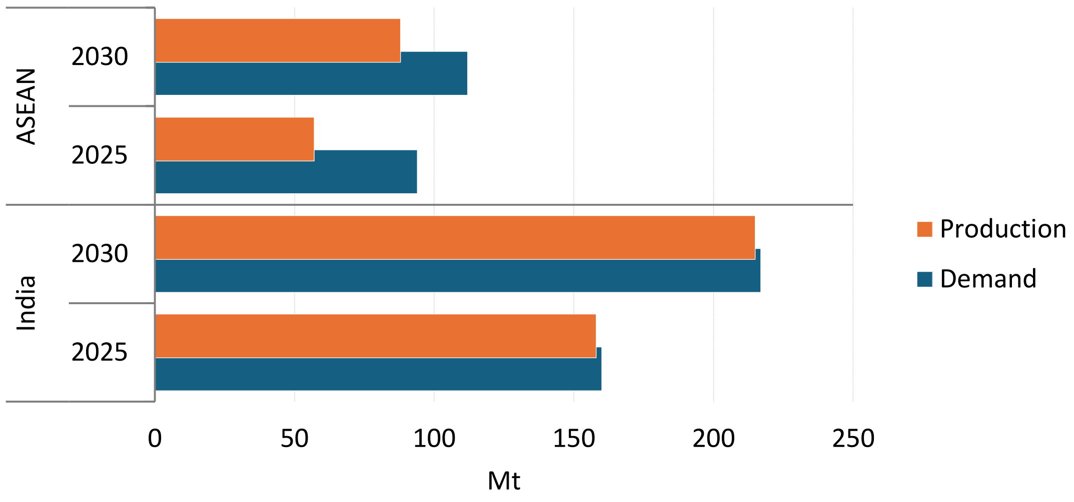
1.6. Quantitative analysis of crude steel production in the ASEAN region

Crude steel, being a typically heavy good, is generally considered economically rational to produce close to the place of consumption. In the case of the blast furnace route in particular, the scale of domestic demand has significant implications for the choice of production location, as it requires substantial capital investment.

The minimum efficient scale for an integrated steelworks using the blast furnace route is estimated at an annual crude steel production capacity of 3 million tonnes (Kawabata, 2005).

As noted above, if ASEAN is treated as a single region, it can be assumed that economic development will lead to a reasonable amount of steel consumption and encourage the expansion of the crude steel production system, given the region's large population. For example, OECD (2025) also projects that ASEAN's steel production, which is currently below its demand, will expand at a faster pace than demand, as shown in Figure 2.12.

Figure 2.12: Steel Demand and Production



Source: OECD (2025).

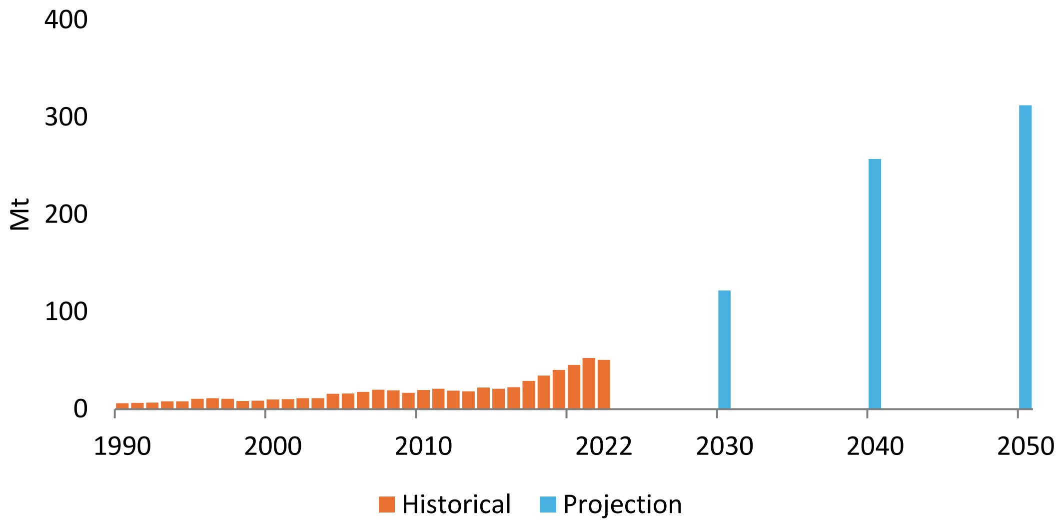
The equations related to crude steel production in the ASEAN pilot model are as follows:

CS_PR_AU_ASEAN = exp(0)/(1+exp(1.68568+0.892833*(log(exp(0)/CS_PR_AU_ASEAN(−1)−1))−3.66070*(VAIND_ASEAN/GDP_ASEAN)−3.06293*((FSP_AU_ASEAN(−2)+FSP_AU_ASEAN(−3))/10^6))),

CS_PR_ASEAN = CS_AU_ASEAN*CS_PR_AU_ASEAN

where CS_PR_AU_ASEAN is the ratio of crude steel production to crude steel apparent use, GDP_ASEAN is GDP (US$2015 billion), and CS_PR_ASEAN is crude steel production (kt). Specifically, the self-sufficiency rate of domestic production relative to consumption is estimated, and this is multiplied by the consumption volume to estimate crude steel production. Based on this ratio and the values shown in Figure 2.11, the future projection for crude steel production is as shown in Figure 2.13.

Figure 2.13: Tentative Results of Crude Steel Production in ASEAN



Note: Trial calculations.
Source: Authors.

Shown as above, a pilot model was developed to quantitatively analyse crude steel production for the ASEAN region as a whole. The structure assumed that (i) an increase in the value added of the industrial sector as a share of GDP and (ii) an increase in the consumption of steel products would boost the ratio of crude steel production to apparent use. The effects of (i) and (ii) are assumed to occur with a time delay, as crude steel production facilities cannot be installed or removed quickly.

Specifically, logistic regression was conducted to estimate various parameters, setting the upper limit of the ratio of crude steel production to apparent consumption at unity.[12] Crude steel production was then estimated from the apparent use of crude steel (as estimated in Section 1.5) and the ratio of crude steel production to apparent use estimated in this section.

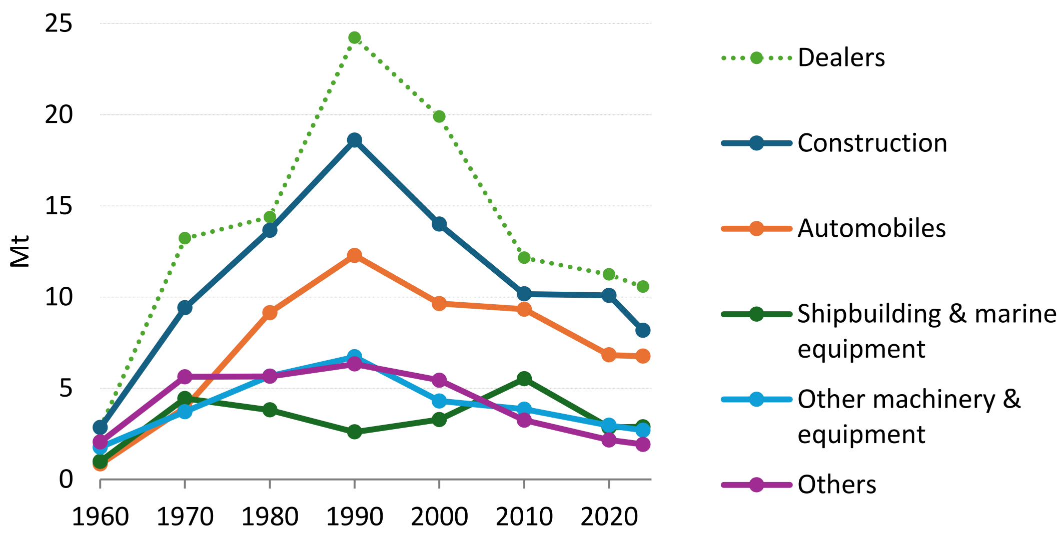
1.7. Quantitative analysis of crude steel production by route in the ASEAN region

Crude steel production routes are closely related to shifting demand for different steel grades. The blast furnace route is generally suitable for the production of high-grade steel sheets, such as automotive steel sheets, for which excellent quality is required. On the other hand, the electric furnace route is strong in the production of middle-grade steel plates, such as roofing steel and coloured steel plates, low-grade steel plates such as guardrail sheets, and steel bars and shapes such as shaped steel for construction and

[12] When the ratio is 1, self-sufficiency in crude steel is achieved. As with the consumption estimates, this upper limit may require further study. However, given net steel exporters in the vicinity, ASEAN would need to develop considerable international competitiveness to achieve a significant net export position.

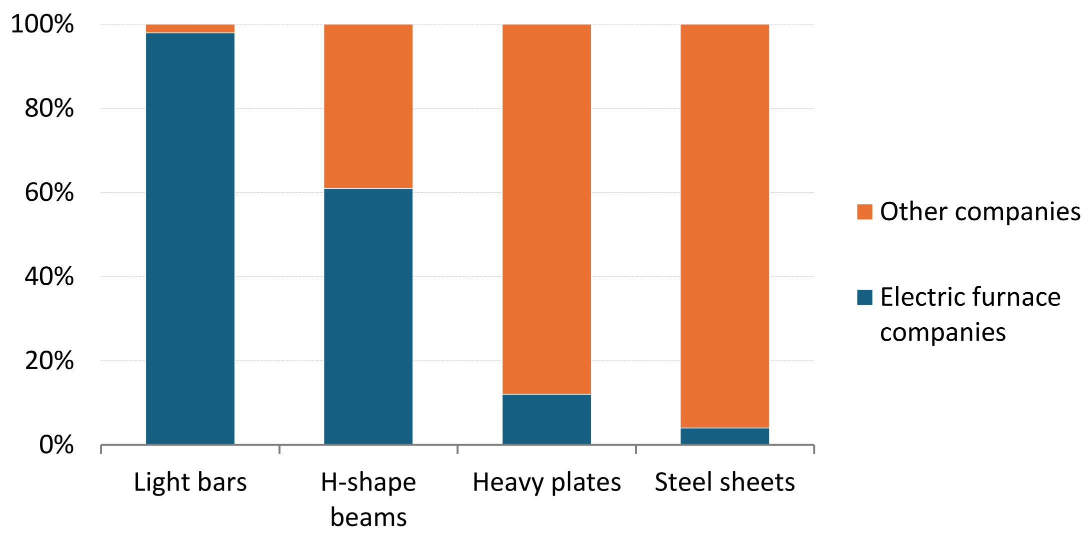
civil engineering applications, and pipes. The evolution in the types of steel products demanded (Figure 2.14) will indirectly influence changes in crude steel production routes (Figure 2.15).

Figure 2.14: Domestic Orders for Ordinary Steel Products in Japan



Notes: Fiscal year (April of the current year to March of the following year). The largest use of dealers is estimated to be construction.
Source: JISF, 'Statistical Handbook of Iron and Steel.'

Figure 2.15: Shares of Selected Steel Products in Japan, 2018



Source: Tokyo Steel Corporation (2023).

Crude steel production routes are also related to the scale of production. As mentioned above, the minimum efficient scale of an integrated steel plant using blast furnaces is estimated at 3 Mt/y, whereas that of an electric furnace is 300 kt/y (Kawabata, 2005). Although electric furnaces are becoming larger, the average production capacity of operating blast furnaces remains several times that of electric furnaces. In addition, the capacity for technical and quality control throughout the supply chain, the availability of feedstocks, and financial ability also influence the choice of production route.

However, the outlook for crude steel production by route presented here is not something that can be built up by developing business plans for individual steel mills. Rather, a macro approach is adopted, which, like steel product consumption and crude steel production, is expected to remain valid for projections extending decades into the future, whilst taking into account but not being restricted by micro-level circumstances. In other words, the share of crude steel production by route will be affected by changes in the types of steel products demanded and the consumed amounts in accordance with the stage of economic development. Trends in the share by route (blast furnaces[13] and others[14]) are estimated using logistic regression. Specifically,

S_CS_PR_BF_ASEAN =
exp(0)/(1+exp(−0.162320+0.016047*(GDP_ASEAN/POP_ASEAN)−0.085500*(CS_PR_ASEAN/10^6)+0.933268*(log(exp(0)/S_CS_PR_BF_ASEAN(−1)−1))))*(0.58039/0.58927),

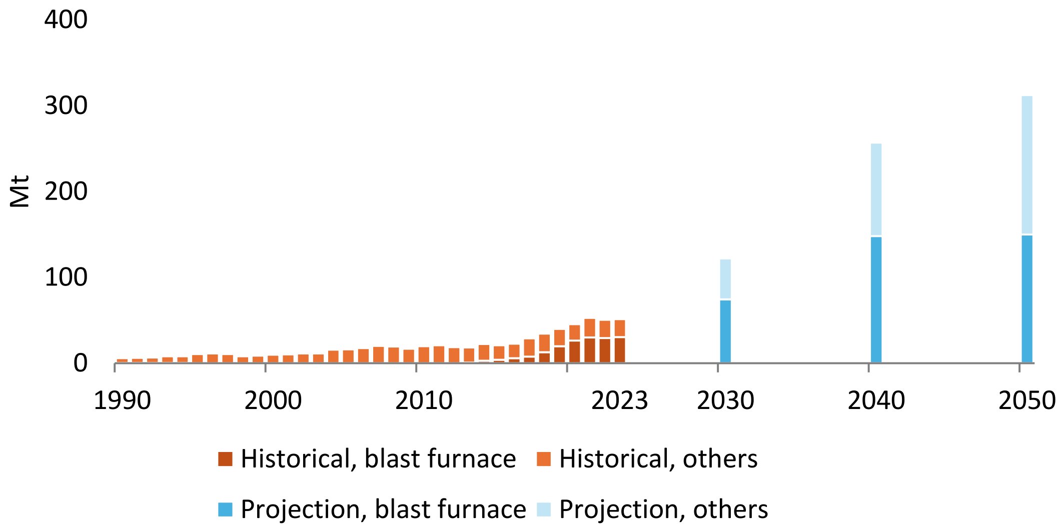
CS_PR_BF_ASEAN = CS_PR_ASEAN*S_CS_PR_BF_ASEAN,

CS_PR_NBF_ASEAN = CS_PR_ASEAN−CS_PR_BF_ASEAN

where S_CS_PR_BF_ASEAN is the share of production by blast furnaces, CS_PR_BF_ASEAN is production by the blast furnace route (kt), and CS_PR_NBF_ASEAN is production by other routes (kt). The multiplier at the end in the first estimated equation is an adjustment based on 2022 values. The results obtained are as shown in Figure 2.16.

[13] Equivalent to basic oxygen furnaces in World Steel Association, 'Steel Statistical Yearbook.'
[14] Equivalent to electric furnaces and other processes in World Steel Association, 'Steel Statistical Yearbook.'

Figure 2.16: Tentative Results of Crude Steel Production by Route in ASEAN



Note: Trial calculations.
Source: Authors.

It is important to note that the future outlook created by this so-called extension of past trends is based on historical figures and is not the image that will emerge once the decarbonisation of the steel industry in Asia comes to fruition. It is intended only as a reference; a future scenario reflecting the achievement of decarbonisation will be analysed in Phase 3.

1.8. Towards Phase 2

In Phase 1, the availability of relevant datasets – such as energy statistics and production capacity – was assessed, revealing potential challenges related to data collection, boundary accuracy, and the availability of relevant data, including energy statistics and production capacity. During this process, potential challenges concerning energy data collection and the accuracy of system boundaries were identified.

A preliminary pilot model was also prototyped to look at crude steel consumption, treating ASEAN as a single region, and a certain degree of validity was confirmed. However, some argue that the intensity-of-use hypothesis, which focuses on the relationship between real GDP per capita and crude steel consumption per unit of real GDP or per capita, is an effective method for analysing specific countries but can be difficult to apply universally. There is also a view that in countries where economic development begins later, the rise in production per capita tends to occur earlier in the development process.

Meanwhile, the analysis of the production side also has its limitations when taking an ASEAN-wide view. Indeed, the ASEAN Industrial Project, attempted in the 1980s and 1990s to develop industries requiring large amounts of capital through large-scale projects coordinated by the member countries, was not successful. However, ASEAN has already introduced a number of blast furnaces, and the possibility of large-scale future investment plans including Chinese capital are under consideration. At the same time, there are indications that excess production capacity may already be present in the region.

In Phase 2, it is necessary to shift the perspective to the country level and refine the model structure and parameters for the major iron and steel countries, taking into account data availability.

In conjunction with the challenges of decarbonisation, the emerging demand for green steelmaking, and the accelerating constraints on resource procurement such as high quality scrap, the steel industry may be entering a new phase of development in the ASEAN region.

2. Guidelines for the Asian steel industry: 'Towards a Net-Zero Steel Industry in Asia'

2.1. Overview of the Guidelines

The iron and steel sector are highly energy-intensive and CO_2-intensive and is a key focus area for achieving decarbonisation worldwide. In Southeast Asia and India, however, new investment in BF-BOF facilities is expected in the medium to long term to meet growing regional steel demand. Achieving decarbonisation of the steel industry whilst meeting demand will be a major challenge.

Reducing CO_2 emissions from the iron and steel sector requires lowering energy consumption, using low-carbon energy source (such as electrification of the facilities or utilising renewable energy), and developing innovative technologies such as hydrogen-reduction steelmaking and CCUS. Above all, reducing energy consumption is a basic activity that should be continuously implemented at all steel plants. According to the *Iron and Steel Technology Roadmap* published by the IEA (2020), 'technologies categorised as mature or in the early adoption phase account for about 70% of cumulative direct CO_2 emission reductions to 2050.' Mature technologies, namely best available technologies (BATs), are generally already in use in the iron and steel sector and are highlighted for their importance.

Reducing energy consumption is a first step towards long-term decarbonisation in the iron and steel sector. However, efforts to reduce energy consumption are not yet maximised in some countries, indicating potential for further energy efficiency improvements through the sharing of knowledge in the sector. The iron and steel sector involves a variety of steel manufacturing processes, from crude steel production to steel casting, rolling, and processing. How to treat the raw materials, manufacturing processes, and types of steel product varies from steel plant to steel plant, so the equipment configurations are diverse and complex. In addition, the steel manufacturing equipment is usually large in scale and highly durable, so it tends to be expensive and used for a long time once invested in. Therefore, there are many types of energy-saving equipment in the steel industry, but it is difficult to determine which facilities are effective and appropriate for saving energy.

For this reason, it is important to provide information on how to improve energy efficiency in steel plants by offering the 'Towards a Net-Zero Steel Industry in Asia' Guidelines, which describe how improving energy efficiency in steel plants would be profitable. The 14 evaluation criteria for appropriate equipment selection are shown on Table 2.7. When selecting equipment and equipment suppliers, it is important to consider not only the capital investment but also the life cycle cost (Clause 5.4.3.6), such as the availability of support after installation (Clause 5.4.3.12) and equipment reliability. These considerations are crucial for preventing equipment failures and unexpected operational shutdowns. Improving energy efficiency can be considered through the Plan-Do-Check-Action (PDCA) cycle, as follows: understanding the current energy usage at the steel plants and identifying manufacturing processes with possibility of reducing energy usage (Plan); selecting and introducing appropriate energy-saving technologies and equipment (Do); and implementing appropriate operation, evaluation of equipment and revision for further improvements (Check, Action). The Guidelines aim to be a reference document for steel plants to improve energy efficiency by implementing the PDCA cycle on their own. Whilst mainly referencing ISO 50001, they incorporate specific perspectives tailored to the iron and steel sector to make the Guidelines more practical.

Table 2.7: Fourteen Criteria for Appropriate Equipment Selection

Clause	Evaluation Criteria
5.4.3.1	Appropriate equipment specifications
5.4.3.2	Physical feasibility of installation
5.4.3.3	Safety
5.4.3.4	Environmental and social considerations
5.4.3.5	Appropriate schedule management
5.4.3.6	Life cycle cost
5.4.3.7	Guaranteed performance
5.4.3.8	Reduction potential of energy consumption
5.4.3.9	Operational availability of equipment
5.4.3.10	Durability
5.4.3.11	Maintainability
5.4.3.12	Availability of support after installation
5.4.3.13	Additional benefits
5.4.3.14	Supply record of installation or advanced technology

The Guidelines have three features. First, they present criteria for selecting comprehensive and high-performance energy-saving equipment, namely BATs. In some cases, steel companies are only interested in how to minimise initial investment costs when they invest in equipment. However, this approach can lead to undesirable results, such as equipment that does not withstand long-term use due to inadequate maintenance or operation, equipment that does not consistently or stably perform in line with specifications, equipment that does not ensure safety, equipment that does not sufficiently consider environmental impact, and equipment that increases overall life cycle costs, and so on. If appropriate energy-saving equipment is not introduced and properly operated, improvements in energy efficiency in steel plants cannot be fully achieved. The Guidelines currently propose 14 criteria for appropriate equipment selection. Users can prioritise each criterion according to the characteristics of the equipment and the circumstances of their organisation to make a decision on which equipment to select and introduce. ISO 50001 does not include such criteria for equipment selection, but they are a unique feature of the 'Towards a Net-Zero Steel Industry in Asia' Guidelines, specifically created for the iron and steel sector.

Secondly, it is important to link the Guidelines with existing tools that support improvements in energy efficiency in the iron and steel sector, such as ISO 14404 and the Technologies Customized Lists (TCL, see Section 2.2). The ISO 14404 series is an international standard that provides a methodology for calculating CO_2 emissions and energy consumption at steel plants. One of its key features is that it enables the calculation of energy consumption and energy intensity for the entire steel plant. To improve energy efficiency at steel plants, it is desirable to understand energy consumption and energy intensity for the entire plant rather than for individual processes or pieces of equipment. In integrated steel plants, by-product gases and waste heat generated in each manufacturing process are recycled into other processes or utilised in in-house power plants etc., all inside the same steel plant to achieve overall optimisation of energy consumption. Therefore, the Guidelines specify the ISO 14404 series to calculate the energy consumption and energy intensity of entire steel plants. The TCL lists recommended technologies for improving energy efficiency and protecting the environment. Steel manufacturing companies can refer to the TCL when considering which energy-saving technologies will help reach their targets. The Guidelines aim to provide information to steel manufacturing companies in a practical and comprehensive manner by presenting tools such as ISO 14404 and the TCL, and by encouraging their use.

Thirdly, when steel companies try to improve the energy efficiency of their plants by using the Guidelines' PDCA cycle, they can also reduce energy costs, strengthen competitiveness, and reduce CO_2 emissions and other related environmental impacts. Whilst investments aimed at achieving net zero and decarbonisation can be a significant burden for companies, utilising the Guidelines to improve energy efficiency offers companies these benefits.

The draft Guidelines were developed by experts with experience in improving energy efficiency in steel plants. Through this project, the draft will be revised and refined based on feedback from the intended users, such as steel companies and other related parties involved in the iron and steel sector in Asian countries. For more information on the feedback received from the stakeholders, see Section 2.4.

2.2. Draft Technologies Customized List (TCL)

The TCL is a list of energy-saving, CO_2-reducing, and environmental facilities that collects BATs that meet the needs of the target countries. By using the TCL, steel plants can identify the high-priority energy-saving and CO_2 emission-reducing technologies that should be introduced at their respective plants. In addition, the TCL includes a list of recommended technologies and a part called the 'one-by-one sheet' that provides a detailed explanation of each technology on each page. At the end of the document, a list of contact information for Japanese suppliers of each technology is included, allowing steel companies to review the technology in the TCL and, if they are interested in a particular technology, contact the equipment manufacturer directly.

The JISF has published TCLs for India and ASEAN. The JISF released TCL version 1 for BF-BOF plants following the Public and Private Collaborative Meeting between Indian and Japanese Iron and Steel Industry in February 2013. Based on discussions at the 8th Public and Private Collaborative Meeting between Indian and Japanese Iron and Steel Industry, the growing importance of small and medium-sized steel plants was recognised, leading to the development of the TCL for EAF plants in India in 2019. For ASEAN, the TCL for EAF plants was published under a collaborative scheme with the AJSI in 2014, followed by the TCL for BF-BOF plants.

The 'Towards a Net-Zero Steel Industry in Asia' Guidelines encourage steel plants to set targets for energy conservation and CO_2 reduction and to select appropriate technologies accordingly. The Guidelines include descriptions of utilising the TCL when selecting a technology, so that both the TCL and the Guidelines can be used effectively to achieve their goals. The TCL is therefore a highly useful collection of BATs that steel manufacturers can refer to when considering the capital investment necessary to achieve their objectives. Through the JISF's long-standing activities, the TCL has already gained trust as a familiar tool for steel industry stakeholders in India and ASEAN, serving as a reference for proven BATs in the Japanese steel industry. It is anticipated that the TCL will further enhance its value and create synergistic effects by being cited in the 'Towards a Net-Zero Steel Industry in Asia' Guidelines.

During Phase 1 of the project, the technologies listed, the energy prices and CO_2 emission factors (which form the basis for estimating the payback period), and the supplier list were reviewed and updated to reflect recent trends, using information from suppliers and literature.

Based on the TCL version established in Phase 1, further revisions are planned for Phases 2 and 3 to ensure that the TCL content is appropriate as an accompaniment to the Guidelines. Specifically, this includes consolidating the TCLs, which are currently divided into two parts per region due to past development history, into a single volume per region with unified list items, and conducting further review of the technologies and their content based on insights gained from the case study of steel plant diagnosis (see Section 2.3). The goal is to establish a more refined and streamlined TCL suitable for the project's final output.

2.3. Case study of steel plant diagnosis

As a Phase 1 case study, a steel plant diagnosis was conducted at a steel plant in Thailand in November 2024. The outline of the diagnosis is as follows.

- Diagnosis duration: 21–28 November 2024 (4 days of on-site survey; online reporting session on 8 January 2025)
- Diagnosed site: EAF steel plant (Company A, Plant B) in Thailand

Objectives and methodology of the steel plant diagnosis

(1) To support the diagnosed plant in planning and implementing energy-efficiency projects towards decarbonisation.
(2) To realise the previous objective, the most effective greenhouse gas (GHG) emission reduction measures are proposed at the diagnosed plant by introducing BATs. In addition, ISO 14404 is used to evaluate energy consumption and GHG emissions at the plant.
(3) To contribute to the development of the 'Towards a Net-Zero Steel Industry in Asia' Guidelines under the ERIA project, discussions were held with the diagnosed plant during the diagnosis process.

The diagnosis focused on upstream processes (including EAFs) and RHFs for rolling mills. These consume large amounts of energy and emit GHGs mainly at the plant. The measures proposed through the diagnosis focused on BATs, and state-of-the-art technologies still under development or demonstration were excluded. In addition, operational improvement measures requiring minimal expenditure were introduced and discussed during the diagnosis.

The overall procedure for the steel plant diagnosis is shown in Figure 2.17.

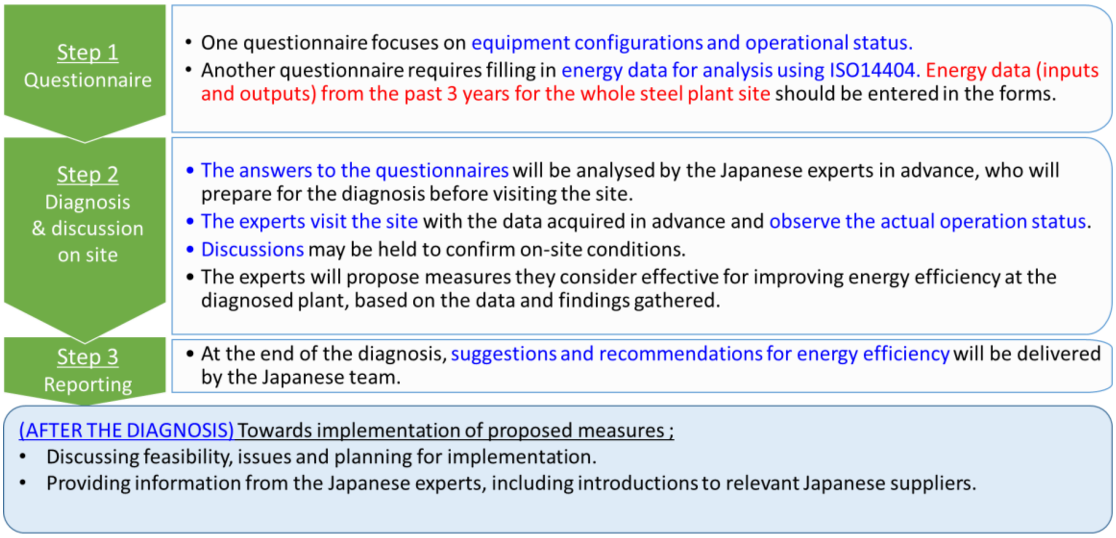
In the first step, preliminary questionnaires were carried out for the diagnosed plant. One questionnaire focused on equipment configurations and operational status of EAFs and RHFs, whilst the other questionnaire focused on energy data used to calculate energy intensity and CO_2 intensity based on ISO 14404.

After acquiring the answers from the diagnosed plant, experts evaluated the actual state of energy consumption and operational status at the plant in advance of the on-site diagnosis.

In the second step, the on-site diagnosis was carried out to confirm the actual situation at the plant. The on-site diagnosis was scheduled for four days at the plant. The actual timetable of the diagnosis is shown in Figure 2.18.

After the on-site diagnosis, the experts analysed the plant's performance and prepared the diagnosis report. In the third step, the diagnosis results were reported to the diagnosed plant during an online meeting.

Figure 2.17: Procedure of the Steel Plant Diagnosis



Source: Authors.

Figure 2.18: Timetable of the On-site Diagnosis

	Day 1 (21 Nov 2024)	Day 2 (22 Nov 2024)	Day 3 (25 Nov 2024)	Day 4 (26 Nov 2024)
AM	Start at 10:00 am • Opening session • Confirmation of operational status and equipment configurations (based on preliminary questionnaire) End at 3:30 pm	Start at 9:30 am • Explanation and discussion on 'Towards a Net-Zero Steel Industry in Asia' Guidelines • Explanation of ISO 14404	Start at 10:00 am • Confirmation of operational status for downstream (rolling)	Start at 10:00 am • General confirmation from experts • Introduction and preliminary discussion of items to be proposed at the online reporting session • Closing of plant site survey End at 2:30 pm
PM		• Confirmation of operational status at the EAF and upstream processes; on-site observation End at 3:30 pm	• On-site observation and discussion of operational conditions at downstream process End at 3:30 pm	

Online reporting session (8 Jan 2025)
• Reporting & QA session • Discussion on feasibility of proposed measures

Source: Authors.

Outline of the diagnosed plant

- Major equipment: One EAF (capacity: 42 tonnes), ladle furnace, continuous casting machine, and rolling mill
- Iron source: Mainly scrap, partly DRI and pig iron
- Products: Mainly wire rod
- Production amount: Approximately 190,000 tonnes per year (2023), production capacity approximately 300,000 tonnes per year

ISO 14404 calculation results

The results of the ISO 14404 analysis for the diagnosed plant are shown in Table 2.8. The calculations were carried out using data for the years 2021, 2022, and 2023 provided at the diagnosed plant.

From 2021 to 2023, crude steel production decreased by more than 40%, primarily due to weak steel demand in Thailand. In addition, equipment issues at the plant affected production levels in 2023. These factors resulted in an increase in energy and CO_2 emission intensities during the period.

When comparing the calculated energy and CO_2 intensities at the plant with the global intensities issued by the World Steel Association (worldsteel), those at the diagnosed plant are generally close to the global figures and are evaluated to be around the average level. The steel plant produces a wide variety of products in small quantities, many of which are difficult to manufacture. Considering this point, the plant's energy and CO_2 intensities can be considered favourable.

The plant also conducted its own CO_2 intensity calculations independently of ISO 14404. The calculation results were found to be close to the ISO 14404 results, with the differences attributable to variations in the CO_2 emission factors used in the calculations.

Table 2.8: Calculation Results Based on ISO 14404

	2021	2022	2023
Crude steel production (t/y)	297,532	270,484	170,729
Change rate (%)	100%	91%	57%
Total energy (GJ/y)	2,999,167	2,773,828	1,866,906
Energy intensity (GJ/t-steel)	10.08	10.26	10.93
Change rate (%)	100%	102%	108%
Total CO_2 (t-CO_2/y)	187,939	173,406	114,233
CO_2 intensity (t-CO_2/t-steel)	0.63	0.64	0.67
Change rate (%)	100%	101%	106%
Supplied CO_2 intensity value (calculated individually by the diagnosed plant) (t-CO_2/t-crude steel)	0.666	0.673	0.737

Global energy intensity of scrap EAF by worldsteel* (GJ/t-crude steel)	10.00	10.13	10.24
Global CO_2 emission intensity of scrap EAF by worldsteel* (t-CO_2/t-crude steel)	0.66	0.67	0.70

Source: Authors, except for data denoted by * from world steel (2024b).

Outline of the diagnosis results

Through the diagnosis, a total of 10 energy-saving measures were proposed. As shown in Table 2.9, the proposed items include four operational improvements for EAFs, three operational improvements for RHFs, and three equipment revamping measures.

In the upstream process, the total CO_2 reduction from the proposed measures is estimated approximately 10,570 t-CO_2/y. In the downstream process, a total CO_2 reduction of approximately 2,000–2,900 t-CO_2/y is expected through implementing the proposed measures.

It is noted that each CO_2 reduction amount is roughly calculated based on the condition of the diagnosed plant (production capacity, etc.) and additional assumptions. For more detailed and precise estimations, it is necessary to consult with the equipment suppliers on equipment revamping. For operational improvements, the CO_2 reduction amount depends on the condition of implementation at the plant. It should also be noted that estimates of CO_2 reduction amounts will vary depending on individual conditions, such as the size of the steelworks, production volume, and equipment capacity.

Table 2.9: Proposed Measures in the Steel Plant Diagnosis

No.	Process	Type	Measure	Expected CO_2 Reduction Amount (Rough Estimation)
1	EAF	Revamping	Scrap preheating EAF	8,470 t-CO_2/y
2	EAF	Revamping	PC burner for improvement of coke post combustion in EAF	1,440 t-CO_2/y
3	EAF	Operational	Reduction of excess oxygen supply	3,440 t-CO_2/y
4	EAF	Operational	EAF power-cut operation	970 t-CO_2/y
5	EAF	Operational	Reduction of EAF tapping temperature	730 t-CO_2/y
6	EAF	Operational	Increase of aluminium dross consumption in EAF	3,990 t-CO_2/y
7	RHF	Operational	Appropriate management of air ratio	1,200 t-CO_2/y
8	RHF	Operational	Prevention of air invasion to upraise preheated air temperature	720 t-CO_2/y

9	RHF	Operational	Periodical cleaning of recuperator heat exchanger	960 t-CO_2/y
10	RHF	Revamping	Regenerative burner for RHF	5,340 t-CO_2/y (including fuel conversion)

Source: Authors.

The CO_2 emission factors used in the calculation are based on ISO 14404, as shown in Table 2.10.

Table 2.10: CO_2 Emission Factors (ISO 14404) Used in the Calculations of the CO_2 Reduction Amounts

CO_2 emission factor of electricity	0.504 t-CO_2/MWh
CO_2 emission factor of natural gas	0.05613 t-CO_2/GJ (converted units from 2.015 t-CO_2/1,000 Nm^3)
CO_2 emission factor of fuel oil	0.076138 t-CO_2/GJ (converted units from 2.907 t-CO_2/m^3)
CO_2 emission factor of oxygen	0.355 t-CO_2/1,000 Nm^3
CO_2 emission factor of coke	3.257 t-CO_2/t-coke

Source: Authors.

The operational measures are considered relatively easy to implement in the short term without a large cost burden. The steel plants reacted positively, indicating that the proposed items could be studied as soon as possible for implementation.

The equipment revamping measures, on the other hand, are proposed as part of a mid- to long-term plan. There was a technology that seemed to have potential for introduction, whilst there are some challenges associated with implementing each of the proposed equipment revamping measures, as shown in

Table 2.11.

Table 2.11: Challenges and Opportunities in Implementing Proposed Equipment Revamping Measures

1	Scrap preheating EAF	Requires large amount of capital expenditure for installation. No current plans for replacing EAF at the diagnosed plant. It was recommended that this option be considered when planning future EAF replacements.
2	PC burner for improvement of coke post combustion in EAF	Relatively small capital expenditure and high cost-effectiveness. It was recommended for short-term study and potential installation. The diagnosed plant reacted positively, indicating willingness to consider the measure.
3	Regenerative burner for RHF	At present, the plant uses fuel oil as the energy source for the RHF. Fuel oil containing sulphur is not suitable for regenerative burner. It is recommended to study this option once conditions permit, such as after converting the fuel source to natural gas, etc. Modification of the furnace body is required to install the regenerative burner. The cost of modification and the arrangement with the existing furnace supplier must also be considered. The heat accumulator of the regenerative burner requires space for installation. It is necessary to confirm whether the installation space can be secured.

Source: Authors.

2.4. Needs and opinions from ASEAN countries and others regarding the 'Towards a Net-Zero Steel Industry in Asia' Guidelines

The main characteristics of the 'Towards a Net-Zero Steel Industry in Asia' Guidelines, as described in Section 2.2, are as follows:

(1) The Guidelines focus on the introduction of BATs to improve energy efficiency as a first step towards decarbonisation (a common approach in the 2050 CN scenario adopted by many countries, and the 2070 CN scenario adopted by India).

(2) The Guidelines recommend the use of tools such as ISO 14404, a methodology for calculating energy consumption and CO_2 emissions in steel plants, and the TCL, a catalogue of BAT countermeasure technologies.

(3) The Guidelines can be used by steel companies to voluntarily enhance energy efficiency by implementing the PDCA cycle for future decarbonisation of the steel industry.

Regarding BATs, the Guidelines emphasise the importance of selecting the most appropriate technologies from amongst the multiple suppliers. In general, the supplier with the lowest initial investment cost is selected. However, the Guidelines list 14 evaluation criteria, including consideration of post-operational costs (so-called 'life cycle cost' (LCC)). If a supplier is selected solely on the basis of a low initial investment cost, not only will the cost of repair and maintenance be higher than expected but the low facility utilisation rate (or high failure rate) will cause operations (and production) to be halted, which in some cases can be a major disadvantage, as this may disrupt production activities. In addition to obtaining basic information to evaluate suppliers appropriately, it is beneficial to have technical discussions (and technical evaluations) through interviews, etc. as necessary. Information on past delivery records and the supplier's customer evaluation are also important. In particular, it is useful to collaborate with Japanese steel experts, some of whom have extensive experience in these areas.

With the above perspectives in mind, an overview of the draft Guidelines was introduced and opinions were exchanged with steel companies, the assumed users of the Guidelines, as well as with local steel industry representatives. The following is a list of the parties with whom opinions were exchanged and the main opinions and questions raised.

(1) Thailand

- Contact points:
  Iron and Steel Institute of Thailand (ISIT), Steel Company A

- Opinions and questions:

• The Guidelines are extremely useful for Thai steel companies. Given the Thai steel industry's priority on reducing emissions and improving energy efficiency, the Guidelines are well aligned with Thailand's broader sustainability goals.
• The evaluation criteria are quite comprehensive and reasonable. In particular, LCC evaluation encourages companies to consider not only the initial costs but also long-term operating costs and energy savings, thus preventing excessive spending and operational inefficiencies. (Currently, not all Thai companies consider LCC; some focus only on the initial investment.)
• Case studies and examples of Thai steel companies that have successfully implemented these energy conservation measures would make the Guidelines more informative and practical. The criteria for selecting appropriate equipment would also help to consider all perspectives. On the other hand, there may be cases where suppliers do not provide information or it is not possible to collect information, and some perspectives may not be feasible to evaluate, especially in new or unproven technologies.
• As related guidelines, the Thailand Greenhouse Gas Management Organization has issued net-zero guidelines for all industries. Detailed guidelines specifically for the steel industry, such as those prepared by the Japanese side, would be useful.
• Some of the criteria included in the draft 'Towards a Net-Zero Steel Industry in Asia' Guidelines, such as LCC, are already incorporated in the company criteria. However,

there are some items that are not included and are, therefore, worth referring to, such as maintainability.

(2) India

- Contact points:
  Public and Private Collaborative Meeting between Indian and Japanese Iron and Steel Industry, Indian Steel Association (ISA), The Energy and Resources Institute (TERI), The Sponge Iron Manufacturers Association (SIMA), Engineering Company B, Steel Company C

- Opinions and questions:

• Are these Guidelines the same as the draft international standard (ISO/Preliminary Work Item-13055) that was explained by Japan at the World Steel Association's Environment Committee and other meetings?
  ⇒ Answer from Japan side: This Guidelines follow the concept of the draft international standard. However, the goal of developing these Guidelines is not to establish them as an international standard but to ensure they function beneficially for the steel industry. In particular, the aim is to make the Guidelines more practical and useful by taking into account actual examples. Since this is a multi-year project, it will continue to exchange opinions with steel professionals in each country and reflect their views.
• The idea of including LCC as well as initial costs is both practical and important.
• The basic idea of considering not only initial costs but also LCC is close in concept to the Indian government's procurement guidelines (to reflect not only price points but also technical points in the evaluation of procurement bids). However, although some companies in India are using them, there is an issue that many companies evaluate only the initial investment cost.
• What exactly are the 14 evaluation criteria?
• ⇒ Answer from Japan side: Representative items were shared in the presentation materials.

Through discussions with stakeholders in Thailand and India, approval and positive feedback were collected on the draft Guidelines and their development objectives. It was confirmed that both countries recognise the importance of LCC and agree that further awareness is necessary. In Thailand, the existence of net-zero guidelines for all industries published by the Thailand Greenhouse Gas Management Organization was confirmed. Similarly in India, the existence of public procurement guidelines issued by the Indian government was confirmed. Comparing and ensuring consistency between these existing guidelines and the 'Towards a Net-Zero Steel Industry in Asia' Guidelines is important and should be carried out in Phases 2 and 3 of the project. Unlike Thailand, where EAF steel production is predominant, countries such as Indonesia and Viet Nam have blast furnaces, and even within the same ASEAN region, the characteristics of the steel industry vary country by country. Approaching these countries and conducting discussions in Phases 2 and 3 should also be considered.

3. International advocacy

3.1. ASEAN Japan Steel Initiative (AJSI) Seminar

3.1.1.Overview of the seminar

The project team conducted the AJSI Seminar to share and disseminate initiatives related to decarbonisation in the steel sector, gather opinions, and promote collaboration amongst ASEAN countries. The seminar was held on 20 November 2024 in Bangkok, Thailand, as part of the SEAISI event titled '2024 ASEAN Iron and Steel Forum: Sustainable Steel and Green Construction.'

This was the first time the seminar was held in person, and it was attended by 85 participants. The distribution of participants by office location was as follows: Japan (23.5%), China (21.2%), Thailand (14.1%), Malaysia (12.9%), Indonesia (8.2%), Singapore (7.1%), the Philippines (4.7%), and others (8.2%).

The agenda consisted of the following three sessions, with representatives from both the public and private sectors in ASEAN countries, as well as Japan, presenting their policies, initiatives, and challenges:

1. Policy developments toward carbon neutrality
2. Activities and challenges of steelmakers
3. Technology developments for energy saving and carbon neutrality

3.1.2.Summary of the presentations

In Session 1, Ms. Izumi Imai (JISF) provided an overview of SteelEcosol activities, including the Cleaner Energy Future Initiative for ASEAN (CEFIA), diffusion of BATs, and the AJSI. Mr. Koji Takahashi (Ministry of Economy, Trade and Industry, Government of Japan) presented on Japan's policies for carbon neutrality and the steel industry's efforts to achieve carbon neutrality. Mr. Rio Jon Peter Silitonga (ASEAN Center for Energy) delivered a presentation on the increasing energy demand in the steel industry in ASEAN and the critical importance of government support. Ms. Miki Yanagi (IEEJ) introduced the IEEJ's simulation of CO_2 emissions in ASEAN using a linear programming method and involving cost-optimal combinations of energy technologies.

In Session 2, Dr. Yoshitsugu Suzuki (JISF/JFE Steel Corporation) discussed the critical need for green steel during the transition period and emphasised the importance of establishing a standardised global calculation method, which is also mentioned in the JISF guidelines. Dr. Fumitaka Kato (JISF/Nippon Steel Corporation) presented various emission calculation methodologies and emphasised the importance of ensuring interoperability and comparability whilst acknowledging their differences. Mr. Noriaki Takamuku (JISF/Kobe Steel) introduced the GX League (GX: Green Transformation), a transformative emissions trading system that the Japanese government has been rolling out on a trial basis since fiscal year 2023 with the aim of achieving GHG emissions reductions, economic growth, and enhanced industrial competitiveness. Mr. Chatrabhop Pontham (Siam Yamato Steel) presented on the challenges faced by the Thai steel industry.

In Session 3, Dr. Toru Kato (The Japan Research and Development Center for Metals) introduced ongoing projects demonstrating different technologies for the reduction of CO_2 emissions from steelmaking. Mr. Nao Yamanaka (Nippon Steel Engineering) discussed the company's three technologies for carbon neutrality in the steel industry and the Joint Crediting Mechanism. Mr. Hajime Yoshida (JP Steel Plantech Co.) presented an overview and benefits of biocoke. Dr. Apichaya Theampetch (Sahaviriya Steel Industries) discussed the activities of the CCUS Technology Development Consortium and efforts to reduce CO_2 emissions in Thailand.

3.1.3.Feedback from participants

An online questionnaire was distributed to the participants to gather feedback on the seminar. A total of 40 out of 85 participants (47.1%) responded. The respondents' nationalities were distributed as follows: Malaysia (17.5%), Thailand (17.5%), Singapore (15.0%), China (12.5%), Indonesia (12.5%), the Philippines (12.5%), and others (12.5%).

Half of the respondents were from steel companies, whilst the others represented technology suppliers, steel organisations, research institutes, and other related entities. The overall evaluation of the seminar was high, with an average score of 4.6 on a five-point scale.

Regarding topics of interest for future AJSI events, 'carbon neutrality' and 'technologies (energy saving and CO_2 reduction)' were selected by more than two-thirds of the respondents. As for organisational priorities in promoting energy saving and carbon neutrality, 'operational improvement' was selected most frequently, followed by R&D.

No negative feedback was received regarding the activities of the project, suggesting that they were positively received. The seminar also served as an opportunity to reaffirm its importance as a valuable platform for sharing technological advancements and innovative solutions, and for strengthening partnerships and collaboration.

However, compared to previous AJSI seminars, which were held online, the number of participants was lower. Holding the next AJSI seminar online may be advantageous in reaching a broader audience interested in this field.

3.2. India–Japan Public and Private Collaborative Meeting on Iron and Steel Industry

3.2.1.Overview of the meeting

The India–Japan Public and Private Collaborative Meeting on Iron and Steel Industry was held with approximately 40 participants, mainly government officials and representatives of steel companies from Japan and India. The participants engaged in lively discussions on the following three topics related to carbon neutrality in the steel industries of both countries:

1. Policies towards carbon neutrality in Japan and India
2. Technological trends toward energy conservation and carbon neutrality
3. Climate change-related issues and initiatives faced by steelmakers

3.2.2.Summary of the presentations

Session 1 included several presentations on India's carbon neutrality policies, including the Green Steel Taxonomy, which calls for limiting CO_2 emissions per tonne of finished steel to 2.2 tonnes, and the National Green Hydrogen Mission, which promotes the use of green hydrogen in steel production. The Japanese side reported on the Green Innovation Fund, which supports R&D, and the Working Group on Decarbonisation of Industry, which was established based on discussions within the G7. The Japanese side also reported on a new indicator called the Reduced Emissions of Product (REP), proposed by the Japanese government for the purpose of establishing a green steel market.

In Session 2, the Japanese side reported on the technology development project for achieving carbon-neutral steelmaking (the Green Innovation in Steelmaking Project), the 'Towards a Net-Zero Steel Industry in Asia' Guidelines, and technologies that Japanese companies are adopting in India. In addition, the Japanese side proposed the adoption of the Quality and Cost Based Selection Method to the Ministry of Steel of India, and the Indian side presented on their green steel development and response to global issues such as CBAM, expecting further collaboration with Japan. The current global steel decarbonisation initiatives were reviewed, and the establishment of global data collection framework was proposed to ensure sustainable business development and decarbonisation.

In Session 3, the Japanese side shared information related to the global discussions on developing methodologies for measuring emissions in the steel industry, as well as the efforts of Japan's GX League. The Indian side presented the challenges and prospects of carbon neutrality in India's steel industry, ongoing technology development, a case study on emission measurement for the EU CBAM in India, potential impacts on taxes and steel trade, as well as India's decarbonisation strategy and roadmap, and emphasised the necessity for cooperation between Japan and India in technology development.

3.2.3.Feedback from participants

Vigorous discussions were held with participation from both sides. The Japanese side shared insightful information about Japan's steel industry, whilst the Indian side provided an outline of their country's strengths, as well as areas where cooperation is needed.

The Indian Ministry of Steel commented that it looks forward to cooperation between Japan and India on decarbonisation, innovative technologies, and operational improvements.

The representatives of both countries also shared a common understanding that decarbonisation in the steel sector is challenging in terms of the costs and market creation, but technologies and solutions already exist at the conceptual or pilot levels. They emphasised the need for awareness amongst both customers and broader society that investment in R&D is essential and should be scaled up to close the gap between the current state of decarbonisation technologies and practices, and the target state.

At a time of so many possible pathways of technological development in the sphere of decarbonisation, it is critical to maintain active engagement in the international standardisation and regulatory process whilst keeping a close eye on ongoing international discussions.

Furthermore, through the India–Japan Public and Private Collaborative Meeting on Iron and Steel Industry, Japan and India expect to be able to continue discussions and increase cooperation towards decarbonisation and carbon neutrality. Both India and Japan agreed to hold the next meeting in Japan in late 2025 or early 2026.

Chapter 3
Way Forward

An outline of the planned activities for Phase 2 is presented below.

1. Draft Asia Steel Decarbonisation Outlook

In Phase 2, the project will focus on the following three activities to further develop the Outlook:

1) Organise existing research, time-series databases, and expert knowledge to inform the long-term decarbonisation Outlook for the steel industry.

2) Gather additional information and conduct preliminary analysis and trial calculations for ASEAN countries, as well as India.

3) Update the database created in Phase 1 and refine the pilot model.

These activities will enable the identification of structural challenges specific to the Asian steel industry, as well as gaps in technology adoption, resource constraints, and data availability. A wide range of information will be integrated to provide a robust, practical, and long-term perspective on decarbonising the regional steel sector.

2. Guidelines for the Asian steel industry: 'Towards a Net-Zero Steel Industry in Asia'

Based on research results and stakeholder opinions collected during Phase 1, the draft 'Towards a Net-Zero Steel Industry in Asia' Guidelines will be formulated. The methods used to collect data during Phase 1 include interviewing a range of steel company representatives and other stakeholders from ASEAN countries, comparing similar guidelines from other countries such as India, and discussions with ERIA experts.

The latest perspectives provided by suppliers will be reflected in the TCL, and its structure and content will be reconsidered.

A steel plant diagnosis will be conducted to inform the Guidelines and the TCL.

3. International advocacy

The AJSI Seminar and the India–Japan Public and Private Collaborative Meeting on Iron and Steel Industry will be held with the aim of sharing and disseminating decarbonisation initiatives in the steel sector, gathering input on industry needs and other opinions, and promoting collaboration amongst ASEAN countries and India. The collected input will be reflected in the Outlook and Guidelines.

The AJSI Seminar will be conducted online to allow more stakeholders to participate compared to Phase 1. The India–Japan Public and Private Collaborative Meeting will be held in Japan and will include a site visit to a steel plant in the Kanto region.

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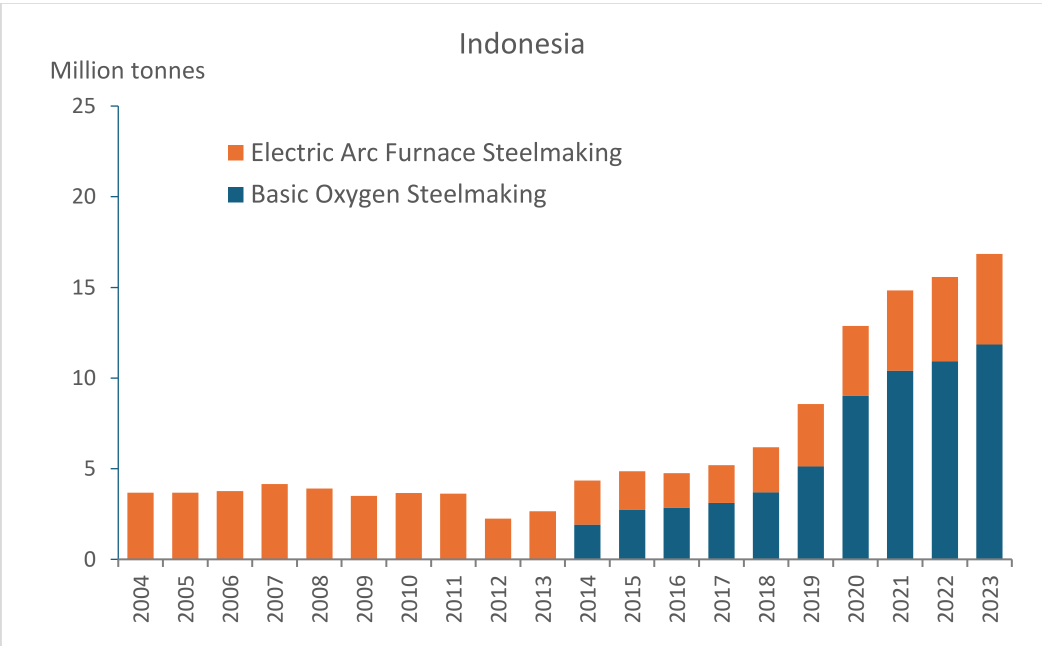
Appendix: Dataset Concerning the Steel Sector in the ASEAN Region

Owing to current limitations in data availability, the analysis in this study relies primarily on energy-related information. The principal data sources are international organisations, including the World Steel Association (world steel), the International Energy Agency (IEA), and the Organisation for Economic Co-operation and Development (OECD).

It should be emphasised that, in some countries, relevant indicators – such as electricity consumption in the steel sector – may be underestimated due to aggregation with data from other manufacturing industries, thereby complicating the compilation of sector-specific statistics. Moreover, estimating the total CO_2 emissions of the steel industry, particularly those associated with energy conversion processes involving blast furnace gas and coke oven gas, continues to pose methodological challenges.

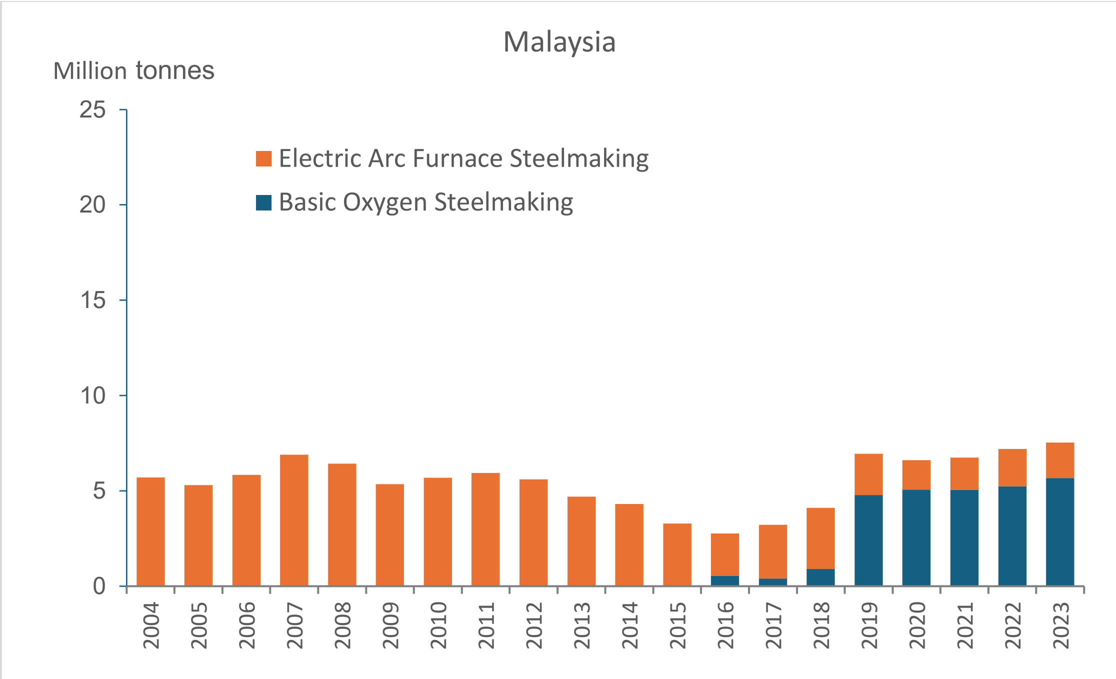
Future analyses may incorporate additional references to the biennial reports submitted to the United Nations Framework Convention on Climate Change (UNFCCC). Nonetheless, the fundamental data limitations outlined above remain, and the challenges of comprehensive and consistent data collection are likely to persist.

Figure A1: Crude Steel Production in Indonesia



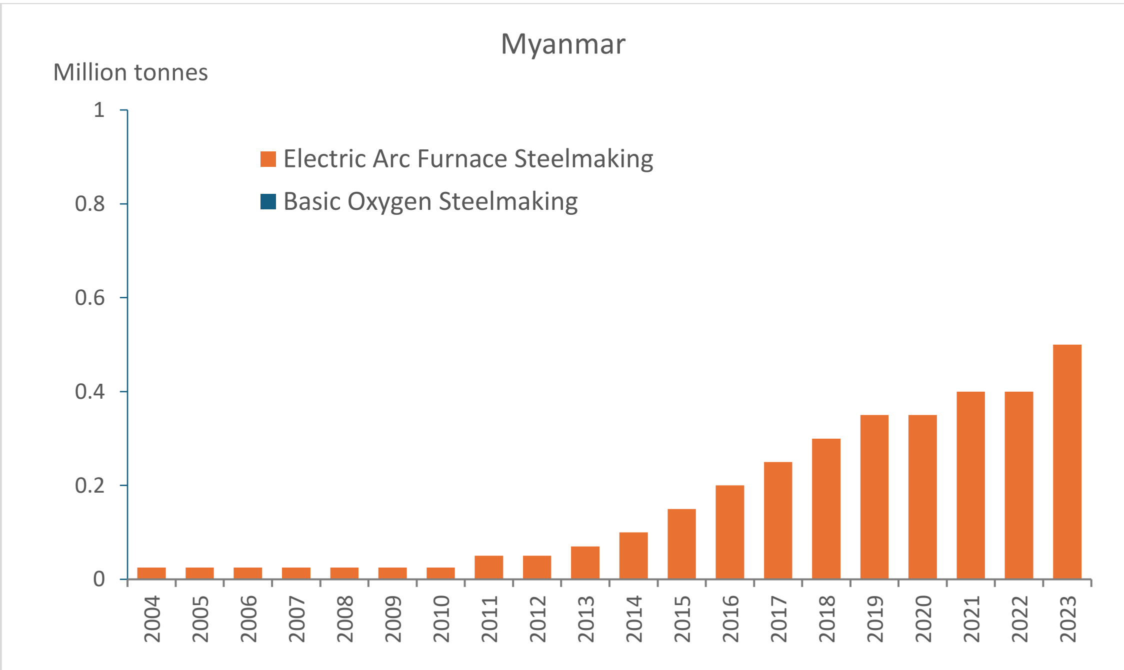
Source: worldsteel (2024a).

Figure A2: Crude Steel Production in Malaysia



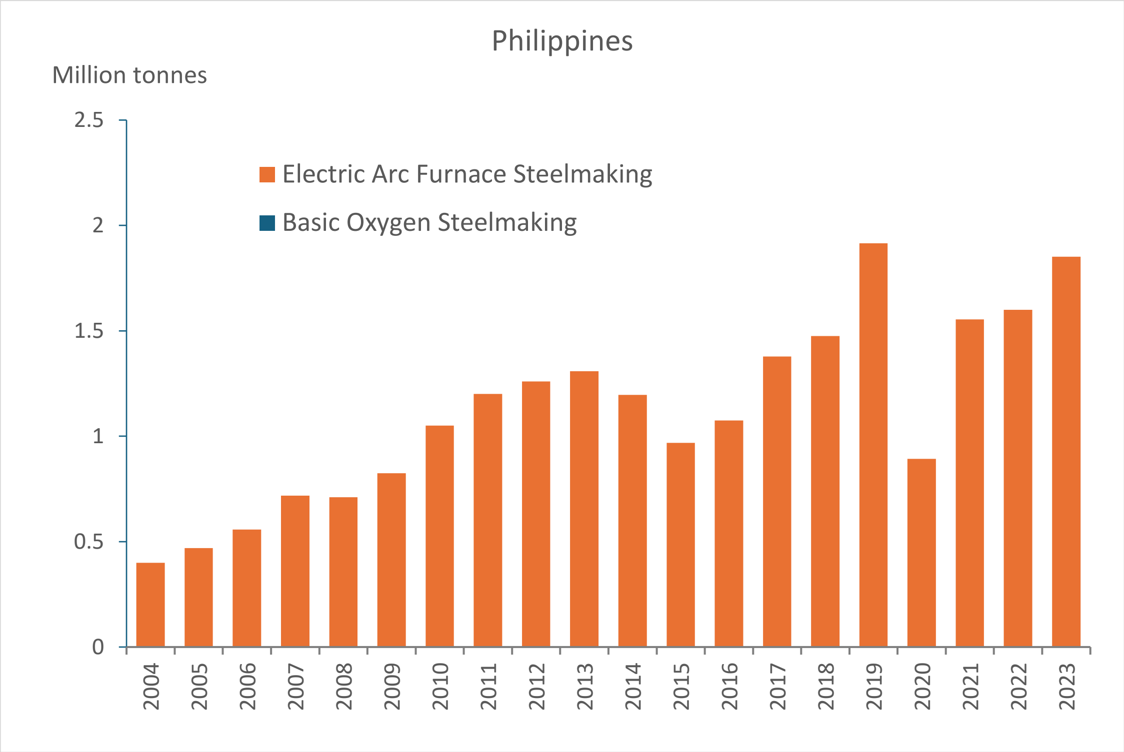
Source: worldsteel (2024a).

Figure A3: Crude Steel Production in Myanmar



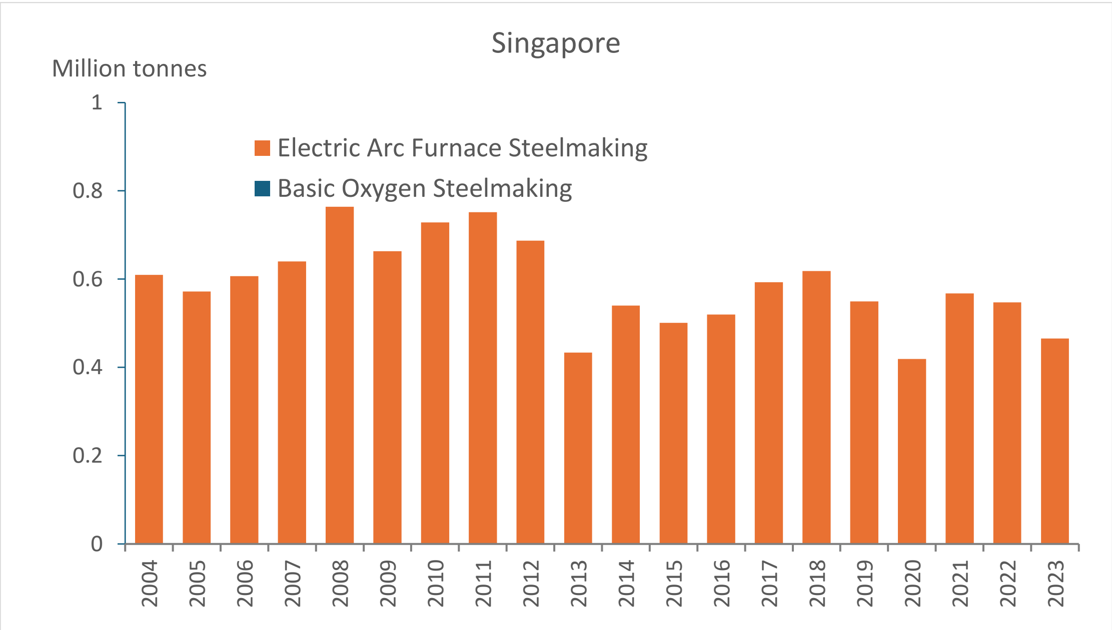
Source: worldsteel (2024a).

Figure A4: Crude Steel Production in the Philippines



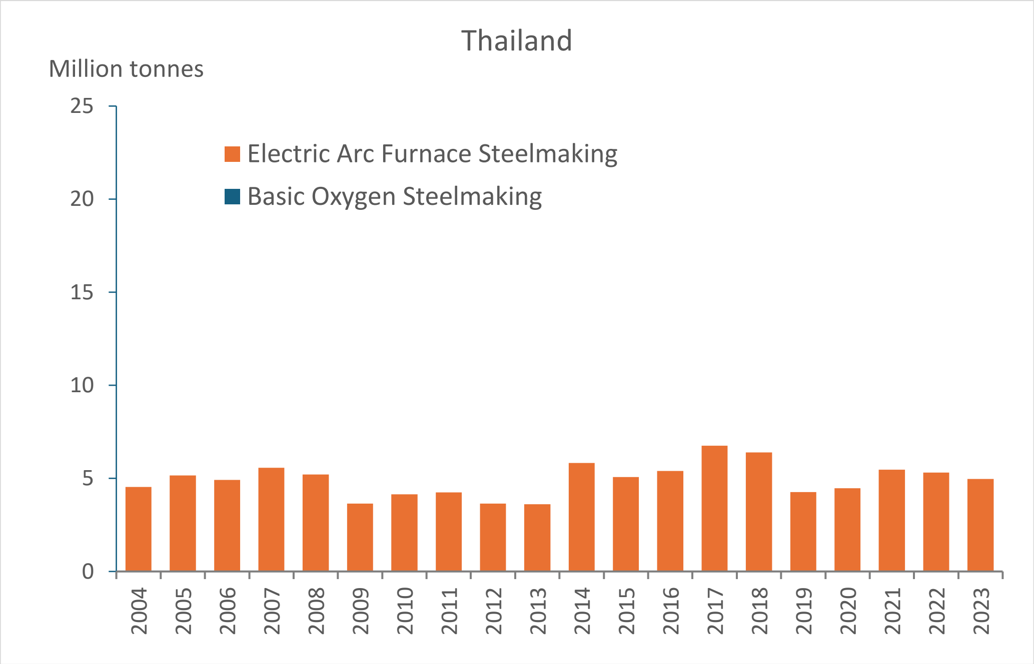
Source: worldsteel (2024a).

Figure A5: Crude Steel Production in Singapore



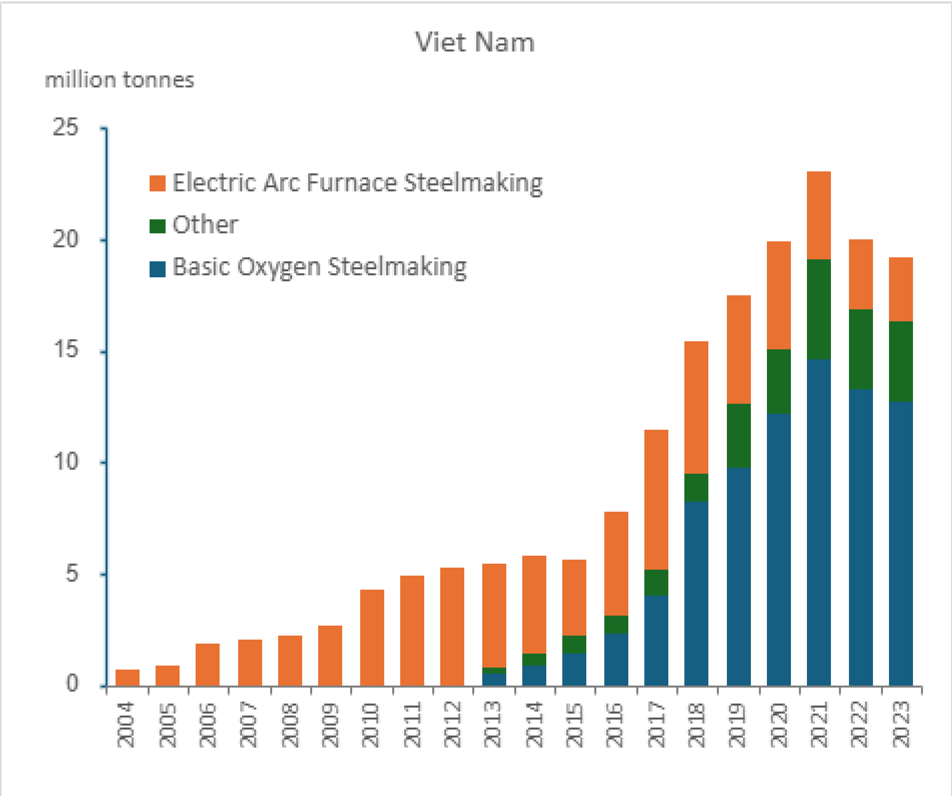
Source: worldsteel (2024a).

Figure A6: Crude Steel Production in Thailand



Source:worldsteel (2024a).

Figure A7: Crude Steel Production in Viet Nam



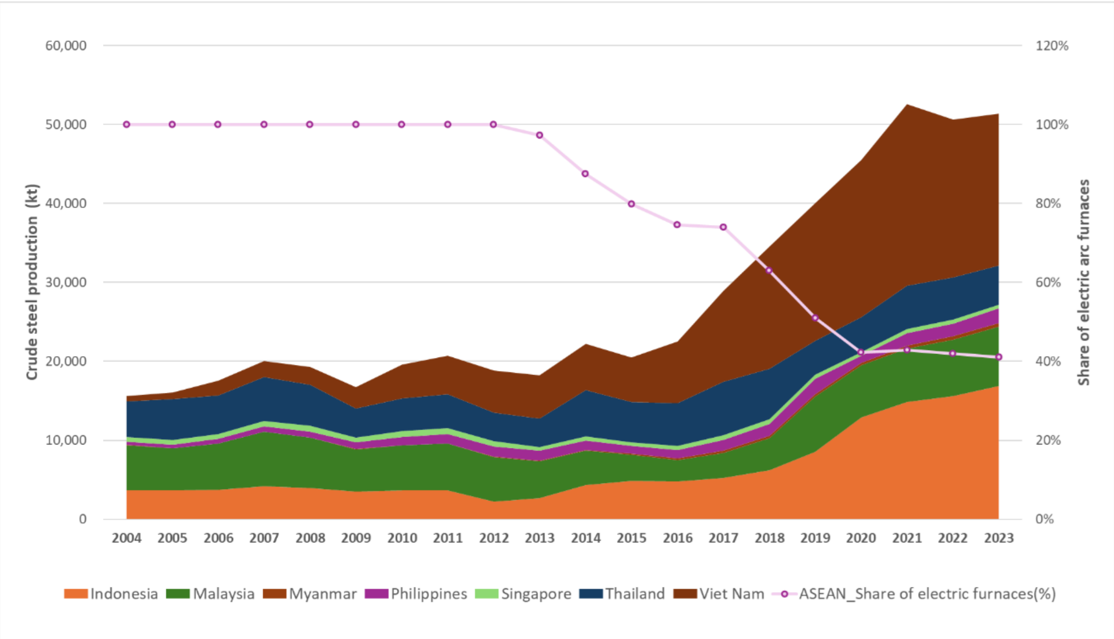
Source: worldsteel (2024a).

Table A1: Steelmaking Capacity by Economy, 2023

	Economy	Capacity (Mt)
1	Indonesia	23.8
2	Malaysia	19.2
3	Myanmar	0.3
4	Philippines	1.8
5	Singapore	0.8
6	Thailand	11.4
7	Viet Nam	26.0
	ASEAN 7	83.3

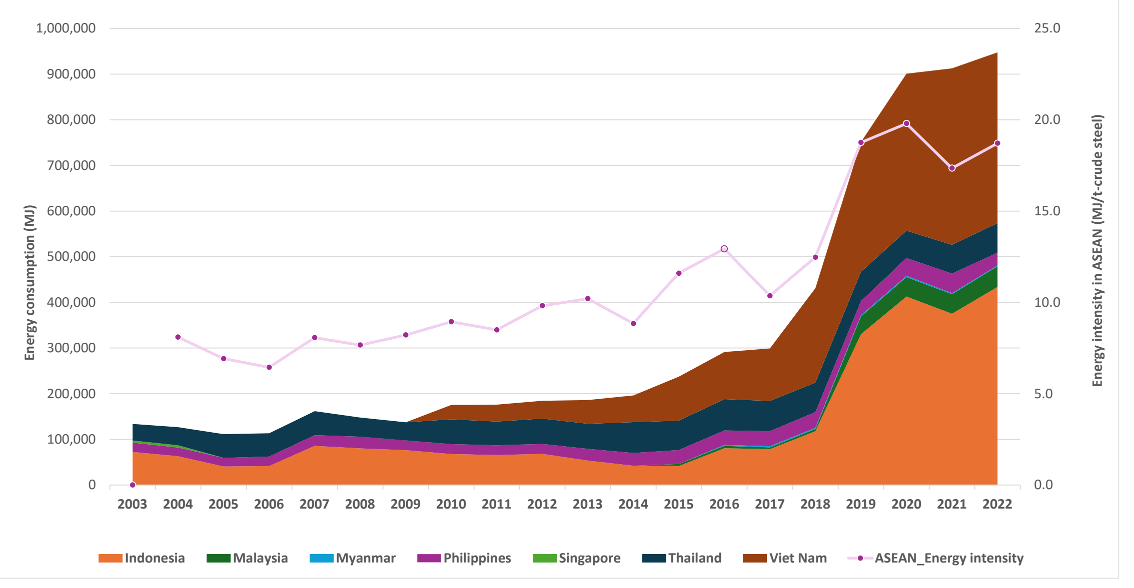
Source: OECD (2025).

Figure A8: Crude Steel Production by Country, and the Share of Electric Arc Furnaces in ASEAN 7



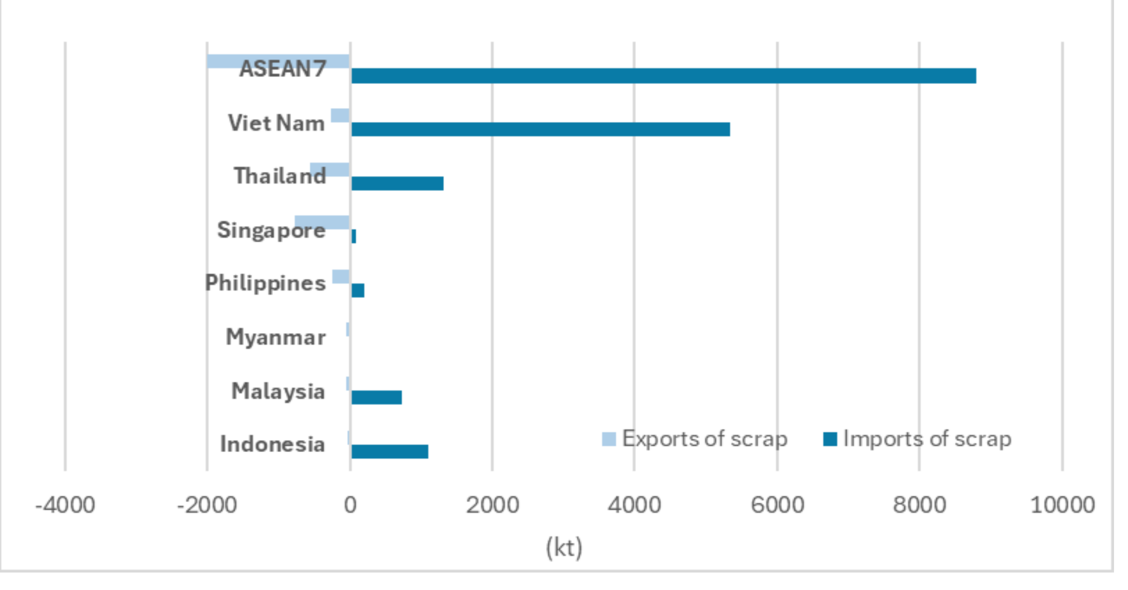
Sources: IEA (2024); worldsteel (2024a).

Figure A9: Steel Sector Energy Consumption by Country, and Energy Intensity for ASEAN 7



Sources: IEA (2024); worldsteel (2024a).

Figure A10: Trade in Ferrous Scrap, 2023



Source: worldsteel (2024a).