

**WORLDWIDE**

**DATA COLLECTION SURVEY ON  
PROMOTION OF “ECO PROCESS” IN  
THE STEEL INDUSTRY FOR GHG  
REDUCTION**

**FINAL REPORT**

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## Abbreviations

Term	Definition
ADB	Asian Development Bank
AI	Artificial Intelligence
AOD	Argon Oxygen Decarburization
ASEAN	Association of Southeast Asian Nations
BAT	Best Available Technologies
BAU	Business As Usual
BCG	Bio-Circular-Green
BEMS	Building and Energy Management System
BF	Blast Furnace
BFG	Blast Furnace Gas
BOF	Basic Oxygen Furnace
CANACERO	Camara Nacional de la Industria del Hierro y del Acero
CBAM	Carbon Boarder Adjustment Mechanism
CCS	Carbon dioxide Capture and Storage
CCUS	Carbon Dioxide Utilization and Storage
CCU	Carbon dioxide Capture and Utilization
CDA	Carbon Direct Avoidance
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CDQ	Coke Dry Quenching
CG	Coat Galvanized
CIS	Commonwealth of Independent States
CMC	Coal Moisture Control
CN	Carbon Neutral
CO2BTP	Australian CO2 Breakthrough Program
COG	Coke Oven Gas
COP	Conference of the Parties
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
COURSE50	CO2 Ultimate Reduction in Steelmaking Process by Innovative Technology for Cool Earth 50
COVID	COroNaVirus Infectious Disease, emerged in 2019
C/P	Counterpart
CSIR	Council of Scientific & Industrial Research
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership

Term	Definition
CTF	the Clean Technology Fund
C&T	Caps and Trade
DC	Direct Current
DCs	Designated Consumers
DEDE	Department of Alternative Energy Development and Efficiency
DIW	Department of Industrial Works
DR	Direct Reduction
DRI	Direct Reduced Iron
DX	Digital Transformation
EAF (EF)	Electric Arc Furnace
EBRD	European Bank for Reconstruction and Development
ECSC	European Coal and Steel Community
ECP Act	Energy Conservation Promotion Act B.E.2535
EEP	Energy Efficiency Program
EGD	European Green Deal
EIE	General Directorate of Electrical Power Resources Survey & Development Administration
EIF	Electric Induction Furnace
EMS	Energy Management System
ENCC	Estrategia Nacional de Cambio Climático. Vision 10-20-40
ENCON Fund	Energy Conservation promotion Fund
ES-CERT	Energy Saving Certification
ETS	Emissions Trading System
EU	European Union
EU-ETS	European Union Emissions Trading System
EUROFER	The European Steel Association
EVFTA	EU-Vietnam Free Trade Agreement
FA	Factory Automation
FIT	Flash Ironmaking Technology
GDP	Gross Domestic Product
GHG	Green House Gas
GI	Green Innovation
GREEN	Global action for Reconciling Economic growth and ENvironmental preservation
GTCC	Gas Turbine Combined Cycle
GtoG	Government to Government
ICAO	International Civil Aviation Organization
IEA	International Energy Authority

Term	Definition
IDF	Induced Draft Fan
IGAR	Injection de Gaz Réformé
IISIA	Indonesian Iron and Steel Industry Association
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IPPU	Industrial Processes and Product Use
ISA	Indian Steel Association
ISIT	The Iron and Steel Institute of Thailand
ISO	International Organization for Standardization
ISP	Iron and Steel Producers
JBIC	Japan Bank for International Cooperation
JCM	Joint Crediting Mechanism
JETRO	Japan External Trade Organization
JHFC	Japan Hydrogen & Fuel Cell Demonstration Project
JI	Joint Implementation
JICA	Japan International Cooperation Agency
JISF	The Japan Iron and Steel Federation
JPC	Joint Plant Committee
KEN	Kebijakan Energi Nasional
LCA	Life Cycle Assessment
LULUCF	Land Use, Land-Use Change and Forestry
MOE	Moltem Oxide Electrolysis
MOF	Ministry of Finance
MOIT	Ministry of Industry and Trade of the Socialist republic of Vietnam
MONRE	Ministry of Natural Resources and Environment
MoP	Ministry of Power
MoS	Ministry of Steel
MPI	Ministry of Planning and Investment
MP3EI	The Masterplan for Acceleration and Expansion of Indonesia's Economic Development
MRV	Measurement Reporting and Verification
NC	Numerically Control
NDC	Nationally Determined Contribution
NECC	National Energy Conservation Center
NEDO	New Energy and Industrial Technology Development Organization
NEPC	National Energy Policy Council
NESDC	National Economic and Social Development Council

Term	Definition
NGO	Non-Governmental Organization
NMEEE	National Mission for Enhanced Energy Efficiency
NSP	National Steel Policy
NTP-RCC	The National Target Program to respond to Climate Change
ODA	Official Development Assistance
OECD	Organisation for Economic Co-operation and Development
PAT	Perform, Achieve and Trade
PCI	Pulverised coal injection
PDCA	Plan-Do-Check-Act cycle
PMR	Partnership for Market Readiness
PND	PLAN NACIONAL DE DESARROLLO
PRE	Person Responsible for Energy
PSE	Programa Sectorial de Energía
RAN-API	National Action Plan of Climate Adaptation
RED	Renewable Energy Directive
RHF	Rotary Hearth Furnace
RIKEN	Rencana Induk Konservasi Energi Nasional
RITE	Research institute of Innovative Technology for the Earth
RPJMN	Rencana Pembangunan Jangka Menengah Nasional
SCU	Smart Carbon Usage
SD	Sustainable Development
SDGs	Sustainable Development Goals
SDS	Sustainable Development Scenario
SEC	Specific Energy Consumption
SEFF	Sustainable Energy Finance Facility
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales
SPCA	Sustainable Production and Consumption Association
SP-RCC	Support Program to Respond to Climate Change
SRTMI	Steel Research & Technology Mission of India
STEPS	Stated Policies Scenario
TA	Technical Assistance
TCL	Technologies Customized List
TCUD	Türkiye Çelik Üreticileri Derneği
TERI	The Energy and Resources Institute
TNA	Technology Needs Assessment
TOBB	The Unions of Chambers and Commodity Exchanges of Turkey
TRL	Technology readiness levels
TRT	Top pressure Recovery Turbine

Term	Definition
TSKB	Türkiye Sınai Kalkınma Bankası
TTGV	Technology Development Foundation of Turkey
TÜBİTAK	Türkiye Bilimsel ve Teknolojik Araştırma Kurumu
ULCOS	Ultra-low Carbon Dioxide Steelmaking
UNFCCC	United Nations Framework Convention on Climate Change
VAP	Verimlilik Arttırıcı Projelerin
VNEEP	Vietnam Energy Efficiency Program
VVF	Variable Voltage Variable Frequency
WG	Working Group
WS	Work Shop
WTO	World Trade Organization

# 1. Global trends and prospects for low-carbon and decarbonized steelmaking

Information on the following items related to the iron and steel industry was collected, organized and analyzed through desktop survey in Japan.

## 1.1 Pathways to a Low-Carbon and Decarbonized Steel Sector Linked to the Paris Agreement

The iron and steel industry is an extremely energy-intensive industry that accounts for 14% of Japan's total CO<sub>2</sub> emissions (National Institute for Environmental Studies<sup>1</sup>, 2019) and 7-9% of the world's energy-derived CO<sub>2</sub> emissions (worldsteel<sup>2</sup>, 2020), and has a significant impact on global warming. With abundant production volume, low cost, and a wide range of material properties, the annual crude steel production reaches 1.95 billion tons (worldsteel<sup>3</sup>, 2021), and is positioned as a basic industry used in all sectors of society.

Although the steel industry is aiming to develop innovative technologies (e.g., hydrogen reduction, underground storage of CO<sub>2</sub>) to develop low-carbon steelmaking processes, the feasibility of such technologies is unclear, as it is expected to take several decades before they can be put to practical use. In the IEA's World Energy Outlook 2020, steelmaking is listed as a sector where the transition to decarbonization will be more difficult and important than in the power sector, and it is attracting increasing global attention from the perspective of combating global warming.

In this context, Japan's steel industry is technologically mature and boasts the world's highest level of energy efficiency in steelmaking. The energy-saving manufacturing process of the Japanese steel industry is called the "eco-process," which consists of process innovation and improvement, by-product gas utilization, waste heat recovery, waste utilization, and optimization of manufacturing processes. By transferring the "steelmaking eco-process" developed and commercialized in Japan to developing countries where the steelmaking industry is growing rapidly, it will be possible to contribute to a significant reduction of greenhouse gases.

In fact, in developing countries, while foreign-owned (modern) iron/steel works have made some progress in energy efficiency and conservation measures, state-owned (outdated) iron/steel works have lagged behind in these measures. In such iron/steel works, the marginal cost of reducing greenhouse gas emissions is considerably lower than the level assumed in developed countries, and basic

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<sup>1</sup> <https://www.nies.go.jp/gio/archive/ghgdata/index.html>

<sup>2</sup> Worldsteel "Climate change and the production of iron and steel"

<sup>3</sup> [https://worldsteel.org/steel-by-topic/statistics/annual-production-steel-data/P1\\_crude\\_steel\\_total\\_pub/CHN/IND](https://worldsteel.org/steel-by-topic/statistics/annual-production-steel-data/P1_crude_steel_total_pub/CHN/IND)

measures adopted in Japan and other countries can be extremely effective in reducing greenhouse gas emissions and energy costs in developing countries (large effects can be expected with reasonable investment).

Therefore, in order to understand the current status and opportunities for improvement of iron/steel works in the candidate countries for cooperation, we will work with our counterparts at the management and operational levels, and consider the use of ISO 14404 (method for calculating steel CO<sub>2</sub> emissions and intensity), which was developed at the initiative of Japan, and analytical tools based on detailed energy and material balances. It is believed that finding and promoting effective measures that contribute to the reduction of greenhouse gases and energy costs at iron/steel works, will make a practical contribution to the significant reduction of greenhouse gases.

In recent years, a number of countries around the world have declared themselves carbon neutral. In Japan, Prime Minister Suga announced a policy goal of achieving net zero carbon dioxide emissions (carbon neutrality) by 2050 in his policy speech at the extraordinary Diet session on October 26<sup>th</sup>, 2020. The carbon-neutral targets of major countries are shown in the following Table 1-1.

Table 1-1 Carbon neutrality targets for major countries

	Carbon Neutral Target
Japan	<b>2050 Carbon Neutral</b> (Prime Minister's Speech, 2020 October)
US	<b>2050 Carbon Neutral</b> (Biden's election pledge, 2020 July)
EU	<b>2050 Carbon Neutral</b> (Long Term Strategy, March 2020)
UK	<b>2050 Carbon Neutral</b> (Long Term Strategy, December 2020)
China	<b>2060 Carbon Neutral</b> (General debate of the UN General Assembly, September 2020)
Korea	<b>2050 Carbon Neutral</b> (Long Term Strategy, December 2020)

Source: Ministry of Economy, Trade and Industry, Agency for Natural Resources and Energy

In order to achieve carbon neutrality, it is necessary to mobilize a variety of options. In the scenario analysis for carbon neutrality by 2050 that is currently under discussion, the share of hydrogen and ammonia in power generation is set at 10-20%, and JERA, the largest power generation company in Japan, has published a roadmap for the use of hydrogen and ammonia as fuels for power generation in its "JERA Zero Emissions 2050" report. In the iron and steel industry, the Japan Iron and Steel Federation (JISF), in its long-term vision for global warming countermeasures, has positioned "hydrogen reduction ironmaking" as a promising technological option for achieving zero-carbon steel.

The unprecedented hydrogen reduction ironmaking process, which can be called the ultimate ironmaking process, has been the subject of intense

technological development in Japan and other countries, but the hurdles to the development of the technology itself are extremely high. In other words, in order to make these innovative elemental technologies a reality in the areas of renewable energy power generation, water electrolysis, electricity storage, iron ore reduction, etc., and to achieve significant cost reductions, discontinuous innovation that greatly surpasses the level of conventional technology is essential. The road to the realization of economical zero-carbon steel production is still too long.

According to the IEA's net-zero emission scenario (Table 1-2), in addition to the above-mentioned hydrogen reduction ironmaking, electrolysis of iron ore and CCUS are expected to be utilized in the 2050 timeframe, but these technologies are not yet commercially available, and further innovation is needed in this regard as well.

Thus, although technology development toward carbon neutrality by 2050 is being promoted worldwide, the technology development will take a long time due to the need for multiple disruptive innovations, and the challenge is to develop a "transition strategy" on how to connect the two.

Table 1-2 Key milestones in transforming global heavy industry sub-sectors (excerpt)

Share of Primary Steel Production			
	2020	2030	2050
Hydrogen-based DRI-EAF	0%.	2%.	29%.
Iron ore electrolysis-EAF	0%.	0%.	13%.
CCUS-equipped processes	0%.	6%.	53%.
CO <sub>2</sub> captured (Mt CO <sub>2</sub> )	1	70	670

Source: IEA Special Report "Net Zero by 2050".

As for the transition strategy to overcome the above issues, a realistic solution would be to reduce CO<sub>2</sub> emissions globally by introducing Japan's expertise and existing state-of-the-art energy conservation technologies to developing countries where there is still plenty of room for energy conservation.

Figure 1-1 shows the CO<sub>2</sub> emission reduction path to achieve the sustainable development scenario ( $\approx 2^{\circ}\text{C}$  scenario) as described in the IEA's steel roadmap. It suggests that the scenario for the next 10 years is to continue to reduce CO<sub>2</sub> emissions by adopting existing technologies to achieve carbon neutrality. In other words, it can be said that this project, which promotes the deployment of Japan's leading-edge energy-saving technologies to developing countries, is in line with the world's trend toward net-zero emissions.

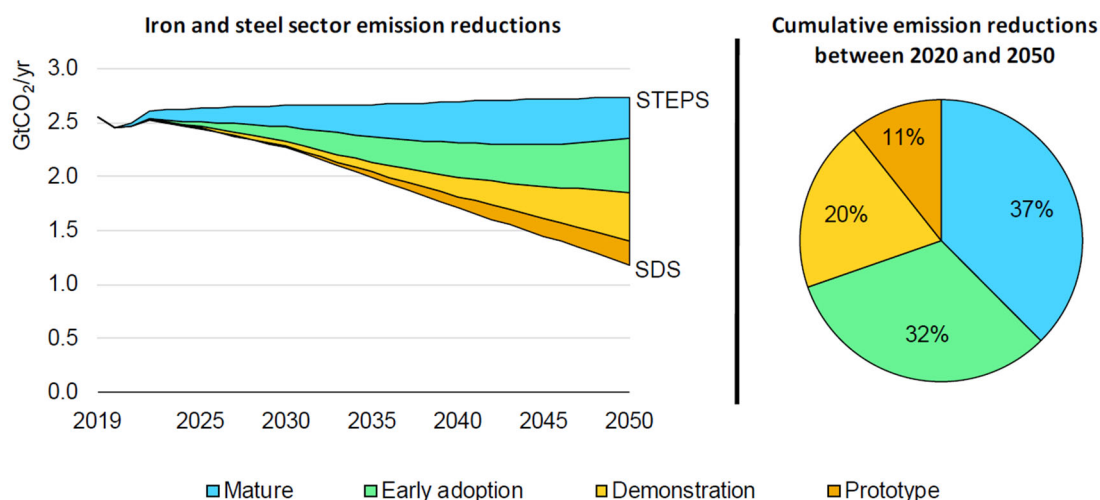


Figure 1-1 Direct CO<sub>2</sub> emission reductions in the steel sector under the sustainable development scenario

Source: IEA Iron and Steel Technology Roadmap

STEPS: Stated Policies Scenario, SDS: Sustainable Development Scenario

## 1.2 Crude steel production, greenhouse gas emissions, and energy efficiency of each country

Crude steel production, greenhouse gas emissions, energy efficiency, etc. of each country in the world, including Japan, are shown below.

### 1.2.1 Crude steel production

Table 1-3<sup>4</sup> shows the crude steel production of each country and the ratio of blast furnace steel to electric furnace steel (the difference between blast furnace and electric furnace is explained in the next section). The world as a whole produce about 1.87 billion tons of crude steel, more than half of which is produced in China. Blast furnace steel accounts for more than 70% of the world's steel production, more than 2.5 times the 27.7% accounted for by electric furnace steel, which is mainly made from scrap. This indicates that global demand for steel is so strong that scrap alone is not enough to meet steel demand. In addition, the ratio of blast furnace steel to electric furnace steel varies greatly by country. Looking at the top five countries in terms of crude steel production, all countries except the U.S. use mainly blast furnace steel. This is because the blast furnace-basic oxygen furnace process (BF-BOF method) is suitable for mass production and the manufacture of high-grade steel. In India, too, electric furnace steel accounts for more than half of the production, but most of this is made by melting reduced iron based on iron ore in electric furnaces, which is similar to blast

<sup>4</sup> worldsteel "2020 World Steel in Figures

furnace steel in terms of the origin of the raw materials. On the other hand, in the U.S., blast furnace steel used to be the main type of steel, but now electric furnace steel is the main type of steel. The reason for this is assumed to be the large amount of scrap discharged from end-of-life vehicles and old buildings. The countries in red in the table below are those that were candidates for the survey at the time of the project proposal. Among these countries, India, Turkey, Vietnam, and Mexico produce more than 10 million tons per year.

Figure 1-2 and Figure 1-3 show the trend of crude steel production in major countries. Figure 1-2 shows the crude steel production of major countries including the entire world. The world's crude steel production is increasing, but this is almost linked to China's production. The ratio of China to the world total (China/the world in the figure: dotted line) has been increasing every year and has been over 50% since 2018.

In Figure 1-2, the production volume of major countries other than China is much smaller than that of China and the changes in production volume cannot be observed. Figure 1-3 shows the changes in crude steel production in major countries excluding China.

Japan was the world's second largest producer until 2017, but production has been declining. As of 2019, Japan is the third largest producer.

India's production has been increasing every year, and in 2019 it is 1.6 times higher than in 2010. It exceeded 100 million tons in 2017 and overtook Japan in 2018 to become the world's second largest producer.

The U.S. production had been hovering between 80 million and 90 million tons but dropped below 80 million tons in 2015. It has been recovering since then.

In Russia, production has been stable at around 70 million tons for several years.

Turkey's production has fluctuated between 30 million and 40 million tons.

Mexico's production has been stable at less than 20 million tons for the past several years.

Vietnam's production, after a growing trend, has noticeably increased since 2016. This may be due to an increase in production resulting from the construction of an integrated blast furnace steel mill.

Table 1-3 Crude steel production by country (2019 Results, in million tons)

Ranking	Country/Region	2019	Ratio(%)	Blast Furnace	Electric Furnace
—	World	1868.8	100.0%	71.9%	27.7%
—	EU(28)	157.1	8.4%	58.7%	41.3%
1	China	996.3	53.3%	89.6%	10.4%
2	India	111.2	6.0%	43.8%	56.2%
3	Japan	99.3	5.3%	75.5%	24.5%
4	United States	87.8	4.7%	30.3%	69.7%
5	Russia	71.9	3.8%	64.1%	33.6%
6	Korea	71.4	3.8%	68.2%	31.8%
7	Germany	39.7	2.1%	70.0%	30.0%
8	Turkey	33.7	1.8%	32.2%	67.8%
9	Brazil	32.2	1.7%	76.1%	22.2%
10	Iran	25.6	1.4%	9.6%	90.4%
11	Italy	23.2	1.2%	18.1%	81.9%
12	Republic of China(Taiwan)	22	1.2%	61.9%	38.1%
13	Ukraine	20.8	1.1%	71.2%	5.8%
14	Vietnam	20.1	1.1%	55.8%	28.2%
15	Mexico	18.5	1.0%	22.8%	77.2%
16	France	14.4	0.8%	69.6%	30.4%
17	Spain	13.6	0.7%	31.2%	68.8%
18	Canada	12.9	0.7%	60.6%	39.4%
19	Poland	9	0.5%	54.9%	45.1%
20	Saudi Arabia	8.2	0.4%	0.0%	100.0%
21	Belgium	7.8	0.4%	68.3%	31.7%
22	Austria	7.4	0.4%	90.4%	9.6%
23	Egypt	7.3	0.4%	2.5%	97.5%
24	United Kingdom	7.2	0.4%	78.8%	21.2%
25	Netherlands	6.7	0.4%	100.0%	0.0%
26	Indonesia	6.4	0.3%	41.0%	59.0%
27	South Africa	5.7	0.3%	58.8%	41.2%
28	Australia	5.5	0.3%	73.2%	26.8%
29	Slovakia	5.3	0.3%	93.0%	7.0%
30	Sweden	4.7	0.3%	66.2%	33.8%
31	Argentina	4.6	0.2%	45.5%	54.5%
32	Malaysia	4.5	0.2%	10.6%	89.4%
33	Czech Republic	4.4	0.2%	94.7%	5.3%
34	Thailand	4.2	0.2%	0.0%	100.0%
-	Bangladesh	5.1	0.3%	0.0%	100.0%
-	Philippines	1.4	0.1%	0.0%	100.0%

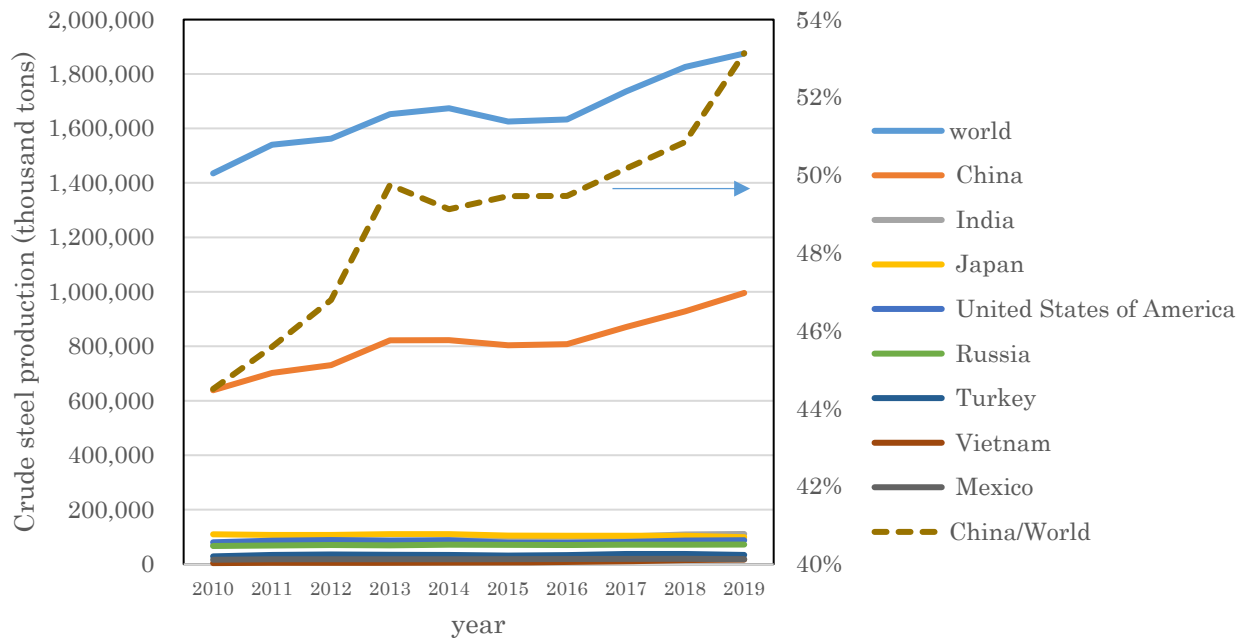


Figure 1-2 Crude steel production of major countries

China/World: China's share of the world

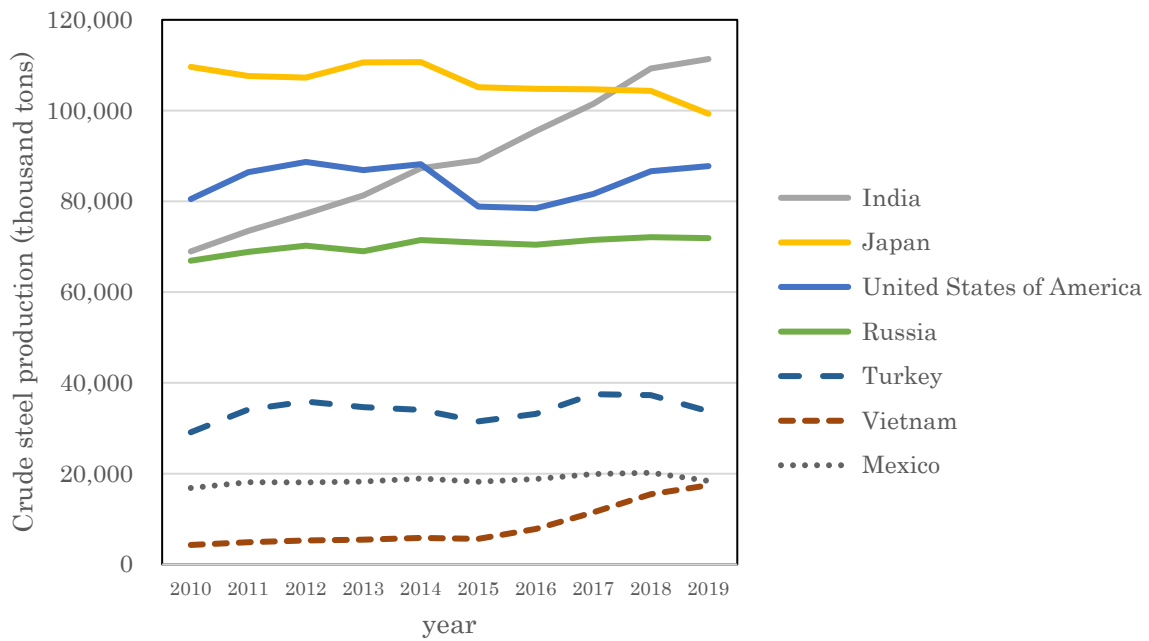


Figure 1-3 Crude steel production of major countries (excluding China)

### 1.2.2 Energy intensity

As shown in Figure 1-4, there are two types of steel manufacturing processes: the blast furnace-basic oxygen furnace process, which uses iron ore as the main raw material, and the scrap-electric arc furnace process, which uses scrap iron as the main raw material.<sup>5</sup>

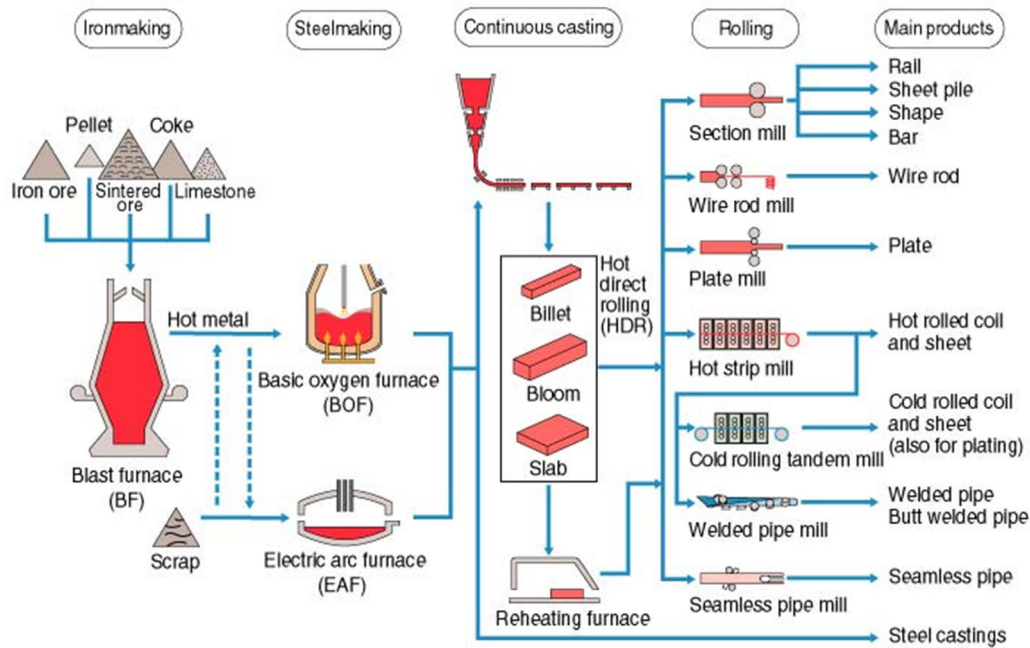


Figure 1-4 Steel manufacturing process

Source: Kawasaki Steel 21st Century Foundation, "An Introduction to Iron and Steel Processing", Chapter 2

In the scrap - electric arc furnace process, the main energy used is the energy (electric power) to dissolve the scrap. On the other hand, in the blast furnace-basic oxygen furnace process (BF-BOF method), the main energy used is the energy (mainly coal) to reduce and dissolve iron ore (iron oxide), and the energy intensity (energy consumption per unit of crude steel) of the blast furnace-basic oxygen furnace is higher than that of the scrap-electric arc furnace process (EAF method) due to the energy required to reduce iron ore. For this reason, steel production from scrap is said to be an eco-friendly method of steel production. However, on a global scale, steel demand is expected to continue to grow due to the growth of developing countries. Scrap alone cannot meet this demand, and a process using iron ore as a raw material is also necessary, and the iron ore and scrap processes are expected to work in tandem to meet global steel demand in the coming decades. Since the ratio of the BF-BOF method to EAF method differs from country to country, calculating and presenting the energy intensity of each

<sup>5</sup> [https://www.jisri.or.jp/common/wp-content/themes/jisri/img/r\\_sikumi03.jpg](https://www.jisri.or.jp/common/wp-content/themes/jisri/img/r_sikumi03.jpg)

country's steelmaking process based on the average of the BF-BOF method and EAF method in that country is misleading. Since the ratio of the BF-BOF method to EAF method differs from country to country, the energy intensity of countries with a high ratio of the EAF method appears to be low. However, when considering energy efficiency and conservation measures, it is necessary to separate the BF-BOF method and EAF method and evaluate them using the same standards.

The energy intensity of the steelmaking process is described in the reports of companies and steel associations of various countries, as well as in the IEA statistics<sup>6</sup>, etc. However, the reports of companies and steel associations of various countries differ in the scope of calculation (boundary) and calculation method. RITE (Research Institute of Innovative Technology for the Earth) developed a fair estimation method by analyzing various reports and statistical data, and estimated the energy intensity of the BF-BOF method and EAF method for major countries based on annual data of 2005, 2010, and 2015<sup>7</sup>

Figure 1-5 shows the estimation results for the BF-BOF method. For the BF-BOF method, Japan has the highest energy efficiency at 22.9 GJ/t crude steel, and Ukraine has the lowest at 30.2 GJ/t crude steel. It indicates that the energy intensity in Ukraine is about 1.3 times as high as in Japan. The reason for this is that Japan has almost completely adopted energy-saving technologies for continuous casting and other processes, effective use of by-product gas, and recovery of waste energy, while Ukraine, Russia, the U.S., and other countries with high energy intensity have not yet adopted energy-saving technologies, especially for effective use of by-product gas and recovery of waste energy. With the exception of South Korea, other countries are also considered to be more or less behind in the introduction of energy efficiency and conservation technologies for effective use of by-product gas and recovery of waste energy. In Europe, such as the U.K. and France, the introduction of energy efficiency and conservation technologies has not progressed because the EU Emissions Trading Scheme (EU-ETS) does not evaluate the recovery of electricity from waste energy. In India and Brazil, the introduction of energy efficiency and conservation technologies has not progressed because the focus is on improving production capacity rather than energy efficiency and conservation. In China, the energy intensity of the most advanced iron/steel works is assumed to be comparable to that of Japan, but there is a mix of older equipment, so the energy intensity is presumably high on average.

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<sup>6</sup> IEA: World Energy Balances

<sup>7</sup>[https://www.rite.or.jp/system/latestanalysis/2018/07/Comparison\\_EnergyEfficiency2015steel.html](https://www.rite.or.jp/system/latestanalysis/2018/07/Comparison_EnergyEfficiency2015steel.html)

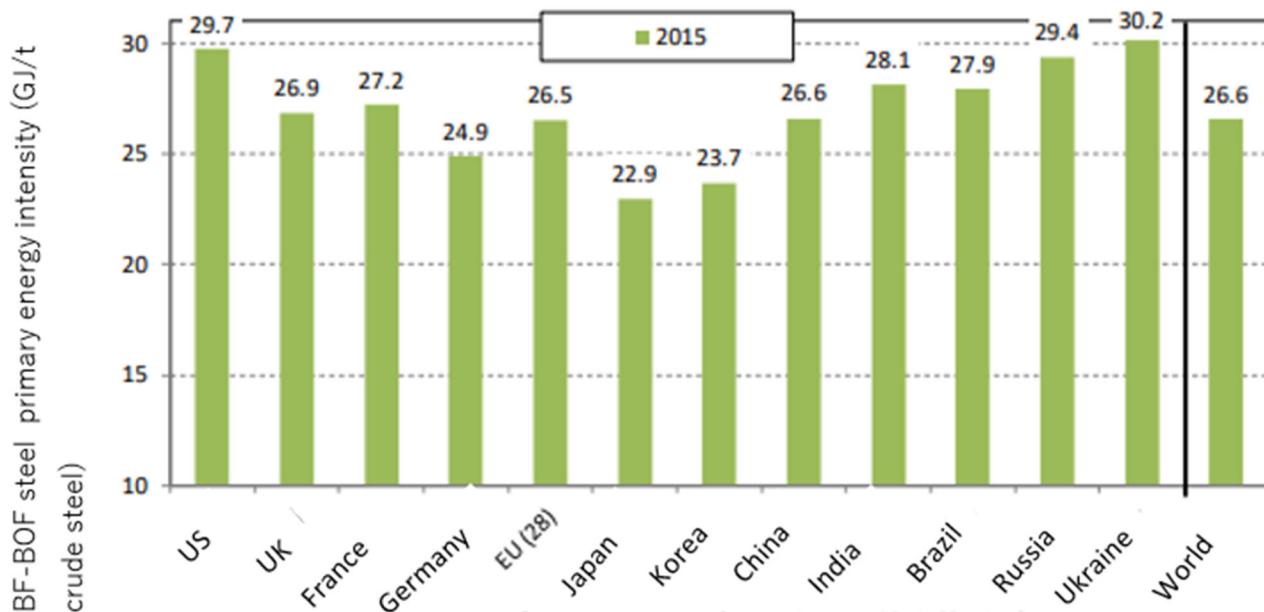


Figure 1-5 Estimation of the energy intensity of the BF-BOF method (2015)

Figure 1-6 shows the estimation results for the EAF method. In the EAF method, Japan has the highest energy efficiency at 8.3 GJ/t crude steel, and India and Russia have the lowest at 9.4 GJ/t crude steel. It indicates that India and Russia have about 1.1 times as high energy intensity as Japan. Technological exchange is very active among Japanese EAF companies, and they are open to adopt improved technologies from other companies. This is a characteristic not seen in many other countries. In addition, compared to the BF-BOF method, there is less variation in the basic unit in each country. This can be attributed to the simpler process and smaller energy-saving potential compared to the BF-BOF method.

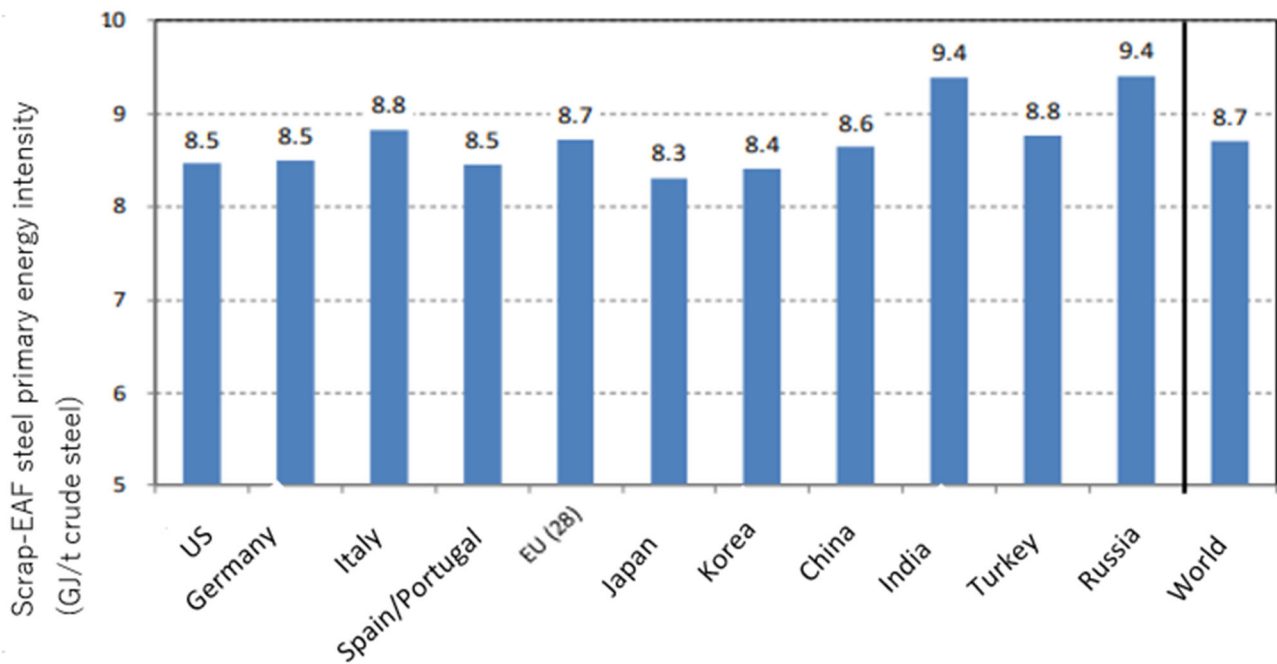


Figure 1-6 Estimated energy intensity of Scrap-EAF method (2015)

According to the energy intensity data in Figure 1-5 and Figure 1-6, and the ratio of the BF-BOF method to the EAF method in Table 1-3, it is possible to calculate the average energy intensity of the steel industry for the United States, Germany, Japan, South Korea, China, and India. The results are shown in Table 1-4, and India, which has the lowest intensity in both the BF-BOF method and the EAF method, looks better than Japan, which has the highest intensity in both the BF-BOF method and the EAF method. This is because it depends heavily on the ratio of electric furnaces, and such a comparison based on average values is meaningless and should be withdrawn.

Table 1-4 Average energy intensity of steel industry in major countries

Energy intensity	China	India	Japan	Germany	U.S.	Russia	S Korea
GJ/t crude steel	24.7	17.6	19.3	20.0	14.9	22.0	18.8

(Reference) RITE's latest estimate of steel energy intensity (BF-BOF method only)

In January 2022, RITE released an estimate of the energy intensity of the BF-BOF method based on 2019 data<sup>8</sup> (the energy intensity of the EAF method will be analyzed in the future). In this document, the energy intensity of Japan is standardized as 100. Since there is almost no change in Japan's energy intensity

<sup>8</sup> [https://www.rite.or.jp/system/global-warming-ouyou/download-data/Comparison\\_EnergyEfficiency2019steel.pdf](https://www.rite.or.jp/system/global-warming-ouyou/download-data/Comparison_EnergyEfficiency2019steel.pdf)

between 2015 and 2019 due to widespread energy efficiency and conservation measures, it is possible to compare 2015 and 2019 directly even if Japan is standardized as 100 (Table 1-4). The energy intensity of China and India, which are developing countries, has improved significantly. This can be attributed to the construction of the state-of-the-art energy-efficient steel mills as steel production increased from 2015 to 2019, and the spread and expansion of energy-saving technologies such as TRT and CDQ.

Table 1-5 Comparison of energy intensity of BF-BOF method

Energy Intensity (Japan=100)	Japan	S Korea	Germ any	China	U.K.	Franc e	India	Russi a	U.S.
Year 2015	100	103	109	116	117	119	123	128	130
Year 2019	100	102	110	111	115	116	119	128	129

### 1.2.3 CO<sub>2</sub> emissions intensity

Various CO<sub>2</sub> emissions intensity figures for the iron and steel industry have been published, but since the calculation method and boundary of the calculation are different, it is not possible to compare intensity figures from different publishers. Examples of published CO<sub>2</sub> intensity are shown below.

#### (1) Published values of CO<sub>2</sub> emission intensity

##### a) worldsteel<sup>9</sup>

worldsteel publishes the average CO<sub>2</sub> emission intensity of its member companies (including blast furnaces and electric arc furnaces) as in Figure 1-7. This value seems to be the average value of the companies that provide data to the worldsteel CO<sub>2</sub> data collection. The number of participating companies and the ratio of blast furnaces to electric arc furnaces may differ from year to year.

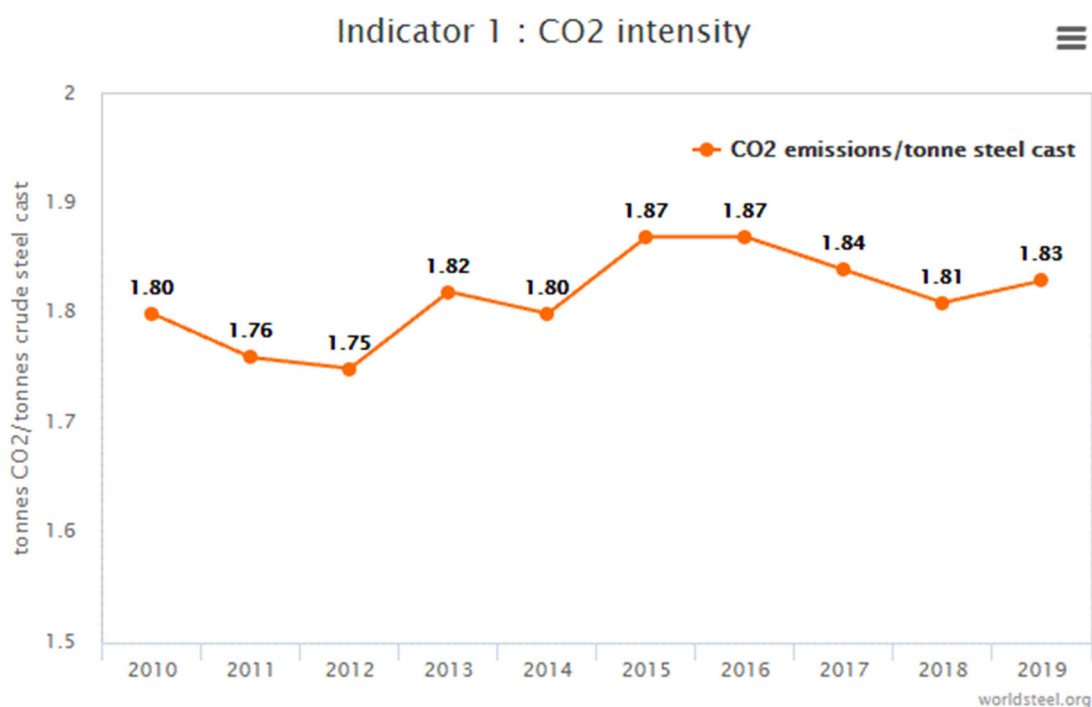


Figure 1-7 Trends in worldsteel's CO<sub>2</sub> emission intensity

<sup>9</sup> <https://www.worldsteel.org/steel-by-topic/sustainability/sustainability-indicators.html>

## b) CDP<sup>10</sup>

CDP is a UK charity-managed non-governmental organization (NGO) that operates a global disclosure system to help investors, companies, nations, regions and cities manage their environmental impacts. In CDP, leading companies from around the world provide their climate change-related information to the Climate Change Program. Information on companies that have requested disclosure is available. The following Table 1-6 shows the CO<sub>2</sub> emission intensity of the steel companies that requested disclosure in 2018. The CO<sub>2</sub> intensity of SSAB and Hyundai is small, but this is due to the high ratio of electric arc furnaces. The CDP is not calculated by a unified method but by each company's method, so the boundary, calculation method, emission factor, etc. may be different.

Table 1-6 CO<sub>2</sub> Emissions intensity of CDP public steel companies

Company name	POSCO	SSAB	Hyundai	Arcelor Mittal	CSC	JSW	TATA	Voestalpine
Country name	South Korea	Sweden	South Korea	Multi-national	Taiwan	India	India and the Netherlands	Austria
CO <sub>2</sub> intensity (t-CO <sub>2</sub> /t)	1.9	1.34	0.91	2.00	2.32	2.43	1.70	1.97

## c) Japan

In Japan, CO<sub>2</sub> emissions from the iron and steel industry are calculated using the same boundary, calculation method, and emission factors in two forms. One is the Greenhouse Gas Emissions “Calculation, Reporting, and Publication System”<sup>11</sup> based on the Act on Promotion of Global Warming Countermeasures (hereinafter referred to as the APGWC) and the other is “Commitment to a Low Carbon Society” of the Japan Iron and Steel Federation (JISF). Under APGWC, it is possible to obtain information on CO<sub>2</sub> emissions on a company-by-company basis (free of charge and open to the public) and on a business-by-business basis (fee-based subscription). Although it is easy to obtain information on a company-by-company basis, companies like Kobe Steel, which are involved in many other businesses in addition to the steel industry, need to be carefully treated. In this case, it is necessary to obtain data for each business site. An example of a comparison of CO<sub>2</sub> emissions between blast furnaces and electric arc furnaces using data from APGWC is shown in Table 1-7<sup>12</sup>. The coverage rate in this tabulation is more than 90%, which is representative of the Japanese steel industry.

<sup>10</sup> <https://www.cdp.net/en/data>

<sup>11</sup> <https://ghg-santeikohyo.env.go.jp/>

<sup>12</sup> <http://www.tokysteel.co.jp/eco/about/>

Table 1-7 CO<sub>2</sub> emission intensity of the Japanese steel industry based on the APGWC

	Greenhouse gas emissions (tCO <sub>2</sub> )	Crude steel production (t)	tCO <sub>2</sub> /t-crude steel
Total of 10 electric arc furnace companies (Top 10 companies in terms of crude steel production)	4,535,986	11,160,414	0.40
Blast furnace companies total	162,227,415	79,960,304	2.02

Source: Ministry of the Environment, "Summary of Greenhouse Gas Emissions in Fiscal Year Heisei 29 (2017) under the Greenhouse Gas Emissions Calculation, Reporting and Publication System Based on the Act on Promotion of Global Warming Countermeasures," etc."

The Japan Iron and Steel Federation reports the total amount of CO<sub>2</sub> emissions of its member companies in its "Commitment to a Low Carbon Society"<sup>13</sup>. Since it also publishes crude steel production, it is easy to calculate the CO<sub>2</sub> emission intensity (Figure 1-8). The coverage rate is more than 95%, but it should be noted that the published figures are the sum of blast furnaces and electric arc furnaces.

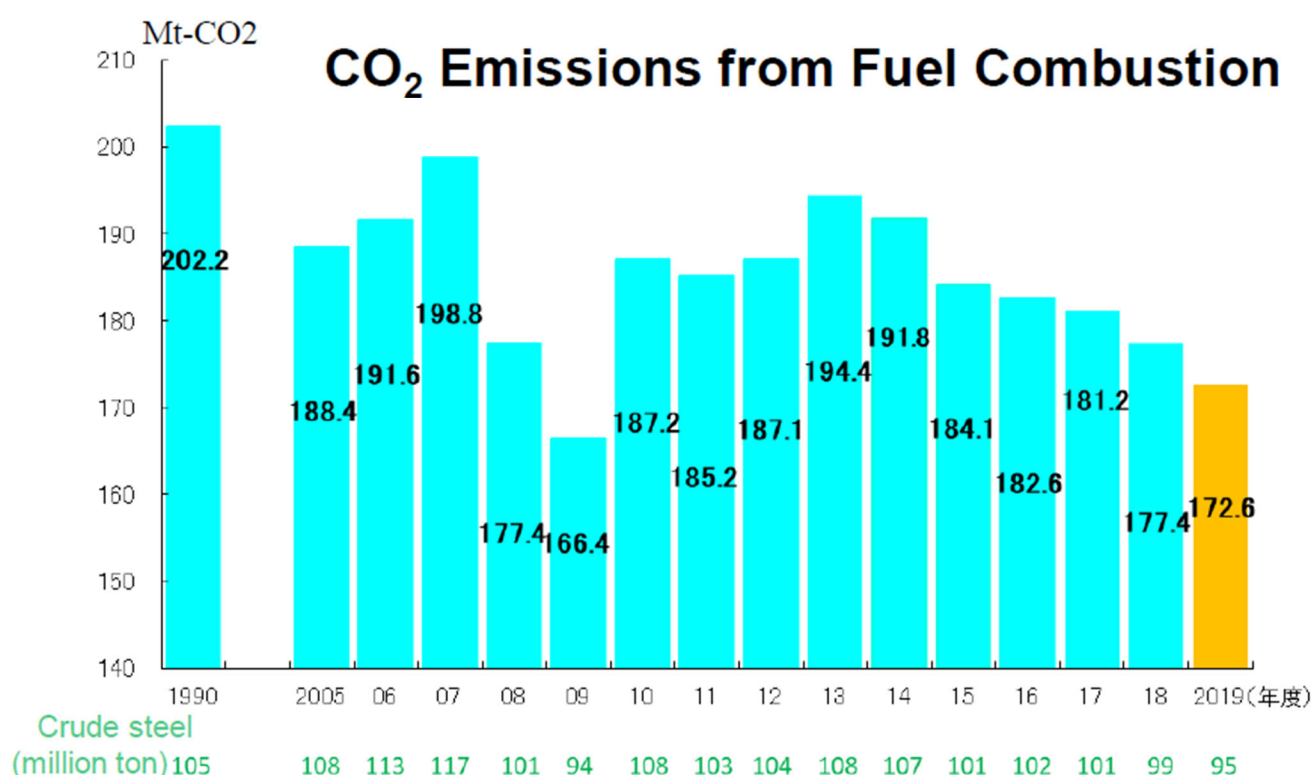


Figure 1-8 Trend of CO<sub>2</sub> Emissions of Member Companies of the Japan Iron and Steel Federation

<sup>13</sup> <https://www.jisf.or.jp/business/ondanka/kouken/keikaku/>

(2) Calculation of CO<sub>2</sub> emissions by country

There is no country in the world that publishes the CO<sub>2</sub> emissions of the steel industry under a national law or an initiative of an industry group, as seen in Japan in cases of APGWC or “the Commitment to a Low Carbon Society”. At present, it is difficult to collect and organize the CO<sub>2</sub> emissions intensity of the steel industry by country. If data by business site becomes available through the worldsteel CO<sub>2</sub> data collection initiative, it will be possible to organize the CO<sub>2</sub> emissions intensity of the steel industry by country.

The CO<sub>2</sub> emission intensity of the steel industry is shown by the following equation.

$$\begin{aligned} \text{CO}_2 \text{ emissions intensity} = & (\text{CO}_2 \text{ emissions [t]} / \text{energy consumption [GJ]}) \times (\text{energy consumption [GJ]} / \text{crude steel production [t]}) \\ <\text{CO}_2 \text{ concentration of energy}> & <\text{energy intensity}> \end{aligned}$$

As shown in the above equation, the CO<sub>2</sub> emissions intensity is the energy intensity multiplied by the CO<sub>2</sub> concentration of the energy (CO<sub>2</sub> emission factor). If the CO<sub>2</sub> concentration of the energy is the same in each country, then the CO<sub>2</sub> emissions intensity can be calculated from Figure 1-5 and Figure 1-6, but since the CO<sub>2</sub> concentration of energy is not disclosed to the public, CO<sub>2</sub> emissions intensity cannot be easily calculated.

(3) Ultra-macro estimates of CO<sub>2</sub> emissions from the steel industry in the candidate countries for the study and their ratio to national emissions

Since the CO<sub>2</sub> emission intensity of the iron and steel industry in each country is not known, we estimated the CO<sub>2</sub> emissions of the steel industry in each country using the reported value based on APGWC (Table 1-7) and RITE's energy intensity comparison (Figure 1-5, Figure 1-6) and calculated its ratio to the national emissions. Assumptions are as follows.

Assumptions

- The production volume of blast furnace steel and electric arc furnace steel is based on the 2019 worldsteel statistics.
- Japan's CO<sub>2</sub> intensity for blast furnaces and electric arc furnaces is based on the figures published in 2017 by all blast furnace companies and top 10 electric arc furnace companies (Table 1-7). In addition, India was taken as a representative value of developing countries, and its CO<sub>2</sub> emission intensity was calculated using RITE's energy intensity comparison (Figure 1-5, Figure 1-6), calculating the India's ratio to Japan, and then multiplying it to Japan's CO<sub>2</sub> emission intensity.
- Since this estimation is made with an ultra-macro approach, the CO<sub>2</sub> emission intensity of electric arc furnaces is assumed to be constant (the

same as that of Japan) without considering the power source composition of each country.

- Emissions for each country are calculated from IEA's Energy Balance Data.

Table 1-8 Ultra-macro estimates of CO<sub>2</sub> emissions from the steel industry in the candidate countries for the study and their share of national emissions

Country	Crude steel production volume		Japanese Level			Indian Level			National CO <sub>2</sub> (million t) from IEA	Steel emission rate(%)
	Blast furnace (million t)	Electric furnace (million t)	Blast furnace CO <sub>2</sub> (million t)	Electric furnace CO <sub>2</sub> (million t)	J Steel CO <sub>2</sub> (million t)	Blast furnace CO <sub>2</sub> (million t)	Electric furnace CO <sub>2</sub> (million t)	I Steel CO <sub>2</sub> (million t)		
India	48.7	62.5	98.4	25.0	123.4	120.7	28.3	149.0	2601.1	4.7% ~ 5.7%
Turkey	10.9	22.8	21.9	9.1	31.1	26.9	10.4	37.2	356.4	8.7% ~ 10.5%
Vietnam	11.2	5.7	22.7	2.3	24.9	27.8	2.6	30.4	234.4	10.6% ~ 13.0%
Mexico	4.2	14.3	8.5	5.7	14.2	10.5	6.5	16.9	433.2	3.3% ~ 3.9%
Egypt	0.2	7.1	0.4	2.8	3.2	0.5	3.2	3.7	218.9	1.5% ~ 1.7%
Indonesia	2.6	3.8	5.3	1.5	6.8	6.5	1.7	8.2	563.4	1.2% ~ 1.5%
Malaysia	0.5	4.0	1.0	1.6	2.6	1.2	1.8	3.0	223.1	1.2% ~ 1.3%
Thailand	0.0	4.2	0.0	1.7	1.7	0.0	1.9	1.9	279.6	0.6% ~ 0.7%
Bangladesh	0.0	5.1	0.0	2.0	2.0	0.0	2.3	2.3	93.4	2.2% ~ 2.5%
Philippines	0.0	1.4	0.0	0.6	0.6	0.0	0.6	0.6	147.4	0.4% ~ 0.4%

Table 1-8 shows the results of the estimation. For Turkey and Vietnam, the steel industry's share of the country's total emissions was about 10%. As for India, the impact on the country was smaller than that of Turkey and Vietnam, at about 5%. This may be because in India, DRI is used as a raw material for electric arc furnace steel in addition to scrap, but the emissions from DRI production are not taken into account. For countries below Mexico, the percentage is as low as 4% or less. This may be due to the low steel production and the high ratio of electric arc furnace steel, which has a small CO<sub>2</sub> intensity.

### **1.3 Policy and technology development for low-carbon and decarbonized steelmaking in major countries and regions**

This section describes the policy and technology development for low-carbon steelmaking in the EU and China, as well as the efforts of public institutions and donors across countries to reduce carbons and decarbonize the steelmaking sector.

#### **1.3.1 EU**

The United Nations Framework Convention on Climate Change (UNFCCC) and its underlying Kyoto Protocol and Paris Agreement have had a major impact on the policies of countries and regions in response to climate change (Figure 1-9).

Europe has ratified both of these schemes, and has taken a proactive and leading position in addressing climate change issues. In particular, the European Emissions Trading Scheme (EU-ETS), which imposes a total cap on GHG emitters in the region and provides a carbon pricing, was introduced in 2005 as the first phase, and has been implemented in successive phases up to the present.

In recent years, the European Commission has announced the European Green Deal in December 2019, positioning it as a new growth strategy for the EU to achieve climate neutrality by 2050 and transition to a fair and prosperous society with a resource efficient and competitive economy. This includes tightening the EU's 2030 and 2050 climate change targets. In order to achieve climate neutrality by 2050, it is necessary to set a target of 50-55% reduction by 2030 compared to 1990 (further stretching the previous target of 40% reduction), and since this cannot be achieved by conventional policies alone, it is necessary to promote further climate change policies such as reviewing the EU-ETS system.

Based on this, the European Commission has adopted a comprehensive climate change policy package (Fit for 55) consisting of 18 policies including revision of EU-ETS and Carbon Border Adjustment Mechanism (CBAM). This includes the revision of the EU-ETS and other policies that could affect the international competitiveness of the steel industry in Europe and around the world. (In particular, the European steel industry may be impacted from the gradual reduction of the current free allocation in the EU-ETS and the reduction to zero annual free allocation in 2035. For non-European countries, they may be impacted from CBAM and other measures when exporting to Europe).

In addition to the EU-ETS, the European Commission has already introduced a financial support system for the development of innovative technologies such as hydrogen reduction steelmaking, and will continue to increase the size of the budget to promote research and development (See Figure 1-14 to Figure 1-18, Green Deal, Fit for 55, and European Climate Law).

One of the recent concerns in the European steel industry is free allocation in the EU-ETS and CBAM for imports. With the latter, the purpose of free allocation

(leakage problem) will be achieved, and the abolition of free allocation has been proposed. At the start of the emissions trading system (2005), free allocation was based on actual results ("grandfathering", i.e., emissions assumed to be reduced based on actual results), but now free allocation is based on product benchmarks such as pig iron, coke, sintering, and electric furnace materials (some of which need to be purchased), but this will be gradually reduced in the future (by 2026) and eventually (by 2035) abolished (all of which need to be purchased through auctions, etc.). The European steel industry seems to have been negotiating with the European Commission on the benchmark calculation method (by-product gas, ensuring electricity consumption subsidies for electric furnaces, etc.).

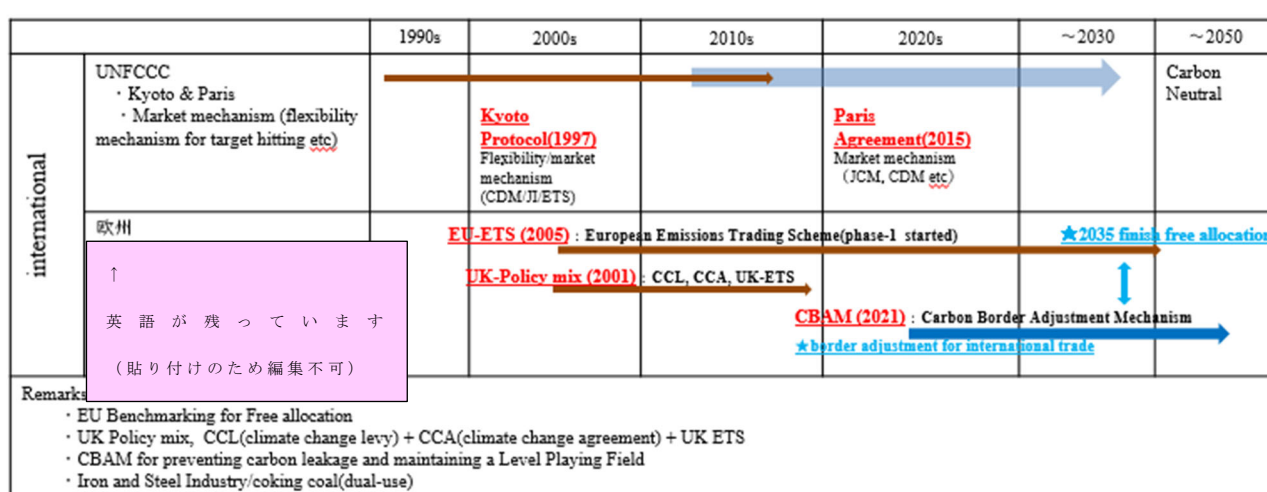


Figure 1-9 Framework Convention on Climate Change, Kyoto Protocol and Paris Agreement

Looking at the trends of roadmaps and announcements in the global steel industry, including those in Europe, The Japan Iron and Steel Federation (JISF) developed and announced “a challenge towards zero carbon steel” in 2018, ahead of the rest of the world's steel industry, as part of its long-term vision for global warming countermeasures (Figure 1-10). After that, the European Steel Association announced its roadmap in 2019, and the IEA announced its roadmap for the global steel industry in cooperation with the World Steel Association in 2020 (Figure 1-10, Figure 1-11).

The starting point for the development of innovative technologies for steel in the world was the launch of innovative technology development in Japan in the early 2000s, as shown Figure 1-10 (national projects on hydrogen and CO<sub>2</sub> capture and storage, followed by COURSE 50).

In 2003, Japan and Europe proposed a global collaboration "CO<sub>2</sub> Breakthrough Program" to the World Steel Association, and a platform for regular information sharing and opinion exchange was started with the participation of steel companies from major countries. The European steel industry has also started to

develop specific technologies through intra-regional cooperation (ULCOS).

In particular, the IEA's Iron and Steel Technology roadmap (October 2020) and Net Zero by 2050 (May 2021) present possible scenarios for the global steel industry towards 2050. This information should be used as a basis for countries and companies to draw their own roadmaps. For example, changes in steel production routes (integrated iron/steel works and electric furnace iron/steel works), changes in the lineup of iron sources (iron ore and scrap), and changes in iron ore reduction routes (blast furnace method and DRI method) and the lineup of reducing materials (coal, natural gas, hydrogen, and electrolysis) are highly suggestive. In addition to innovative technologies, it is also important to promote existing technologies (such as energy-saving equipment and operational improvements). In addition, from the perspective of material efficiency, it is important to improve the efficiency of steel use through the development and diffusion of "eco-products" (e.g., reducing the weight of automobiles by using high-tensile steel) that the Japanese steel industry is developing, and from the perspective of circular economy (e.g., increasing the recovery rate of scrap).

The roadmap for the European steel industry has the following features (for details, see Figure 1-12 and the original document "Low Carbon Roadmap, Pathway to a CO<sub>2</sub>-neutral European Steel Industry").

- Reduce 2050 annual emissions by 80-95% (vs. 1990)
- Conditions for technology transition (e.g., stable and inexpensive supply of CN hydrogen and CN electricity, and fairness in international competition)
- Production cost will be 35% up or as high as double (measures to prevent disadvantage in the market are mandatory)
- Innovation technologies are implemented in terms of both Carbon Direct Avoidance (CDA, such as iron ore hydrogen reduction and electrolysis) and Smart Carbon Usage (SCU, such as CCUS).
- Although there are some technology development projects from the ULCOS era, from ULCOS, which was a collaboration centered on steel companies, there are now many cases where steel companies form international consortiums with electric power companies, chemical manufacturers, engineering companies, research institutes, etc. based on technical connections (to secure public support).

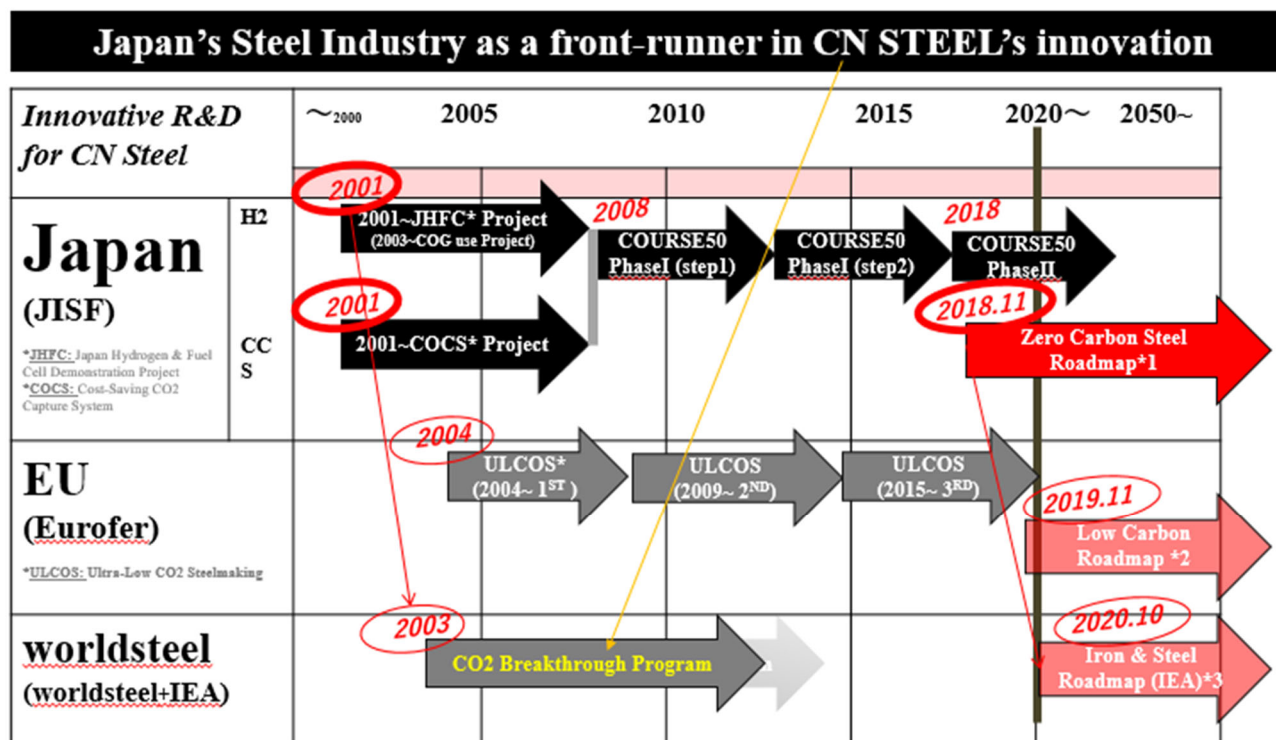


Figure 1-10 Japan leads the world in technological development for CN in the steel industry<sup>14</sup>

<sup>14</sup> \*1: <https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/>

\*2: <https://www.eurofer.eu/assets/Uploads/EUROFER-Low-Carbon-Roadmap-Pathways-to-a-CO2-neutral-European-Steel-Industry.pdf>

\*3: [https://aceroplatea.es/docs/Iron\\_and\\_Steel\\_Technology\\_Roadmap\\_IEA.pdf](https://aceroplatea.es/docs/Iron_and_Steel_Technology_Roadmap_IEA.pdf)

Table 1-9 Major steel CN technology development projects in Europe and elsewhere

Region/country [Crude steel production in 2018]	Program/project	Participants	Description of project
<b>JAPAN</b> <b>[0.10Gt]</b>	• <b>COURSE50</b> & Ferro-coke	• BF steelmaker + universities etc.	• <b>Phase-1 (2008~2017), Phase-2 (2018~)</b> • H2 use / CO2 separation • Test BF with volume of 12m2
EUROPE [0.17Gt]	• <b>ULCOS</b> • <b>Hisarna</b> , • <b>Hybrit/SIDERWIN</b> etc.	• Consortiums	• ULCOS-BF, <b>HISARNA</b> , ULCOWIN(currently <b>SIDERWIN/low temperature iron ore electrolysis</b> ), ULCORED etc • Projects are categorized into CDA(Carbon Direct Avoidance) and SCU(Smart Carbon Use)
CHINA [0.93Gt]	• Hydrogen reduction	• <b>Bao, Tenova</b> (MoU) etc	• Iron ore reduction by <b>Green Hydrogen</b>
Korea [0.07Gt]	• POSCO Program	• POSCO, RIST	• FINEX(coal) based technology for H2 (HYREX)
Australia [0.006Gt]	• <b>Solar Smelting</b>	• Swinburne university	• <b>Solar Reactor</b> (reducing reagent: coal)
USA [0.09Gt]	• Molten Oxide Electrolysis	• MIT	• MOE, <b>high temperature iron ore electrolysis</b>
Brazil [0.03Gt]	• Charcoal BF	• Commercial operation	• <b>Charcoal</b> use in Small BF (Carbon neutral)
<b>World-wide</b> <b>[1.81Gt]</b>	<b>CO2 Breakthrough Program</b>	• Member companies of <b>worldsteel</b>	• <b>A Platform</b> for steel industry's innovative R&D for low carbon steel (CN STEEL)

Source: The list is created by Nippon Steel Research Institute using information published as of January 2021.

Major CN technology development projects in Europe and other major countries are shown in Table 1-9. It is necessary to keep abreast of the trends at the right time.

# CN Steel's Roadmap

## ■ 2018.11 JISF's vision

“JISF's Long-term vision for climate change mitigation, a challenge towards zero carbon steel”

## JISF Long-term vision for climate change mitigation

A challenge towards Zero-carbon STEEL

June 2020 - revised  
Japan Iron and Steel Federation

■ 2018.11 JISF

## ■ 2019.11 EUROFER

“Low Carbon Roadmap, Pathway to a CO2-neutral European Steel Industry”

■ 2019.11 EUROFER

## ■ 2020.5 ARCELORMITTAL

“Climate Action in Europe, Our carbon emissions reduction roadmap, 30% by 2030 and carbon neutral by 2050”

## ■ 2020.10 IEA (+ worldsteel)

“Iron and Steel Technology Roadmap, Towards more sustainable steelmaking”

## ■ 2021.3 Green Steel for Europe Consortium(EU granted)

“Technology Assessment and Roadmapping”

■ 2020.10 worldsteel+IEA

## ■ 2021.5 IEA

“Net Zero by 2050, A Roadmap for the Global Energy Sector”



Figure 1-11 Steel Roadmap (Japan - Europe - World)

## OVERVIEW

### Making a success of the European steel industry's low-carbon transformation

The European steel industry is the most advanced of its kind in the world. As it is, Europe leads the way in environmental and climate performance. CO<sub>2</sub> emissions and energy use in European steel production have been halved since 1960, and the sector has the ambition to further achieve cuts of between 80-95% by 2050, compared to 1990 levels.

This transition will require significant investment in new technological development and deployment, in energy infrastructure, consumption and type, and will require access to high quality materials, such as iron ore and scrap.

EUROFER has established a clear set of pathway scenarios that will deliver this essential change for the sector, ensuring that Europe will remain on track to fulfil its Paris Climate Accords requirements, whilst also making European steel fit for a clean, low-carbon future.

## KEY MESSAGES

This roadmap sets out several of the key elements that will make the transition to a low or carbon-neutral European steel industry possible

- The European steel industry could achieve carbon emissions cuts of between 80-95% by 2050, under the right conditions, through new technological pathways
- Total costs of production will rise by 35-100% per tonne of steel by 2050 as a result of the costs of using new technologies and more energy
- Additional energy requirements will be about 400TWh of CO<sub>2</sub> about seven times what the sector purchases currently.

### Necessary conditions

Various conditions must be satisfied while the steel industry is transitioning to becoming a low-CO<sub>2</sub> sector

The necessary conditions need to be in place to make this transformation happen. In particular, all the necessary ingredients for steel making need to be available in both quality and quantity. These include suitable raw materials, such as iron ore and scrap. It also means having access to sufficient low-CO<sub>2</sub> energy sources, such as electricity and hydrogen, which must be available at commercially viable rates. The energy infrastructure that goes with it is also indispensable, as even cutting-edge, technologically advanced steelmaking facilities would be stranded without access to clean energy.

During the transition, Carbon Capture and Storage (CCS) technology may also be needed in order to support progress along the potential CO<sub>2</sub> reduction pathway.

Finally – both during the transition and once the move to the low or carbon-neutral future of the sector has successfully been completed – there must be regulatory framework that ensures that the EU steel industry remains competitive compared to its global competitors. Most global competitors do not face anything close to the environmental standards or climate constraints of EU players – and as such, do not bear the costs. A suitable regulatory framework would serve to address this fatal and conceived handicap, both now and in the future.



### LOW CARBON ROADMAP

PATHWAYS TO A CO<sub>2</sub>-NEUTRAL EUROPEAN STEEL INDUSTRY  
11th November 2020

## EUROFER published its Low Carbon Roadmap in November 2019

<https://www.eurofer.eu/assets/Uploads/EUROFER-Low-Carbon-Roadmap-Pathways-to-a-CO2-neutral-European-Steel-Industry.pdf>

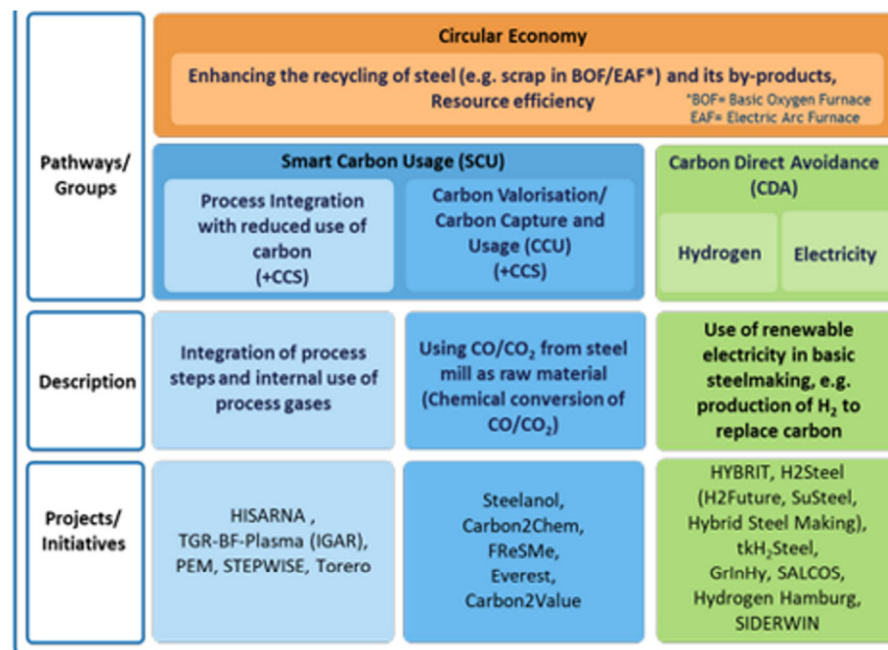


Figure 1: The EU steel industry's strategic technological pathways. This identifies both the main pathways to be pursued and a sample of some of the proposed or ongoing projects in each pathway.

Figure 1-12 Roadmap by the European Steel Association (November 2020)

<Reference-1: List of related roadmaps, etc.>

■ (November 2018) Japan Iron and Steel Federation

“JISF Long-term vision for climate change mitigation, a “challenge towards Zero-carbon steel”

<https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/>

■ (November 2019) European Steel Association

“Low Carbon Roadmap, Pathway to a CO<sub>2</sub>-neutral European Steel Industry.”

[https://www.eurofer.eu/assets/Uploads/EUROFER-Low-Carbon-Roadmap-Pathways-to-a-CO<sub>2</sub>-neutral-European-Steel-Industry.pdf](https://www.eurofer.eu/assets/Uploads/EUROFER-Low-Carbon-Roadmap-Pathways-to-a-CO2-neutral-European-Steel-Industry.pdf)

■ (November 2019) MIDDEN/PBL/ECN (+TATA Europe)

“De-carbonization options for the Dutch Steel Industry.”

[https://www.pbl.nl/sites/default/files/downloads/pbl-2019-decarbonisation-options-for-the-dutch-steel-industry\\_3723.pdf](https://www.pbl.nl/sites/default/files/downloads/pbl-2019-decarbonisation-options-for-the-dutch-steel-industry_3723.pdf)

■ (May 2020) ArcelorMittal

“Climate Action in Europe, Our carbon emissions reduction roadmap, 30% by 2030 and carbon neutral by 2050.”

<https://corporate.arcelormittal.com/sustainability/climate-action-in-europe>

■ (October 2020) International Energy Agency (+ World Steel Association)

“Iron and Steel Technology Roadmap, Towards more sustainable steelmaking.”

[https://aceroplatea.es/docs/Iron\\_and\\_Steel\\_Technology\\_Roadmap\\_IEA.pdf](https://aceroplatea.es/docs/Iron_and_Steel_Technology_Roadmap_IEA.pdf)

■ (March 2021) Green Steel for Europe Consortium (EU granted)

“Technology Assessment and Road mapping.”

<https://www.estep.eu/assets/Uploads/210308-D1-2-Assessment-and-roadmapping-of-technologies-Publishable-version.pdf>

■ (May 2021) International Energy Agency

“Net Zero by 2050, A Roadmap for the Global Energy Sector.”

<https://iea.blob.core.windows.net/assets/4719e321-6d3d-41a2-bd6b-461ad2f850a8/NetZeroBy2050-ARoadmapfortheGlobalEnergySector.pdf>

<Reference-2: Direction of the development of CN technology for steel, including European projects>

- SCU (SMART CARBON USAGE, BF and other coal systems + CCS/CCU)
- CDA (CARBON DIRECT AVOIDANCE, zero carbon electricity, hydrogen)

From basic research to near-commercial operation, the technology level is being evaluated and promoted by TRL. The consortium formation is different from the ULCOS era. Others (Solar smelting, charcoal BF, etc.) are also attracting some attention.

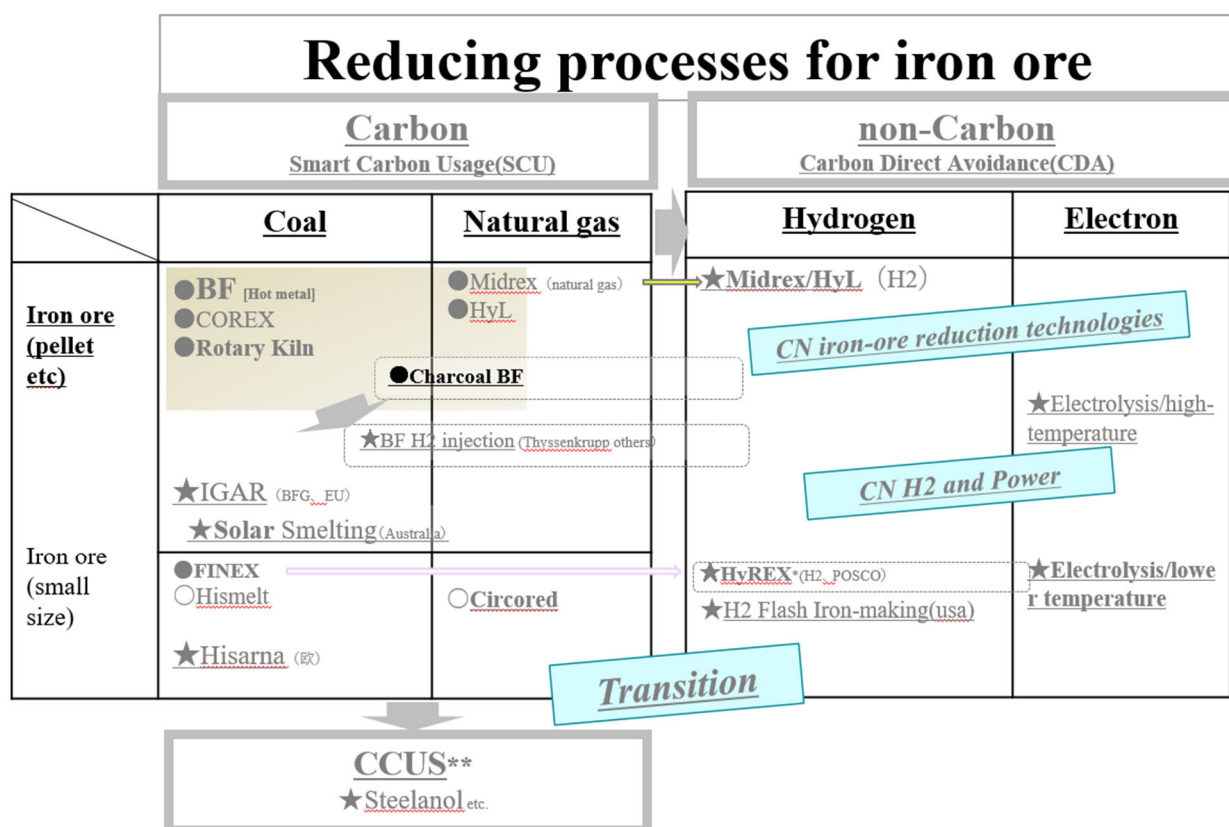


Figure 1-13 Direction of CN technology development in steel (SCU, CDA)

<Reference-3: IEA Net Zero by 2050 for steel (May 2021)>

- By sector, the power generation sector will be the first to achieve Net Zero (around 2040), then will become negative emission sector.
- Based on this "all-electric" orientation, hydrogen production/water electrolysis, iron ore electrolysis, etc.
- In this report, global emissions, GDP, etc. are described as follows

	World total	Year 2020	Year 2050
➤ Amount of emission		33.9⇒	0 billion t-CO <sub>2</sub> /y (net zero)
➤ GDP		128	316 T\$/y
➤ Population		7.75	9.69 billion people
(GDP/Population)		1.7	3.3 (\$10,000/person)

- Steel is depicted as follows (see also Table 1-10)

Year2020	Year2050	
➤ Amount of emission	2.35⇒	2.2 billion t-CO <sub>2</sub> /y
➤ Crude steel production	1.78	1.99 billion t/y
(Emissions from developing countries)		

Table 1-10 Overview of the European Steel Industry and IEA Steel Roadmap

Steel production route in IEA Net Zero by 2050			
		(1) 2020	(2) 2050
		( <b>actual</b> ) <small>worldsteel statistics</small>	(2)-1 <b>IEA Net Zero by 2050</b> (2021.5)
<b>Crude steel production</b> • World (Gt-steel/y) • EAF (%)		<b><u>1.88</u></b> <b>26.3%</b>	<b><u>1.99</u></b> <b><u>53%</u></b>
<b>A. Scrap use</b> (% in Fe input)		31%	<b><u>46%</u></b>
<b>B. iron-ore route</b>	<b>B1. BF etc</b>	<b><u>93%</u></b>	With-CCUS <b><u>53%</u></b> Without-CCUS <b><u>5%</u></b>
	<b>B2. DRI</b>	<b>7%</b>	H2-DRI <b><u>29%</u></b>
	<b>B3. Electrolysis</b>	0	<b><u>13%</u></b>
<b>CO2排出量</b> (Gt-CO <sub>2</sub> /年)		-	2.35(2020) ⇒ 0.22(2050)

# EU Green Deal and Fit for 55

EU Green Deal (December 2019)	<ul style="list-style-type: none"> <li>- Climate neutrality by 2050</li> <li>- New Growth Strategy, resource efficient, competitive economy, equality/impartiality and affluent society</li> </ul> <p style="text-align: right;">etc.</p>
Fit for 55	<ul style="list-style-type: none"> <li>- Raise 2030 target for achieving Climate neutrality by 2050, from an original 40% reduction target of GHGs emissions to 50~55% reduction target vs 1990</li> <li>- Implementation of additional climate policies, including <u>revision of EU-ETS</u></li> </ul>

Figure 1-14 (Reference 1) The European Green Deal and Fit for 55

As measures to cope with carbon leakage in Europe, the EU-ETS free allocation (Benchmark standard) and CBAM (Carbon Border Adjustment Mechanism) have been established in order to deal with fairness of international competition conditions and manufacturing cost increase (burden problem, difference problem among regions and countries). In the current proposal, free emission quotas will be temporarily reduced or abolished by introducing CBAM over the course of a 2035. In such a case, the steel industry, which is exposed to carbon leakage, would have to purchase carbon dioxide allowances (emission quotas) equivalent to the amount of emissions from iron/steel works through auctions from the government, which would impose a considerable economic burden. The introduction of CBAM is also expected to impose substantial tariffs (e.g., border tax adjustments) on companies from countries that export to Europe, which is attracting international attention (Figure 1-15 - Figure 1-17 ).

## Revision of EU-ETS in Fit for 55

<b>Major revising points</b>	<ul style="list-style-type: none"> <li>- Expanding maritime transportation</li> <li>- Decrease of total amount of ETS's cap from -43% to -61% compared to the base year of 1990</li> <li>- Step-wise <u>decrease of free allocation</u> for the sectors covered by CBAM etc.</li> </ul>
<b>Decrease of free allocation for industry sectors</b>	<ul style="list-style-type: none"> <li>- Current: free allocation based on benchmarking for the sectors that have a risk of carbon leakage/</li> <li>- Revision: step-wise decrease (approximately -10%/annual) of free allocation from 2026 toward 2035 for <u>the sectors covered by CBAM</u></li> </ul>

Figure 1-15 (Reference 2-1) ETS amendment and CBAM in Fit for 55 in Europe

## CBAM in Fit for 55 (Carbon Border Adjustment Mechanism)

<b>CBAM</b>	<ul style="list-style-type: none"> <li>- Objective: avoiding carbon leakage</li> <li>- Target sectors: cement, fertilizer, steel, power, aluminum</li> <li>- Requirement/obligation: Importers of designated goods have obligation to buy CBAM certificate</li> <li>- Free allocation of EU-ETS will be decreased by 10%/annual step-by-step toward zero free allocation in 2035</li> <li>- Major discussing points: WTO compatibility, effect of zero free allocation on industry etc.</li> </ul>
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Figure 1-16 (Reference 2-2) ETS amendment and CBAM in Fit for 55 in Europe

## Brief explanation on CBAM

Commencement period	<ul style="list-style-type: none"> <li>- Transition period: 2023~2025</li> <li>- Full-scale introduction: 2026</li> </ul>
Target sectors (goods)	<ul style="list-style-type: none"> <li>- Electricity, Cement/clinker, Chemical fertilizer, Steel products, Aluminum products</li> <li>- Direct emissions only.</li> </ul>
Calculation methodology	<ul style="list-style-type: none"> <li>- One of below</li> <li>- Verified emissions</li> <li>- Average emission intensity of exporting country</li> <li>- Default emission intensity of EU's average of lower ranking 10%</li> </ul>
Penalty	- Equivalent to the penalty of EU-ETS (€100/t-CO <sub>2</sub> )
Others	<ul style="list-style-type: none"> <li>- Procedures</li> <li>- Exporters' obligations</li> </ul>

Figure 1-17 (Reference 2-3) ETS revision and CBAM in the European Fit for 55

### **Structure of European Climate Law (draft)**

1. Subject matter and scope
2. Climate-neutrality objective
3. Trajectory for achieving climate neutrality
4. Adaptation to climate change
5. Assessment of Union progress and measures
6. Assessment of national measures
7. Common provisions on Commission assessment
8. Public participation
9. Exercise of the delegation
10. Amendments to Regulation (EU) 2018/1999
11. Entry into force

Figure 1-18 (Reference 4) European Climate Law

### 1.3.2 China

When China submitted its NDC in 2015, the country announced that it will achieve a peak out of CO<sub>2</sub> emissions by around 2030, and realize this as early as possible.”. Later, at the UN General Assembly held in September 2020, President Xi Jinping declared that China would achieve carbon neutrality by 2060. China is not only the world's largest CO<sub>2</sub> emitter, but also the largest steel producer, and low-carbonization of the steel industry is one of its key issues.

In recent years, in order to curb overcapacity, the government has focused on reducing production capacity by banning energy inefficient steel production facilities and closing down inefficient small-scale enterprises called "chijyoukou". It has also introduced energy conservation regulations, such as requiring key energy companies to report on their energy consumption and intensity. In April 2021,<sup>15</sup> the China Iron and Steel Association announced that it would reduce its crude steel production capacity and cut production of 2021 in order to achieve CO<sub>2</sub> emission peak out by 2030 and carbon neutrality by 2060.

The 14<sup>th</sup> Five-Year Plan announced in March 2021 set a target of lowering energy consumption per unit of GDP by 13.5% and CO<sub>2</sub> emissions per unit of GDP by 18% (cumulative total of 2021 to 2025, vs 2020). It also mentions spreading the circular economy development model in key industries such as steel, non-ferrous metals, metallurgy, petrochemicals, equipment manufacturing, and light industry<sup>16</sup>.

Also in 2021, China's first emissions trading market for the power sector was established. The market is expected to regulate 4 billion tons of CO<sub>2</sub> per year, surpassing the EU-ETS as the largest carbon market in the world. Some steel companies in major cities have been operating carbon trading on a trial basis from 2013 to 2014, and the steel industry is also expected to formally introduce a carbon trading market in the future, which is expected to further increase pressure to reduce emissions.

#### <Technology Trends>

At present, about 90% of steel in China is made using BF-BOF methods, but the country is planning to increase the proportion of scrap EAF method over the long term, and plans to double EAF steel production by 2025 (IEA<sup>17</sup>). According to the study, the availability of scrap in China will be high in the future because of the ongoing decline in crude steel production due to government-led economic structural reforms and the rapid accumulation of domestic steel resources since the 2000s. The share of scrap in raw materials is expected to rise from 25% in 2019 to 50% in the 2050 (Figure 1-19 ). In the Sustainable Development Scenario

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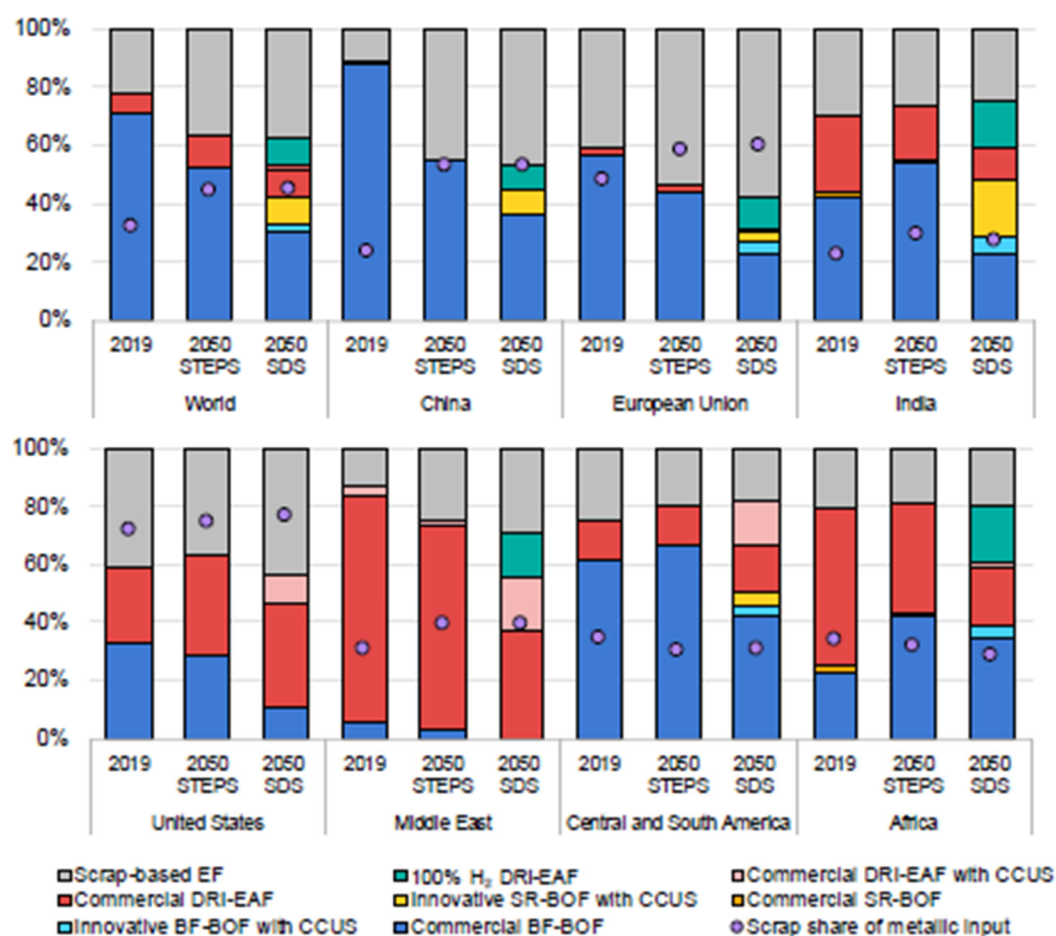
<sup>15</sup> JETRO website: <https://www.jetro.go.jp/biznews/2021/04/73a6ba690b90982d.html>

<sup>16</sup> JETRO website: <https://www.jetro.go.jp/biznews/2021/07/89bde6227de38353.html>

<sup>17</sup> IEA (2020), Iron and Steel Technology Roadmap

(SDS), which is more likely achieve the Paris Agreement, a scenario is presented in which the blast furnace process with CCUS and hydrogen DRI-EAF are introduced in roughly equal proportions and account for one-third of primary steel production capacity. This is due to the fact that China has rich potential of low-cost renewable energy and CCUS is being introduced in other industrial sectors.

**Figure 2.10 Crude steel production by process route and scenario in major steel-producing regions**



**Figure 1-19 Process route for crude steel production by scenario**

Source: IEA, Iron and Steel Technology roadmap

### <Alliances>

China Baowu Steel Group, one of the world's largest producers of crude steel, announced at the end of 2019 that it would establish the Global Green Low Carbon Metallurgy Alliance, but details has not been disclosed yet<sup>18</sup>. At the end of 2020, mining company BHP announced that it would invest up to US\$ 35 million in

<sup>18</sup>

<http://www.asianmetal.com/news/data/1519332/Baowu%20Steel%20Group%20actively%20integrating%20into%20the%20low-carbon%20transformation>

Baowu and signed a memorandum of understanding to work together to reduce greenhouse gas emissions in the global steel industry<sup>19</sup>. The two companies have established the Baowu-BHP Low Carbon Metallurgy Knowledge Sharing Center, which will disseminate knowledge on low-carbon and green technology development to stakeholders in the domestic and global steel sector.

### **1.3.3 Public institutions and donors in each country and region**

The Asian Development Bank (ADB) is an international development financial institution consisting of 67 member countries (among them, 48 countries are in the Asia-Pacific region). The ADB's main partners are governments, the private sector, NGOs, development agencies, community organizations, and foundations. ADB's main partners are governments, the private sector, NGOs, development agencies, community organizations, and foundations, and its main instruments to achieve its vision are loans, technical cooperation, grants, guarantees, equity investments, and policy dialogue. While public sector lending to governments accounts for the major part of financing, the ADB also provides direct support to private sector enterprises in developing countries through equity participation, guarantees and loans.

The cases supported by the ADB on energy conservation and CO<sub>2</sub> reduction in steel sector are shown in Table 1-11.

The modernization and expansion project of China's Laiwu Iron & Steel Group Co., Ltd. was designed to facilitate the transfer of modern technology, increase productivity, improve energy efficiency, reduce pollutants, balance existing steel production capacity and auxiliary equipment for production expansion, improve management and technical skills, and introduce good commercial and governance practices, and is regarded as a success.

In Vietnam, the ADB had approved to provide technical assistance for the preparation of a project on "Energy Efficiency in Industry," but the Vietnamese government judged that the economic situation as of 2013 was not suitable to test energy efficient measures in the steel and cement industries, and the approval expired in July 2013, so the project was not realized.

Since 2008, ADB has been providing technical assistance to countries such as Bangladesh, India, Indonesia, China, and Vietnam to remove institutional, technical, and economic barriers to the introduction of CCUS, an innovative technology.

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<sup>19</sup> <https://www.bhp.com/news/media-centre/releases/2020/11/bhp-partners-with-china-baowu-to-address-the-challenges-of-climate-change>

Table 1-11 Examples of ADB's support for energy conservation and CO<sub>2</sub> reduction in steel

Year	Country	Content of support
1992 to 1999	China	<p>A modernization and expansion project<sup>20</sup> of Laiwu Iron and Steel Company (LISC). The project aimed to facilitate the transfer of modern technology, increase productivity, improve energy efficiency, reduce pollutants, balance existing steel production capacity and auxiliary equipment for production expansion, improve management and technical skills, and introduce good commercial and governance practices. In 1992, the ADB approved a multi-currency loan of 133 million dollars.</p> <p>The project is considered a success based on the criteria of relevance, effectiveness, efficiency, sustainability, institutional development and other impacts. The project achieved its main objective of modernizing and expanding LISC's steel production by introducing modern technology, efficient manufacturing processes, and exposure to international good business practices. As a result of the project, the production of the BF-BOF iron/steel works increased from 240,000 tons per year at the time of appraisal to 687,000 tons per year in 2000, far exceeding the design capacity of 628,000 tons per year. LISC's steel production has also increased from 840,000 tons per year to more than 2.2 million tons per year. The project increased labor productivity by automating and increasing the production of the BF-BOF iron/steel works, introduced advanced technology and modern management systems, and reduced production costs by making LISC a holding company, thereby strengthening LISC's competitiveness. The objective of pollution prevention was achieved, including the construction of a modern integrated wastewater treatment and recycling plant to treat the wastewater generated by the project.</p>
2011 *Technical cooperation approval had expired	Vietnam	<p>On December 2<sup>nd</sup>, 2011, The ADB approved to provide technical assistance to the Government of Viet Nam for the preparation of a project on "Energy Efficiency in Industry" in an amount not to exceed 800,000 dollars. In response to the weakness of the local economy, the Vietnamese government has removed the steel and cement sectors from the list of priority programs and projects to be supported, which had recorded high</p>

<sup>20</sup> PCR: PRC 21064, PROJECT COMPLETION REPORT ON THE LAIWU IRON AND STEEL COMPANY MODERNIZATION AND EXPANSION PROJECT (Loan 1162-PRC) IN THE PEOPLE'S REPUBLIC OF CHINA, September 2001

Year	Country	Content of support
		inventory levels and declining sales volumes. In addition, following the approval of the technical assistance (TA), the government decided to change the executing agency of the TA from the Ministry of Finance to the Ministry of Industry and Trade (MOIT). Although ADB extended the validity of the TA for 6 months from December 1 <sup>st</sup> to June 1 <sup>st</sup> , 2012 to consider changes in the TA implementation arrangements and to reassess the sectors eligible for priority assistance, The MOIT reaffirmed that the current economic situation is not suitable for piloting energy efficient measures in the steel and cement industries. Finally, on July 16 <sup>th</sup> , 2013, the ADB officially notified the State Bank of Vietnam that the TA approval had expired on June 1 <sup>st</sup> , 2013. <sup>21</sup>
2008 ~	Bangladesh, India, Indonesia, China, Vietnam, etc.	ADB has been providing technical assistance to remove institutional, technical, and economic barriers to CCUS implementation, increasing awareness of CCUS and promoting collaboration with regional and international partners on CCUS, through establishing CCUS Centers of Excellence, supporting feasibility studies and pilot projects, workshops and knowledge products. <sup>22</sup>

The European Bank for Reconstruction and Development (EBRD) was established in 1991 to support the transition to a market-oriented economy and the voluntary activities of private sector and entrepreneurs in Central and Eastern European countries. The EBRD has provided assistance in the areas of energy conservation and CO<sub>2</sub> reduction in steel, as shown in Table 1-12.

Under the EBRD's Sustainable Energy Finance Facility (SEFF), the EBRD is partnering with banks and other local financial institutions to establish a sustainable energy finance channel that will provide financing for two key areas: energy efficiency and small-scale renewable energy. The EBRD has established sustainable energy financing channels in partnership with banks and other local financial institutions. In addition to providing financing, the SEFF has also established a "project implementation team" composed of local and international experts to support participating local financial institutions and their clients.

The EBRD has also entered the Turkish sustainable energy market by

<sup>21</sup> Project Number: 41436, PPTA Number: 7942-VIE. August 2013, "Viet Nam: Energy Efficiency in the Industry".

<sup>22</sup> Project Number: 48282-001, Technical Assistance Number: 8714, August 2019, "REG: Promoting Carbon Capture and Storage in the People's Republic of China and Indonesia, Background Study on CCUS Readiness in Power, Iron and Steel, Cement and Petroleum Sectors".

establishing the Turkish Sustainable Energy Financing Facility (TurSEFF) in Turkey in 2010<sup>23</sup>. The EBRD used its own funds, as well as funds from the Clean Technology Fund (CTF) and the EU, to develop sustainable energy financing products for 5 major Turkish banks (Akbank, Denizbank, Garantibank, Isbank, Vakifbank), build project pipelines, review loan requests, and verify project implementation. From June 2010 to January 2013, more than 450 million dollars were invested in sustainable energy projects through TurSEFF, curbing 650,000 tons of CO<sub>2</sub> emissions annually. In addition, energy efficiency and renewable energy projects saved about 1.5 TWh and 1.15 TWh per year, respectively. Furthermore, the participating Turkish banks and EBRD together are building a lasting relationship that will create a strong brand for sustainable energy finance and create new partnerships for financing larger projects.

Table 1-12 Examples of EBRD's support related to energy conservation and CO<sub>2</sub> reduction in steel

Year	Country	Content of support
2021	Turkey <sup>24</sup>	The EBRD is supporting an impact assessment study by the Turkish Ministry of Environment and Urban Development to facilitate an informed discussion on the financial implications and transitional risks for Turkish exporters to the EU. The EBRD's Mid-Size Sustainable Energy Financing Facility (MidSEFF) carbon market development support program provides support at 3 levels; (i) at the national level, by supporting the development of Turkey's carbon market by conducting policy dialogues and promoting initiatives that can further increase sovereign and private sector participation in domestic and international carbon markets, including advising the Turkish government on the impact of CBAM; and (ii) at the bank level, by supporting Turkish banks in developing carbon market services; and (3) at the project level, by supporting the carbon asset development process and providing technical assistance to renewable energy and energy efficiency projects financed by MidSEFF that are eligible for carbon finance.
2016	Poland <sup>25</sup>	The EBRD decided to provide a long-term loan of up to PLN 320 million (equivalent to 75 million euros) to convert the combined heat and power plant at the ArcelorMittal iron/steel works in Krakow owned by TAMEH Polska sp. z o.o. to gas-fired operation. The

<sup>23</sup> [https://c2e2.unepdtu.org/kms\\_object/turkish-sustainable-energy-financing-facility-turseff/](https://c2e2.unepdtu.org/kms_object/turkish-sustainable-energy-financing-facility-turseff/)

<sup>24</sup> <https://www.ebrd.com/news/2021/turkey-and-europes-planned-carbon-border-tax-.html>

<sup>25</sup> <https://www.ebrd.com/news/2016/ebrd-finance-conversion-of-tameh-power-plant-in-krakw.html>

Year	Country	Content of support
		conversion from coal to gas was expected to reduce greenhouse gas emissions by up to 200,000 tons annually and comply with European Union environmental requirements resulting from the Industrial Emissions Directive, which entered into force in Poland in the autumn of 2018.
2015	Turkey <sup>26</sup>	The EBRD is promoting efficiency improvement of the Turkish steel industry and has provided Erdemir and Isdemir with a loan of 75 million euros. The loan will be used to implement a series of energy efficiency improvement measures at the two iron/steel works, including investment in TRTs (blast furnace top pressure recovery turbines), which will lead to significant reductions in greenhouse gas emissions and energy costs. The following benefits are also expected; (1) demonstrate Erdemir's integrated approach to energy and resource efficiency to other Turkish steelmakers and industrial players as an important source of industrial competitiveness, and (2) Erdemir to contribute to the definition of strategic priorities for energy efficiency in the Turkish steel sector as part of a broader policy effort to develop a National Energy Efficiency Action Plan, which the EBRD is leading in collaboration with Turkey's Ministry of Energy and Natural Resources
2015	Slovenia <sup>27</sup>	The EBRD invested 8.5 million euros in bonds issued by SIJ-Slovenska Industrija Jekla d.d., Slovenia's largest producer of special steel, to support the modernization of Slovenia's steel sector. The project aims to reduce energy and water consumption, including the installation of AOD.
2009	Russia <sup>28</sup>	The EBRD will consider financing a comprehensive energy efficiency program (EEP) to be developed by NLMK (Novolipetsk Metallurgical Company) with the support of Russian and international experts. The EEP aims to (1) reduce energy use and related costs, (2) reduce greenhouse gas emissions, and (3) improve production quality. For the EEP, the EBRD will provide a loan of 125 million euros to NLMK, which will be used for the construction of a new heat and power supply system, the introduction of pulverised coal injection (PCI) in some blast furnaces, the expansion of gas turbines in all blast furnaces, the construction of a gas recovery unit in the converter plant.

<sup>26</sup> <https://www.ebrd.com/news/2016/ebrd-supports-turkeys-largest-steelmaker-erdemir-group-in-best-use-of-resources.html>

<sup>27</sup> <https://www.ebrd.com/news/2015/ebrd-supports-investments-in-slovenian-steel-sector.html>

<sup>28</sup> <https://www.ebrd.com/work-with-us/projects/psd/nlmk-.html>

Year	Country	Content of support
		In addition, as a technical cooperation, an energy review was conducted at NLMK.
2006	Ukraine <sup>29</sup>	The EBRD has proposed a working capital revolving loan of US\$ 40 million and a term loan of US\$ 45 million to ISTIL, an electric furnace steel manufacturer. The revolving loan will be used as working capital for increased production, while the term loan will be used for capital investments required to improve cost and energy efficiency and quality control for high value-added products, and to restructure existing debts. Investments in new technologies were expected to significantly improve energy efficiency, resulting in GHG reductions of 300,000 tons of CO <sub>2</sub> by 2012.

#### **1.4 Current Status and Future Prospects of Policies, Systems, and Technological Development by Companies Supporting Low- and Decarbonization of the Japanese Steel Industry**

##### **1.4.1 Energy conservation policies and the performance of the steel industry**

In Japan, the two oil shocks of the 1970s led to increased interest in energy conservation and accelerated promotion of energy efficiency and conservation in the industrial sector. As a result, as shown in Figure 1-20, Japan's energy consumption efficiency (primary energy supply/real GDP, where Japan = 1) has become one of the highest in the world.

<sup>29</sup> <https://www.ebrd.com/work-with-us/projects/psd/istil-restructuring.html>

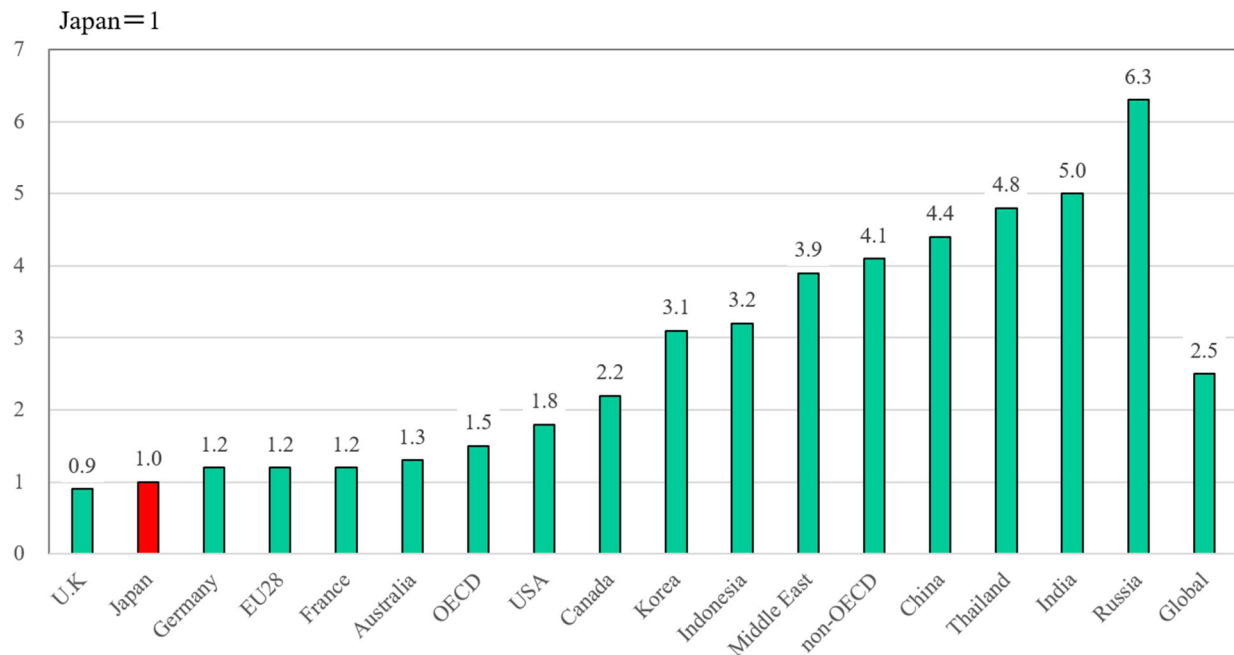


Figure 1-20 Comparison of energy consumption efficiency in each country (2016)

Source: [https://www.enecho.meti.go.jp/category/saving\\_and\\_new/saving/pdf/nihon\\_shouene\\_seisaku.pdf](https://www.enecho.meti.go.jp/category/saving_and_new/saving/pdf/nihon_shouene_seisaku.pdf)

The government enacted the Act on the Rational Use of Energy (Energy Conservation Act) in 1979 to require businesses to implement appropriate energy conservation measures. Under this Act, the government requires factory owners, transporters, and shippers to set standards for facility management and targets for improving energy consumption efficiency (1% per year), and businesses above a certain size to report on their energy use. If efforts are significantly inadequate, guidance, on-site inspections, support, publicity, orders, and penalties are imposed by the government. Due in part to the contribution of such a legal system, Japan has become an advanced country in the area of energy conservation (Figure 1-20). The steel industry has also achieved significant energy savings since the 1970s through aggressive capital investment. Figure 1-21 shows the total amount of investment in energy conservation and environmental protection in the steel industry.

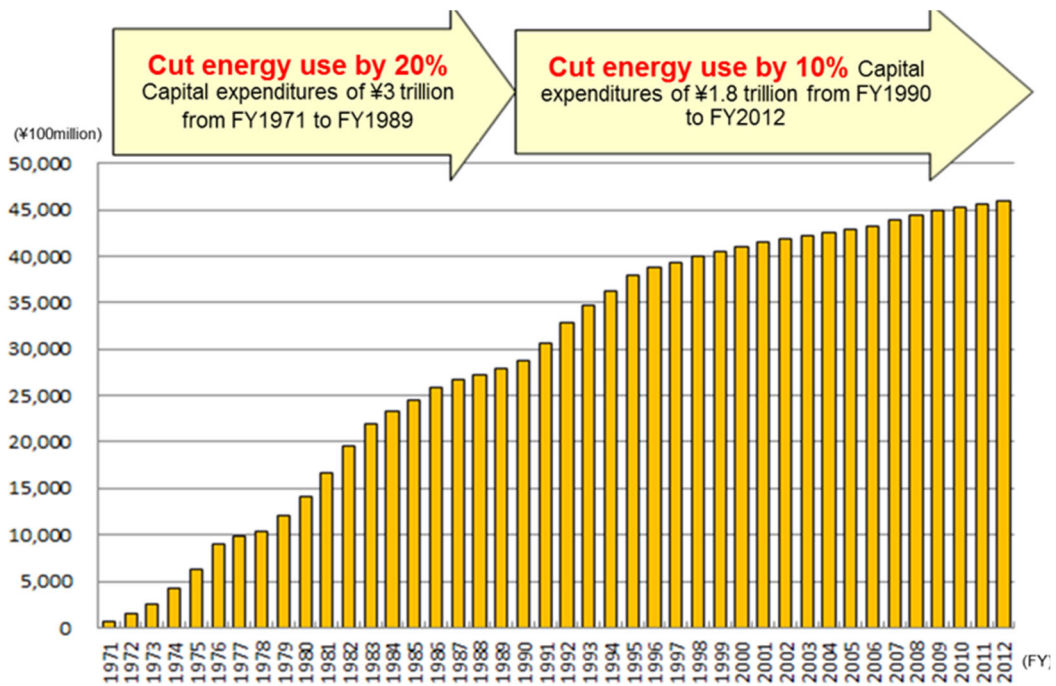


Figure 1-21 Cumulative investment in environmental and energy-saving technologies in the Japanese steel industry

Source: Materials from the International Environment Committee of the Iron and Steel Federation of Japan

Taking advantage of government subsidies for investment in energy-saving equipment, 3 trillion yen was invested from 1971 to 1989 to achieve 20% energy savings, and from 1990 to 2012, about 2 trillion yen was invested, achieving 12% energy savings.

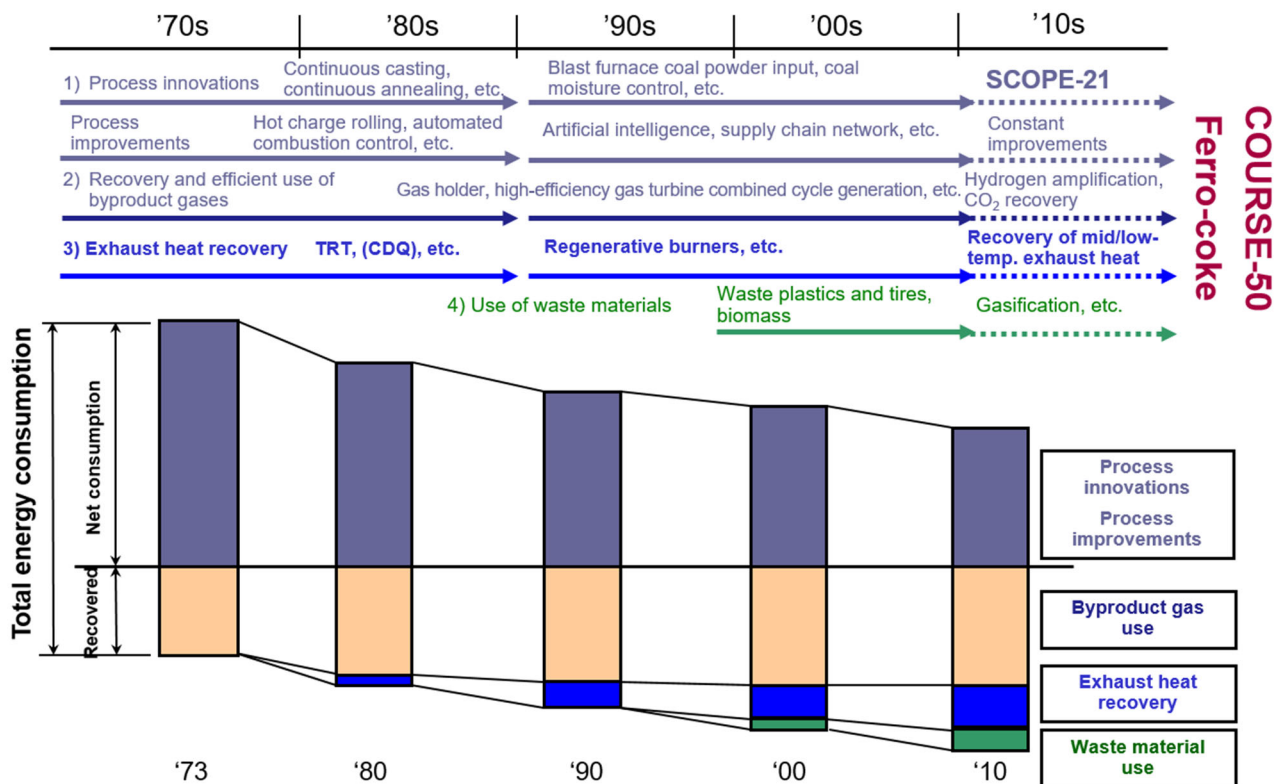


Figure 1-22 Trends in energy conservation efforts in the Japanese steel industry

Source: [https://www.jisf.or.jp/business/ondanka/kouken/keikaku/documents/2021\\_tekkouw\\_g\\_1.pdf](https://www.jisf.or.jp/business/ondanka/kouken/keikaku/documents/2021_tekkouw_g_1.pdf)

Figure 1-22 shows the transition of energy conservation efforts in the Japanese steel industry. As indicated by the figure, the Japanese steel industry has actively promoted energy recovery to reduce net energy consumption to the utmost limit, achieving the world's highest level of low energy intensity in steel production, and accumulating, refining, and developing various energy-saving technologies.

In 2018, the Research Institute of Innovative Technology for the Earth (RITE) published a report on the international comparison of energy efficiency in the steel industry (BF-BOF steel and EAF steel). Similar reports were published in 2005 and 2010, and it was found that the Japanese steel industry maintained the world's highest level of energy efficiency in 2015 (Figure 1-26). This is the result of Japanese steel industry's constant efforts to conserve energy.

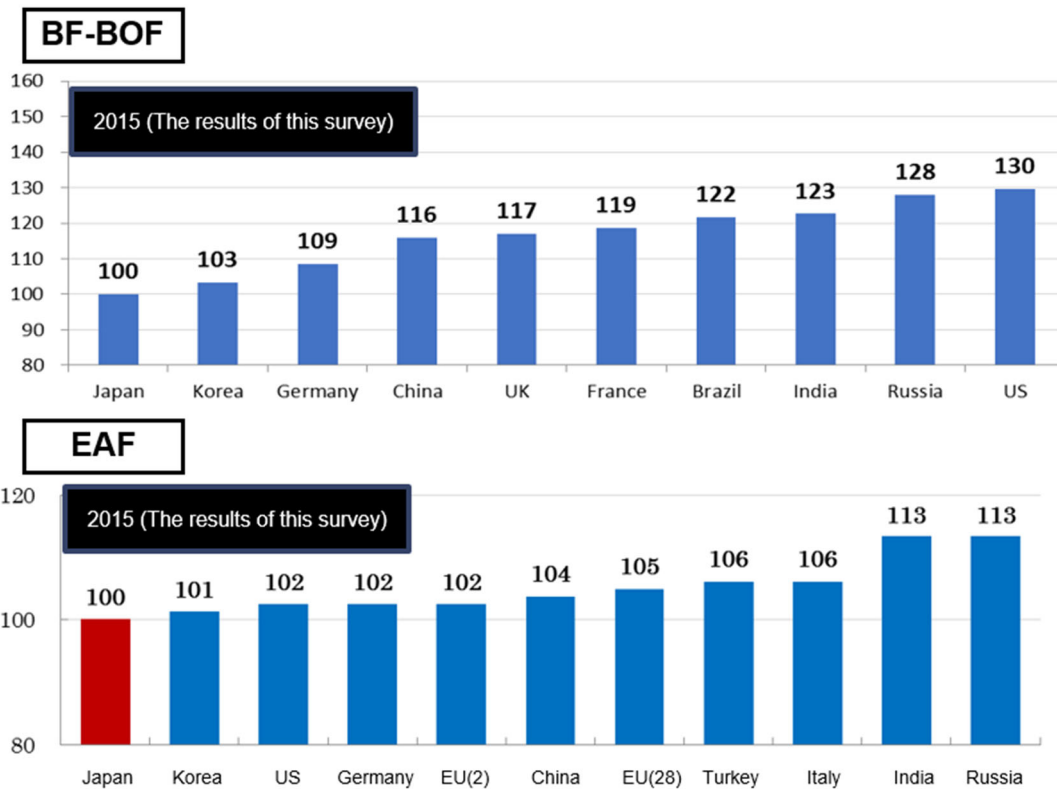


Figure 1-23 Comparison of energy efficiency in the global steel industry (2015, Japan=100)

Source: RITE “Estimated Energy Unit Consumption in 2015”

As mentioned above, Japan's energy-saving technologies are among the best in the world, and the Japanese steel industry, led by the International Environmental Strategy Committee of the Japan Iron and Steel Federation (JISF), has been promoting activities to reduce CO<sub>2</sub> emissions and conserve energy on a global scale (eco-solution activities) mainly by transferring these excellent energy-saving technologies to developing countries. In the eco-solutions activities, the three pillars of cooperation have been ① "steel plant energy efficiency diagnosis," in which the energy efficiency of equipment at local steel mills is evaluated and technical proposals contributing to energy efficiency are made; ② "public-private collaborative meetings," in which steel experts and government officials participate to promote corporate exchange and make policy proposals regarding the transfer of energy-saving technologies; and ③ "technologies customized list," a collection of recommended technologies for each country and region.

## Eco Solution: Global Contribution with Japanese Technologies

### Purpose

Contribute worldwide by transferring the world's most advanced energy-saving technologies to other countries

### Main Activities

#### ① Collaborative Meeting



Held in India and Japan by turn

Partnership

#### Public sector

Ministries and governmental institutions related to steel industry and energy saving

#### Private sector

Steel companies, engineering companies, consulting firms and industry association

#### ② Technologies Customized List



TCL for India ver.5



Technology Seminar

#### ③ Steel Plant Diagnosis



Diagnosis in India using ISO14404

Figure 1-24 Eco-Solution Activities by the Japan Iron and Steel Federation and the International Environmental Strategy Committee

Source: Japan Iron and Steel Federation

The Technologies Customized List (TCL), which is positioned as one of the pillars of eco-solutions activities, is a list of energy-saving and environmental equipment that includes the Best Available Technologies (BAT) tailored to the needs of each country (Figure 1-25). To date, two kinds, one for India and the other for ASEAN countries, have been developed, and their contents are periodically reviewed. When conducting energy efficiency and conservation diagnosis at iron/steel works in India and ASEAN countries, recommended technologies are selected from the TCL and proposed to each steel mill.

The TCL contains a list of recommended technologies, a page by page description of each technology in detail, and at the end of the document, a list of suppliers' contact information. The users of the TCL in the developing countries can contact the equipment manufacturers directly if there is any technology that interests them (Figure 1-26). It also shows the payback period and CO<sub>2</sub> emission reductions, taking into account electricity and energy prices, CO<sub>2</sub> emission coefficients, and other factors that vary from country to country.

TCL is a technology reference covering recommended technology for individual countries and regions. ASEAN and India version is available from JISF HP.

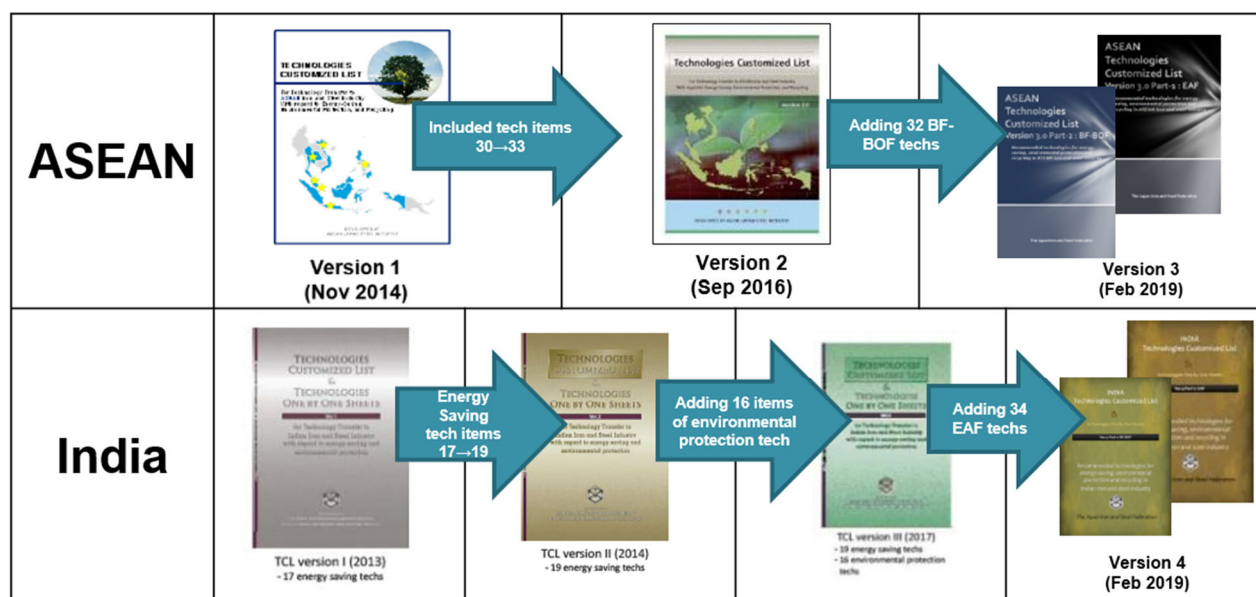


Figure 1-25 Technology customized list

Source: Materials from the International Environment Committee of the Iron and Steel Federation of Japan

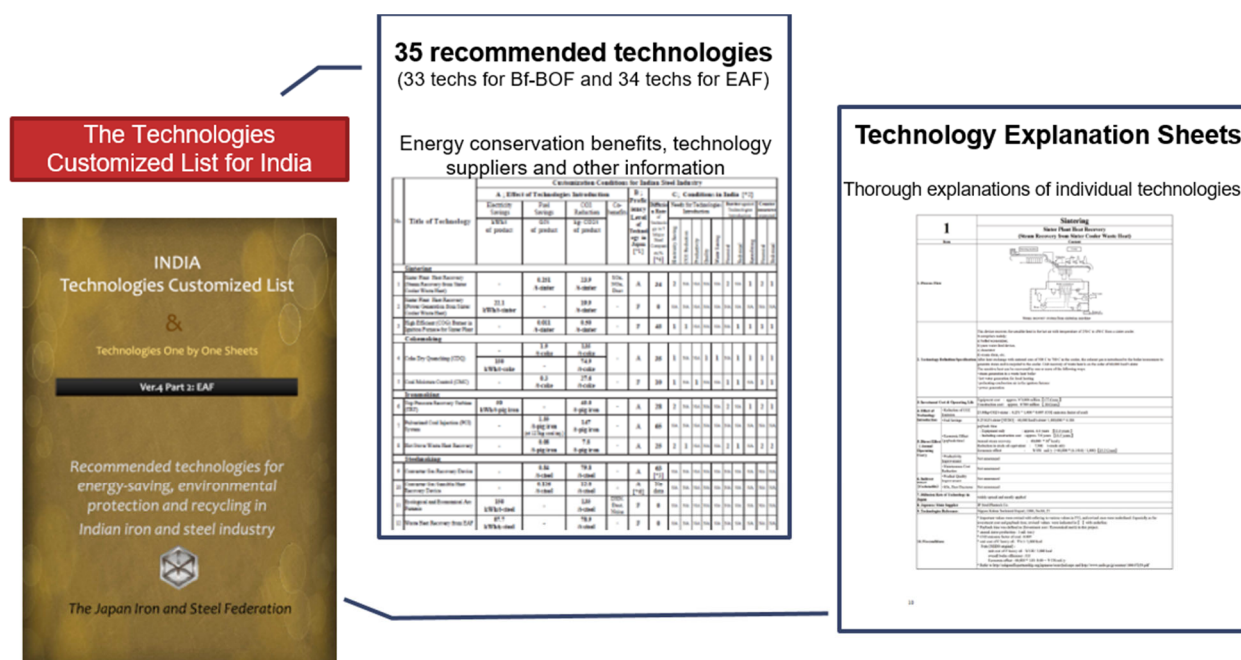


Figure 1-26 Details of the technology customized list

Source: Materials from the International Environment Committee of the Iron and Steel Federation of Japan

In 2020, a follow-up survey was conducted for blast furnace iron/steel works

in India which went through energy efficiency diagnosis of iron/steel works in the past, to confirm whether the equipment selected and recommended from TCL at the time of diagnosis had actually been installed and, if not, what the reasons were. The results are shown in Table 1-13, where "○" indicates that the equipment has been adopted after the diagnosis, "△" indicates that the equipment is being planned, and "×" indicates that there is no plan to introduce the equipment at present. Blank boxes indicate no target equipment or already installed equipment.

Table 1-13 Summary of survey on introduction of TCL technologies in blast furnace steel plants in India

○ : Adopted    △ : Planning    × : No plan

No.	Title of Technology	State-owned management					Private management				Result summary	
		A	B	C	D	E	F	G	H	I	No. of adoption/ proposals	No. of plans/ proposals
A-1	Sinter Plant Heat Recovery (Steam Recovery from Sinter Cooler Waste Heat)	○				△		×		×	1/4	1/4
A-2	Sinter Plant Heat Recovery (Power Generation from Sinter Cooler Waste Heat)		×	△	△		△		△		0/5	4/5
A-3	High Efficient (COG) Burner in Ignition Furnace for Sinter Plant	△	×			×			○		1/4	1/4
A-4	Coke Dry Quenching (CDQ)	○	○	△	△		○			×	3/6	2/6
A-5	Coal Moisture Control (CMC)											
A-6	Top Pressure Recovery Turbine (TRT)		○	×			○	○	△	○	4/6	1/6
A-7	Pulverized Coal Injection (PCI) System											
A-8	Hot Stove Waste Heat Recovery	○	○			○					3/3	0/3
A-9	Converter Gas Recovery Device			△				○		×	1/3	1/3
A-10	Converter Gas Sensible Heat Recovery Device	○	×	△	×	×	△				1/6	2/6
A-11	Ecological and Economical Arc Furnace											
A-12	Waste Heat Recovery from EAF								△	△	0/2	2/2
A-13	Rotary Hearth Furnace (RHF) Dust Recycling System											
A-14	Inverter (VVVF; Variable Voltage Valuable Frequency) Drive for Motors											
A-15	Regenerative Burner Total System for reheating furnace		×							○	1/2	0/2
A-16	Energy Monitoring and Management Systems											
A-17	Cogeneration (include Gas Turbine Combined Cycle (GTCC))	×									0/1	0/1
A-18	Management of Compressed Air Delivery Pressure Optimization											
A-19	Power Recovery by Installation of Steam Turbine in Steam Pressure Reducing Line											
Result Summary	No. of adoption/proposals	32.0%					41.2%				35.7%	
	No. of plans/proposals	32.0%					35.3%					33.3%

Overall, 36% of the technologies recommended at the time of the diagnosis had been adopted, and 33% were under consideration for adoption. Between state-owned and private-owned companies, the rate was higher for private-owned companies in terms of both adopted and planned, suggesting that private-owned

companies are more willing to invest in energy efficiency and conservation. In terms of technology, the adoption rate of CDQ and TRT, which are highly cost effective, was high. The most common reasons for not introducing the equipment were that it was not feasible financially and that the funds were insufficient. Other reasons included lack of cooperation from suppliers and the fact that the equipment was no longer needed due to the introduction of other equipment. The amount of CO<sub>2</sub> reduction due to the introduction of the equipment was estimated to be 1,845,000 tons/year for the adopted equipment and 1,645,000 tons/year for the planned equipment, in total 3,290,000 tons/year. As for the adopted facilities, CO<sub>2</sub> reduction amount was high in CDQ [No. A-4] (911,000 tons/year) and TRT [No. A-6] (421,000 tons/year), and as for the planned facilities, electric furnace exhaust heat recovery [No. A-12] (585,000 tons/year) and CDQ [No. A-4] (388,000 tons/year). This follow-up study has shown some of the results of the transfer of excellent energy-saving technologies promoted by the Japanese steel industry to developing countries and the resulting reduction in CO<sub>2</sub> emissions.

#### **1.4.2 Green Growth Strategy**

As mentioned in 1.1, it is indisputable that the widespread use of BAT, such as those listed in the TCLs, mainly in developing countries, is a very effective way to decarbonize the world in the next 10-20 years. However, in order to achieve complete carbon neutrality (CN), it is essential that developed countries take the lead in developing innovative technologies

In the past few years, the trend of the world as a whole aiming for CN by the middle of this century has quickly become a global consensus and is surging forward as a major wave. In other words, the era in which dealing with global warming as a constraint or cost to economic growth has ended, and we have entered an era in which it is seen as an opportunity for international growth. The "Green Growth Strategy" set forth by the Japanese government is seen as an industrial policy that will create a "virtuous cycle between the economy and the environment," in which a change in conventional thinking and the implementation of proactive measures will lead to a transformation of the industrial structure and the social economy, which in turn will lead to the next major growth.

The strategy sets high targets in 14 key industry sectors expected to grow over the coming years toward 2050 (Table 1-14), and mobilizes all policies, including budget, tax, finance, regulatory reform and standardization, and international cooperation.

### 1.4.3 Green Innovation Fund

The Green Innovation (GI) Fund, as described below, will be established to provide funds to subsidize the development of technologies that form each element of the Green Growth Strategy. The GI Fund, which will be able to contribute 2 trillions of yen by the 2030, will consist of 18 projects as described below. The Table 1-14 shows the relationship between the 14 key industrial sectors identified in the Green Growth Strategy and the project numbers of the GI Fund.

Table 1-14 Relationships between key areas of green growth strategy and green innovation (GI) projects

14 key industrial sectors in the green growth strategy		GI Project Number
1	Next generation renewable energy industry	①、②
2	Hydrogen and fuel ammonia industry	③、④、⑥
3	Next generation thermal energy industry	⑧
4	Nuclear industry	-
5	Next-generation automobiles and storage batteries industry	⑫、⑬、⑭
6	Semiconductor and information and communication Industry	⑮
7	Ship industry	⑰
8	Logistics, human flow, and civil infrastructure industries	-
9	Food, agriculture, forestry, and fisheries industries	⑱
10	Aircraft industry	⑲
11	Carbon recycling & materials industry	⑤、⑦、⑧、⑨、⑪
12	Housing, buildings, and next-generation power management industries	-
13	Resource recycling-related industries	⑩
14	Lifestyle-related industries	-

#### (1) Purpose of the GI Fund

The purpose of the GI Fund is as follows.

- ✓ CN by 2050 is an extremely difficult task and requires more ambitious challenges for innovation than ever before. For particularly important projects, a 2 trillion-yen "Green Innovation Fund" will be created in NEDO to provide comprehensive support from technology development to demonstration and social implementation to companies that have committed to take on the challenge of achieving ambitious and specific goals shared by the public and private sectors.
- ✓ Based on the implementation plan of this strategy, ambitious 2030 targets (performance, amount of introduction, price, CO<sub>2</sub> reduction rate, etc.) will

be set for priority fields that are essential to CN society and form the basis of industrial competitiveness, and ambitious research and development by companies that demonstrate their commitment to these targets will be continuously supported over the next 10 years.

- ✓ In order to make efficient and effective use of the Fund, the Green Innovation Project Subcommittee will be established to discuss the basic policy for managing and operating the entire Fund project, and to check the progress of the entire R&D project implemented with the Fund.
- ✓ At the time of adoption, the project implementing company shall submit a long-term business strategy vision (10-year innovation plan, organization of a team directly connected to management, etc.) in the relevant field under the commitment of top management.
- ✓ The management itself should be asked to clarify its commitment to persistently work on the project as a management issue, and to participate regularly in discussions to ensure the success of the project.
- ✓ Introduce mechanisms such as the cancellation of projects and partial return of commissioning fees in the case of insufficient efforts as a management issue, and incentive measures in which the government pays more according to the degree of achievement of targets.

## (2) GI Project

The current GI projects in 18 field are listed below (steel manufacturing related technology development is included in ⑤).

- ① Lowering the cost of offshore wind power
- ② Development of next-generation solar cells
- ③ Establishment of a large-scale hydrogen supply chain
- ④ Hydrogen production by water electrolysis using electricity derived from renewable energy sources, etc.
- ⑤ Utilization of hydrogen in steelmaking processes
- ⑥ Establishing a fuel ammonia supply chain
- ⑦ Development of technology to produce plastic materials using CO<sub>2</sub> and other substances
- ⑧ Development of fuel production technology using CO<sub>2</sub>, etc.
- ⑨ Development of technology for manufacturing concrete and other materials using CO<sub>2</sub>
- ⑩ Development of technologies for CO<sub>2</sub> separation and recovery
- ⑪ Development of CO<sub>2</sub> reduction technology for waste treatment
- ⑫ Development of next-generation storage batteries and next-generation motors
- ⑬ Development of in-vehicle computing and simulation technology for

energy saving in electric vehicles

- ⑭ Building a Smart Mobility Society
- ⑮ Building the Next Generation Digital Infrastructure
- ⑯ Development of next-generation aircraft
- ⑰ Development of next-generation ships
- ⑱ Development of CO<sub>2</sub> reduction and absorption technologies for food, agriculture, forestry, and fisheries

### (3) Green Innovation Project Subcommittee of the Industrial Science and Technology Council

In order to make efficient and effective use of the 2 trillion-yen Fund, the Industrial Science and Technology Council has decided to establish the GI Project Subcommittee. This subcommittee consists of three working groups (WGs) to discuss the basic policies for the overall management and operation of the Fund projects and to check the progress of R&D projects. The composition of this GI Project Subcommittee is shown in the following Figure 1-27

Green Innovation Project Subcommittee of the Industrial Science and Technology Council  
Chairperson : Mr. Kazuya MASU President, Tokyo Institute of Technology

<b>WG1 Field of promoting green power</b> Chairperson: Mr. Keigo AKIMOTO Chief Researcher	① Lowering the cost of offshore wind power ② Development of next-generation solar cells
<b>WG2 Energy Structural Transformation</b> Chairperson: Prof. Masao HIRANO Waseda University	③ Establishing of a large-scale hydrogen supply chain ④ Utilization of hydrogen through water electrolysis using electricity derived from renewable energy sources, etc. ⑤ Utilization of hydrogen in steelmaking processes ⑥ Establishing a fuel ammonia supply chain ⑦ Development of technology to produce plastic materials using CO <sub>2</sub> , etc. ⑧ Development of fuel production technology using CO <sub>2</sub> , etc. ⑨ Development of technology for producing concrete and other materials using CO <sub>2</sub> ⑩ Technology development for CO <sub>2</sub> separation and recovery ⑪ Development of technology to reduce CO <sub>2</sub> emissions from waste treatment
<b>WG3 Industrial structural transformation</b> Chairperson: Prof. Seikou SHIRASAKA Keio University	⑫ Development of next-generation storage batteries and next-generation motors ⑬ Development of in-vehicle computing and simulation technology for energy saving in electric vehicles ⑭ Building a smart mobility society ⑮ Development of next-generation digital infrastructure ⑯ Development of next-generation aircraft ⑰ Development of next-generation ships ⑱ Development of CO <sub>2</sub> reduction and capturing technology for food, agriculture, forestry and fisheries

Figure 1-27 Green Innovation Project Committee, Industrial Structure Council

Source: Created by NSRI based on

[https://www.meti.go.jp/shingikai/sankoshin/green\\_innovation/index.html](https://www.meti.go.jp/shingikai/sankoshin/green_innovation/index.html)

The following are the members of the Green Innovation Project Subcommittee of the Industrial Structure Council and the status of its meetings as of now.

(Chairperson) Kazuya Masu, President, Tokyo Institute of Technology

(Committee members) Motoshige Ito, Professor Emeritus, University of Tokyo Professor, Faculty of International Social Sciences, Gakushuin University

Hideo Ohno, President, Tohoku University  
Tsuyoshi Kokubu, Chairman, Sumitomo Mitsui Financial Group,  
Inc.

Mitsuie Kurihara, Chairman, Value Research Institute, Inc.  
Yasushi Sekine, Professor, School of Science and Engineering,  
Waseda University

Emi Tamaki, Founder of H2L Corporation, Associate Professor  
at Waseda University

Tomoko Nanba, Chairman and Representative Director, DeNA  
Corporation

Kazumi Miyajima, Commentator, News Department, Nippon  
Television Network Corporation

Status: February 22<sup>nd</sup>, 2021: 1<sup>st</sup> meeting  
March 4<sup>th</sup>, 2021: 2<sup>nd</sup> meeting  
April 6<sup>th</sup>, 2021 :3<sup>rd</sup> meeting  
August 17<sup>th</sup>, 2021: 4<sup>th</sup> meeting  
September 17<sup>th</sup>, 2021: 5<sup>th</sup> meeting  
December 14<sup>th</sup>, 2021: 6<sup>th</sup> meeting

#### 1.4.4 Current status and future prospects of technological development

##### (1) COURSE50 Project

The New Energy and Industrial Technology Development Organization (NEDO) has been implementing the "Environmentally Harmonious Process Technology Development: COURSE50 Project" to reduce CO<sub>2</sub> emissions in the steelmaking process since FY2008<sup>30</sup>. This project aims to develop a technology to reduce CO<sub>2</sub> emissions from blast furnaces by amplifying the hydrogen contained in the high-temperature coke oven gas (COG) generated during coke production and using the hydrogen to reduce iron ore as a partial substitute for coke (technology to reduce CO<sub>2</sub> emissions from blast furnaces) and a technology to separate CO<sub>2</sub> from blast furnace gas (BFG) using unused waste heat in iron/steel works (technology to separate and recover CO<sub>2</sub> from BFG). This is the development<sup>31</sup> of an innovative technology that will contribute to the reduction of CO<sub>2</sub> emissions from the steel industry by approximately 30% (CO<sub>2</sub> reduction by hydrogen utilization: 10%, CO<sub>2</sub> reduction by CO<sub>2</sub> separation and recovery: 20%).

The concept of research and development and the development schedule of this project are shown in Figure 1-28.

<sup>30</sup> <https://www.course50.com/>

<sup>31</sup> [https://www.jisf.or.jp/business/ondanka/kouken/keikaku/documents/2021\\_tekkouw\\_g1.pdf](https://www.jisf.or.jp/business/ondanka/kouken/keikaku/documents/2021_tekkouw_g1.pdf)

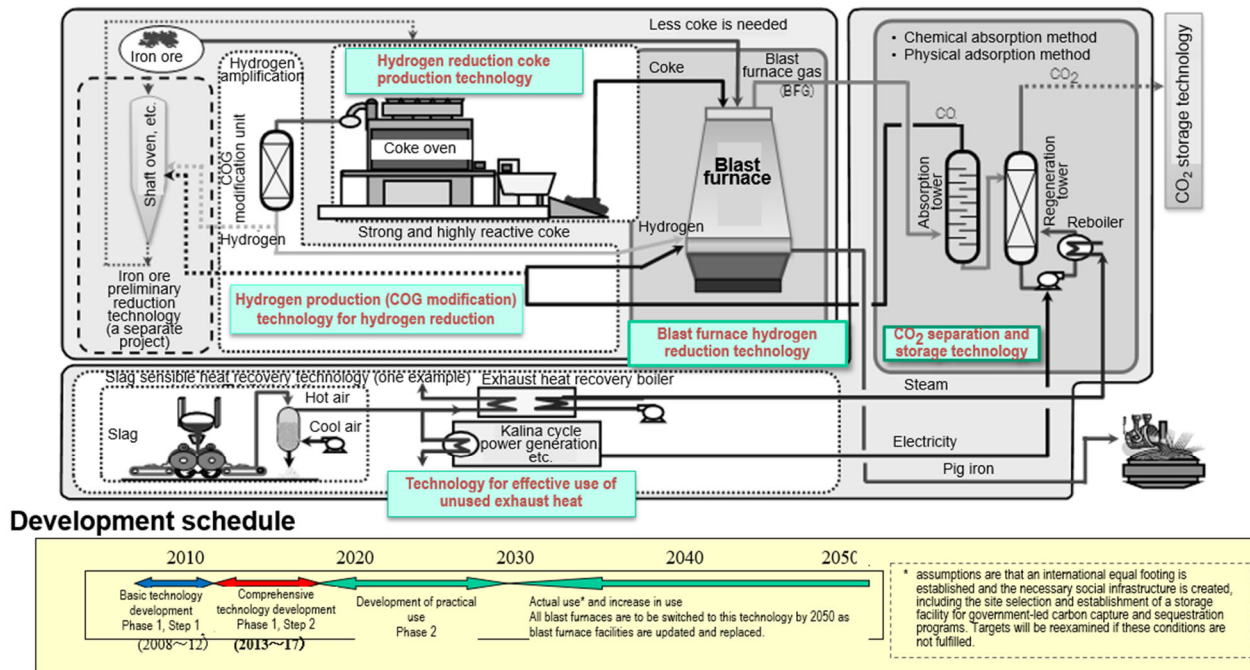


Figure 1-28 Conceptual diagram of the COURCE50 project

Source: [https://www.jisf.or.jp/business/ondanka/kouken/keikaku/documents/2021\\_tekkouw\\_g\\_1.pdf](https://www.jisf.or.jp/business/ondanka/kouken/keikaku/documents/2021_tekkouw_g_1.pdf)

It is positioned as a transition technology in the Zero Carbon Steel project of the Iron and Steel Federation of Japan, which will be described later, and research is being conducted intently with the aim of commercializing it in 2030 (to be implemented from next year using the GI Fund).

## (2) Long-term global warming countermeasures vision announced by the Iron and Steel Federation of Japan

In response to the Paris Agreement adopted in 2015, which set the goal of "limiting the rise in global average temperature to well below 2 degrees Celsius compared to pre-industrial levels, and pursuing efforts to limit the rise to 1.5 degrees Celsius," the Japan Iron and Steel Federation (JISF) has formulated and announced its "Long-term vision for climate change mitigation: A challenge towards Zero-carbon Steel" in November 2018, which aims to eventually achieve zero CO<sub>2</sub> emissions from steel for 2030 and beyond. The vision shows the likelihood of achieving the 2 degrees Celsius scenario in steel production and the necessity of super-innovative technologies for the 1.5 degrees Celsius scenario.

The Long-Term Vision by JISF outlines a roadmap for Japan's steel industry to eventually achieve zero CO<sub>2</sub> emissions in steel production. This roadmap is a step up from the aforementioned COURSE50 project, which is already under steady development, to Super COURSE50, which aims for the lowest possible CO<sub>2</sub> emissions from blast furnaces, and then to hydrogen reduction steelmaking,

the ultimate zero CO<sub>2</sub> emission steelmaking technology (Figure 1-29 ).<sup>32</sup>

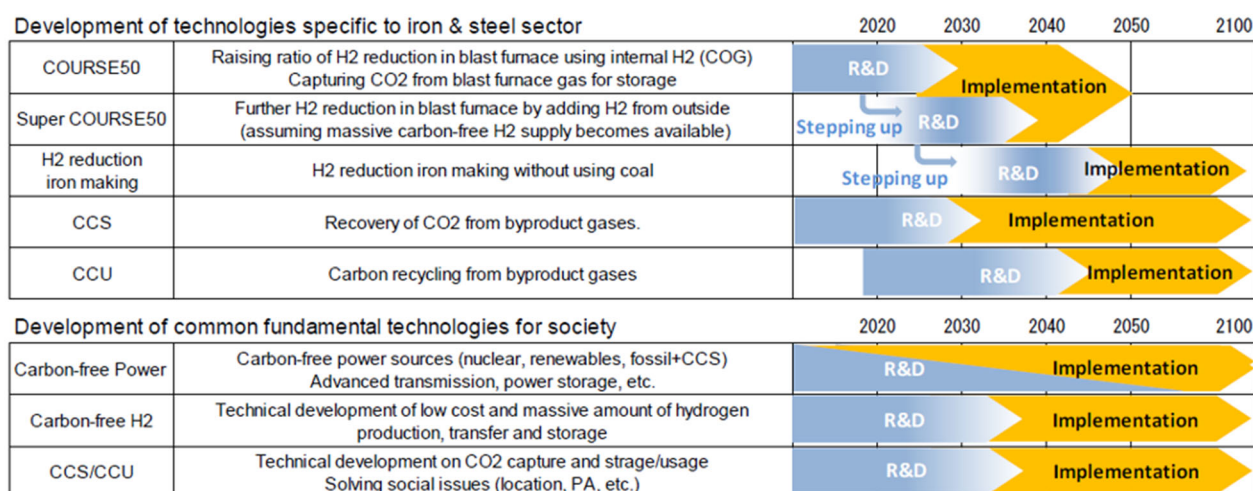


Figure 1-29 Roadmap for the development of innovative new technologies

Source: [https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/documents/zerocarbon\\_steel\\_honbun\\_JISF.pdf](https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/documents/zerocarbon_steel_honbun_JISF.pdf)

For reference, the total global CO<sub>2</sub> emissions under each scenario of this vision are shown in Figure 1-30. As can be seen from this figure, the emergence of multiple super-innovative technologies is essential to achieve carbon neutrality.

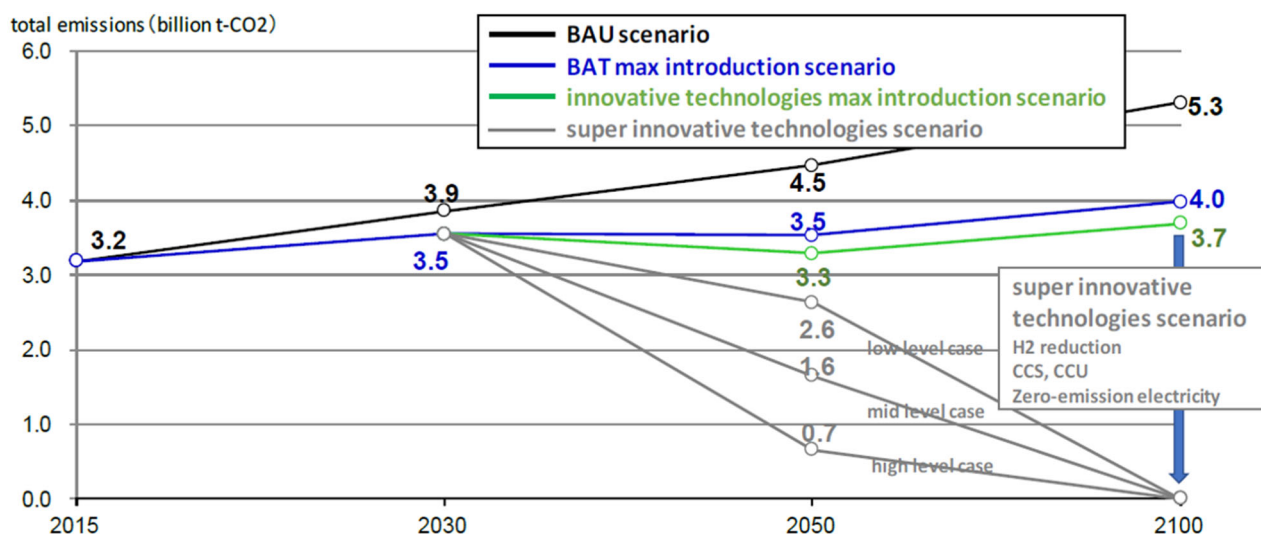


Figure 1-30 Trends in CO<sub>2</sub> emissions under long-term climate change scenarios

Source: [https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/documents/zerocarbon\\_steel\\_honbun\\_JISF.pdf](https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/documents/zerocarbon_steel_honbun_JISF.pdf)

The Long-Term Vision estimates that the demand (production) for crude steel will also increase (2050: 2.68 billion tons, 2100: 3.79 billion tons) as the demand for steel increases in the future (Figure 1-31). Although the generation of waste scrap will increase due to the expansion of steel accumulation, and the overall

<sup>32</sup> <https://www.zero-carbon-steel.com/>

use of scrap will increase (2050: 1.55 billion tons, 2100: 2.97 billion tons), the overall demand for crude steel cannot be met by scrap alone. Therefore, pig iron production using natural resources is expected to be 1.20 billion tons in 2100, about the same as today.

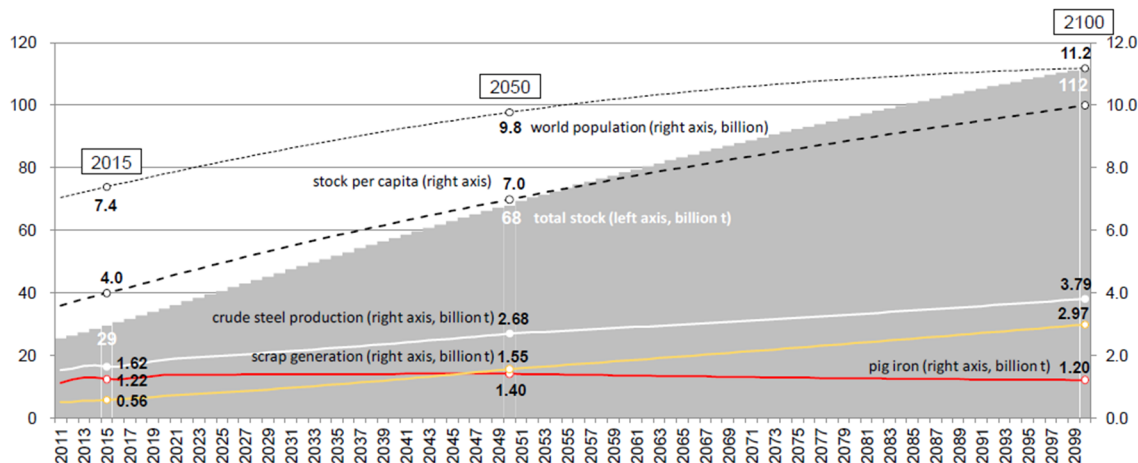


Figure 1-31 Assumption for steel accumulation and steel production (2011~2100)

Source: [https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/documents/zerocarbon\\_steel\\_honbun\\_JISF.pdf](https://www.jisf.or.jp/business/ondanka/zerocarbonsteel/documents/zerocarbon_steel_honbun_JISF.pdf)

## 2. Analysis of current situation, understanding of issues, and consideration of cooperation programs for priority candidate countries for cooperation

Based on the results of the domestic desk-top study, 6 countries were selected as candidate for cooperation, as these countries are likely to achieve a certain level of energy efficiency and conservation through energy efficiency and conservation measures in the steelmaking sector.

Table 2-1 shows the crude steel production and apparent steel consumption (= production + imports - exports) of the candidate countries for the survey (first draft), as well as the percentage of CO<sub>2</sub> emissions from the steel industry in each country, based on the macro-estimate by the survey team (see 1.2 for details). In this study, the degree of impact of CO<sub>2</sub> emissions on the steel industry and the future potential of the steel industry are important perspectives in narrowing down the countries to be surveyed. The percentage of CO<sub>2</sub> emissions from the steel industry is around 10% for Turkey and Vietnam, indicating that the impact on the country is significant. This is followed by India at around 5% and Mexico at around 3%, indicating that the impact of the steel industry cannot be ignored in these countries. For countries below Indonesia, the impact of the steel industry is small (The impact is in the 2% range in Bangladesh, but its crude steel production is an estimate by worldsteel, so its accuracy is questionable).

On the other hand, in Indonesia and Thailand, the impact of the steel industry on CO<sub>2</sub> emissions is currently small, but the apparent consumption of steel products is comparable to that of Turkey and Vietnam, and the steel industry is expected to develop in the future because new and additional iron/steel works are planned. In light of the above, Malaysia, Egypt, the Philippines, and Bangladesh were excluded from the survey considering the impact of the steel industry on CO<sub>2</sub> emissions and the country's future potential of the steel industry.

Table 2-1 Crude steel production, steel apparent consumption, and steel industry CO<sub>2</sub> emission rate in the candidate countries (first draft) for the study (2019)

	Crude steel total (thousand tons)				Apparent Consumption (thousand tons)			Percentage of CO2 emissions from the steel industry (%) [macro-estimate by the research team]	
	Blast Furnace	Electric Furnace	Others		Production	Export	Import		
India	48,680	62,678	0	111,358	104,062	13,356	8,921	99,627	4.7% ~ 5.7%
Turkey	10,859	22,884	0	33,743	33,679	19,660	12,337	26,356	8.7% ~ 10.5%
Vietnam	9,746	4,925	2,798	17,469	15,401	5,213	15,432	25,620	10.6% ~ 13.0%
Mexico	4,242	14,145	0	18,387	18,131	5,142	11,542	24,531	3.3% ~ 3.9%
Indonesia	3,190	4,593	0	7,783	10,890	3,964	13,454	20,380	1.2% ~ 1.5%
Thailand	0	4,246	0	4,246	7,756	1,654	16,745	22,847	0.6% ~ 0.7%
Malaysia	720	6,100	0	6,820	5,304	5,159	7,372	7,517	1.2% ~ 1.3%
Egypt	184	7,073	0	7,257	8,422	1,162	592	7,852	1.5% ~ 1.7%
Philippines	0	1,915	0	1,915	4,727	39	7,214	11,902	0.4% ~ 0.4%
Bangladesh	0	5,100	0	5,100	0	5	3,040	3,035	2.2% ~ 2.5%

Source: Compiled by the research team based on "Steel Statistical Yearbook 2020," worldsteel.

## 2.1 Study of Cooperation Programs

In parallel with the selection of candidate priority countries, the elements of cooperation activities that can be implemented or studied under the cooperation program were arranged as a general menu to contribute to study of a cooperation program for realizing energy savings, low carbon and decarbonization in the iron and steel industries of the target country.

The draft of the general menu was broadly divided into the three aspects; “Technology,” “Finance,” and “Policy.” “Technology” was further divided into “Soft” (i.e., technical guidance that does not require capital investment, introduction of systems and management, etc.) and “Hard” (measures for realizing energy saving, low carbon and decarbonization by equipment improvement, centering mainly on capital investment) aspects.

The proposed menu shown in Figure 2-1 consists of items which are considered possible to offer at present, focusing on the energy saving, low carbon and decarbonization fields in the iron and steel industry. However, the program will be studied considering the needs, areas with future potential, and resources of the countries, including confirmation of actual needs based on coordination with the relevant organizations in each country, and the team organization at project formation. .

As shown in the proposed image in Figure 2-2, multiple elements will be combined to create a program that provides comprehensive support with high total effectiveness so as to contribute to energy saving, low carbon and decarbonization in the iron and steel industry and in industry as a whole in the target country and its neighboring countries and regions.

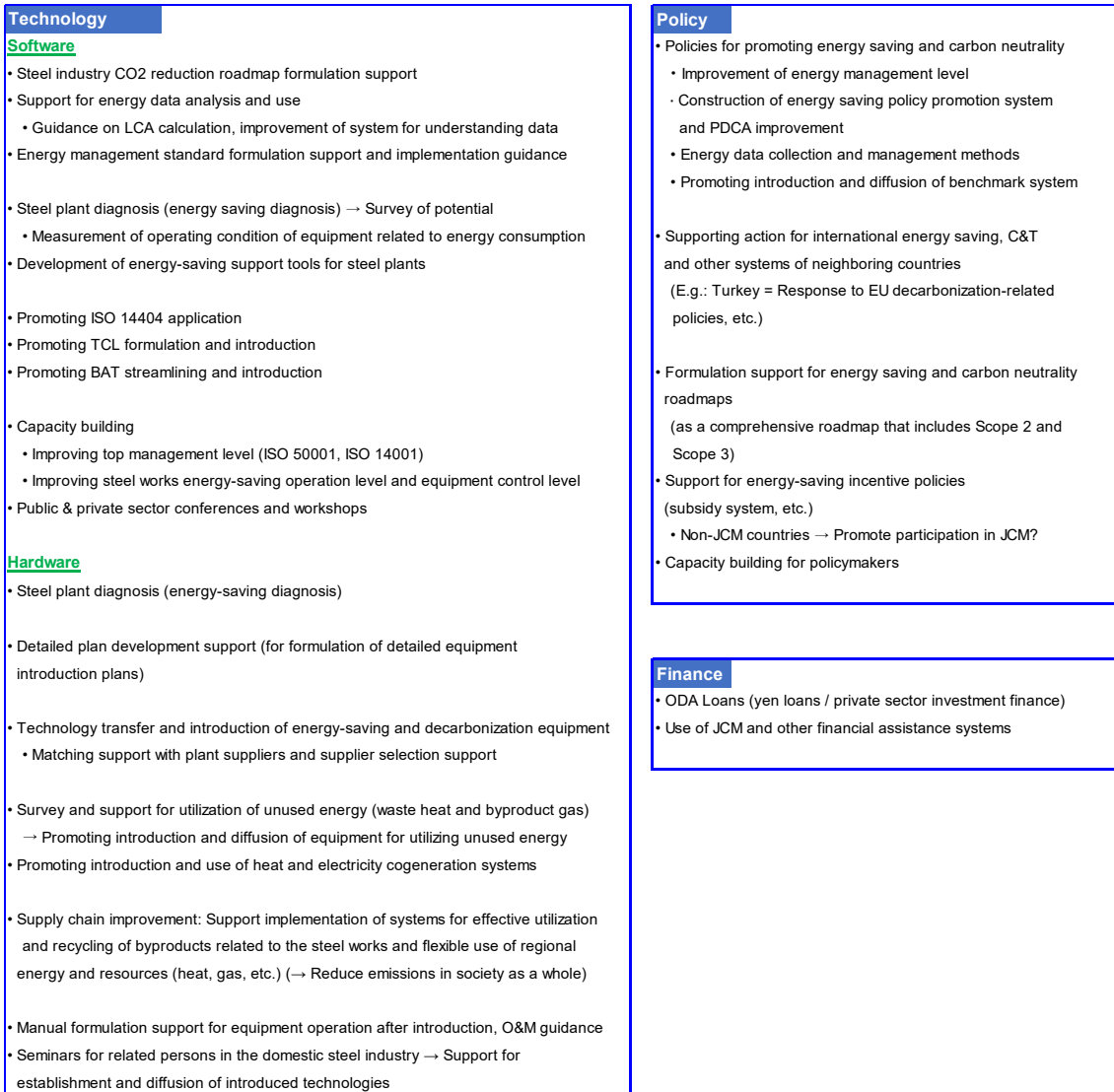


Figure 2-1 General menu (draft) of activities for study in the cooperation programs

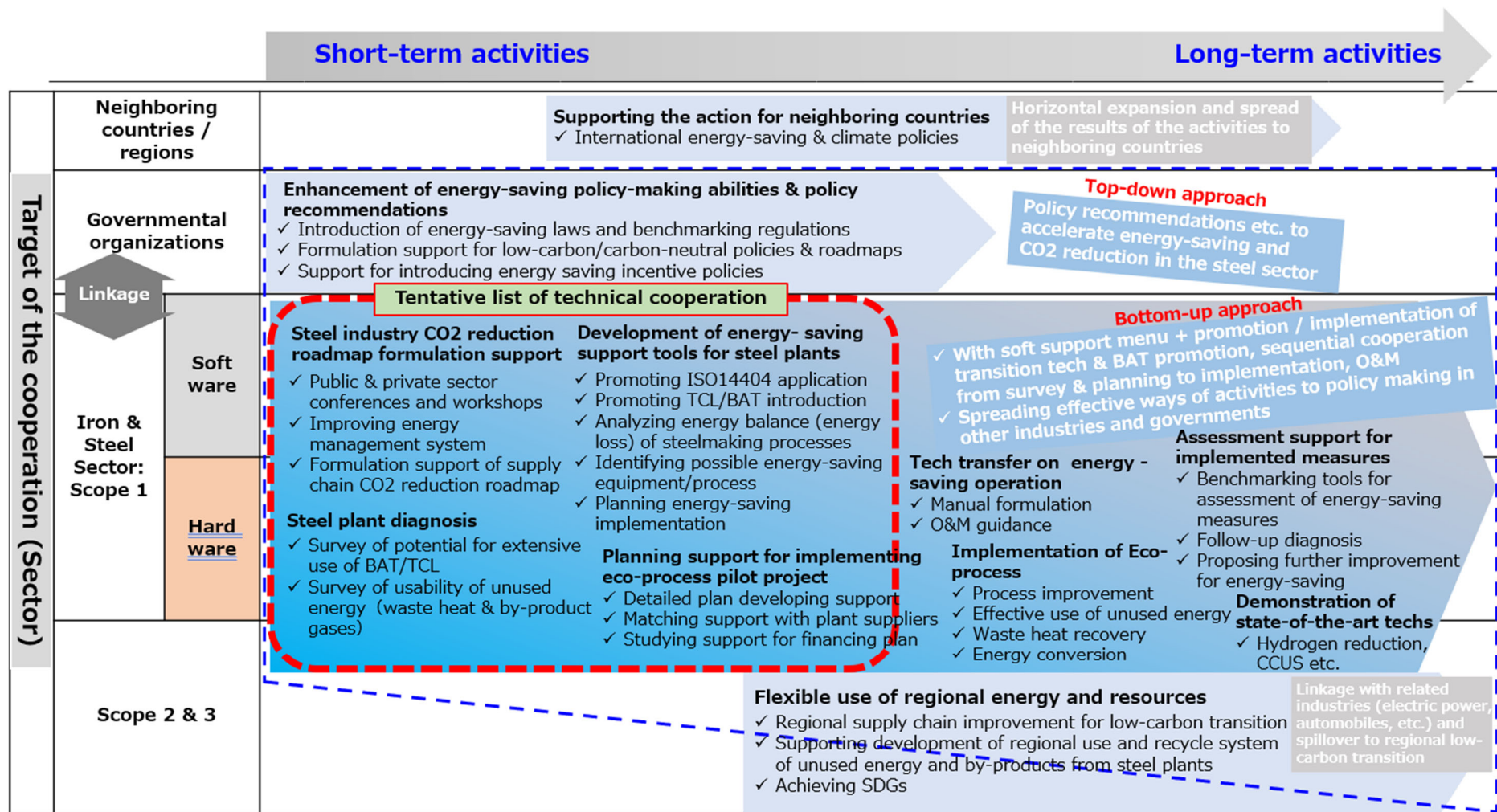


Figure 2-2 Time-series image of technical cooperation program

The following presents an overview of the main elements of the proposed menu in Figure 2-1. Not limited to these items, it is considered necessary to formulate a cooperation program that combines support measures which are expected to be both feasible and highly effective based on the needs and views of the target country. As used here, whether an activity is “highly effective” or not is determined by comparing the input resources, that is, the cost, time and human resources necessary to implement the cooperation, and the outputs and outcomes, that is, the CO<sub>2</sub> reduction and cost-related merits for the target country, relative to those inputs.

### **2.1.1 Main Technical Cooperation Activities (Soft aspects)**

In the technical aspect, “soft” type activities center on improvement of the environment for promoting energy saving (institution and systems, etc.), analysis of the actual condition of energy use in the iron and steel industry and individual iron/steel works, providing or sharing information through conferences and workshops, and similar activities which do not involve a large financial investment like that required for capital investment.

- ✓ **Support for energy data analysis and utilization**

An accurate understanding of the current condition of energy consumption is the basis for energy-saving activities in the target country. Therefore, if an adequate understanding of the energy consumption (energy balance) in steelmaking processes is not possible, this activity will support the creation of a basic environment for collecting and analyzing energy data. This also includes capacity building, for example, developing the capacity to use obtained data to identify equipment and processes with the potential for energy saving.

- ✓ **Support for formulation of steel industry CO<sub>2</sub> reduction roadmap**

This activity will provide support for designing a timeline for CO<sub>2</sub> reduction in the iron and steel industry based on the policies of the target country’s government and steel industry association, the requirements of the market, etc. Where a roadmap already exists in the target country, the challenges and problems of that roadmap will be discussed with the counterparts, future improvement measures will be studied, and the breakdown into specific measures, etc. will be analyzed.

Because the iron and steel industry consumes large amounts of energy and raw materials, it is possible to contribute to CO<sub>2</sub> reduction in industry as a whole by formulating and implementing mid- and long-term plans for CO<sub>2</sub> through the total supply chain of the steel industry, and not simply within

an iron/steel works.



Figure 2-3 Image of formulation of supply chain CO<sub>2</sub> reduction roadmap

- ✓ Support for formulation of energy management standards and implementation guidance

Energy management standards correspond to the operating manuals for energy-consuming equipment. In Japan, the “Act on the Rational Use of Energy” (popular name: “Energy Conservation Act”) requires those who conduct businesses that use energy to prepare and implement energy saving standards in accordance with the “evaluation standards.” If the target country does not have a similar legal system, the purpose of this activity will be to eliminate or improve waste, irrational use and variations in the operation of the iron/steel works by formulating energy management standards and implementing those standards by establishing manuals. As an expected benefit, continued equipment operation in accordance with these

standards will have an energy-saving effect through operational improvement, without requiring capital investment.

✓ Development of energy-saving support tools for iron/steel works

The aim of this activity is to contribute to the formulation of energy-saving measures by developing energy-saving support tools that enable simple, quantitative analysis of equipment and processes with the potential for energy savings in an iron/steel works, based on the operating conditions, equipment specifications and actual energy balance (energy loss) in the iron/steel works, and encouraging widespread use in the target country through seminars, etc.

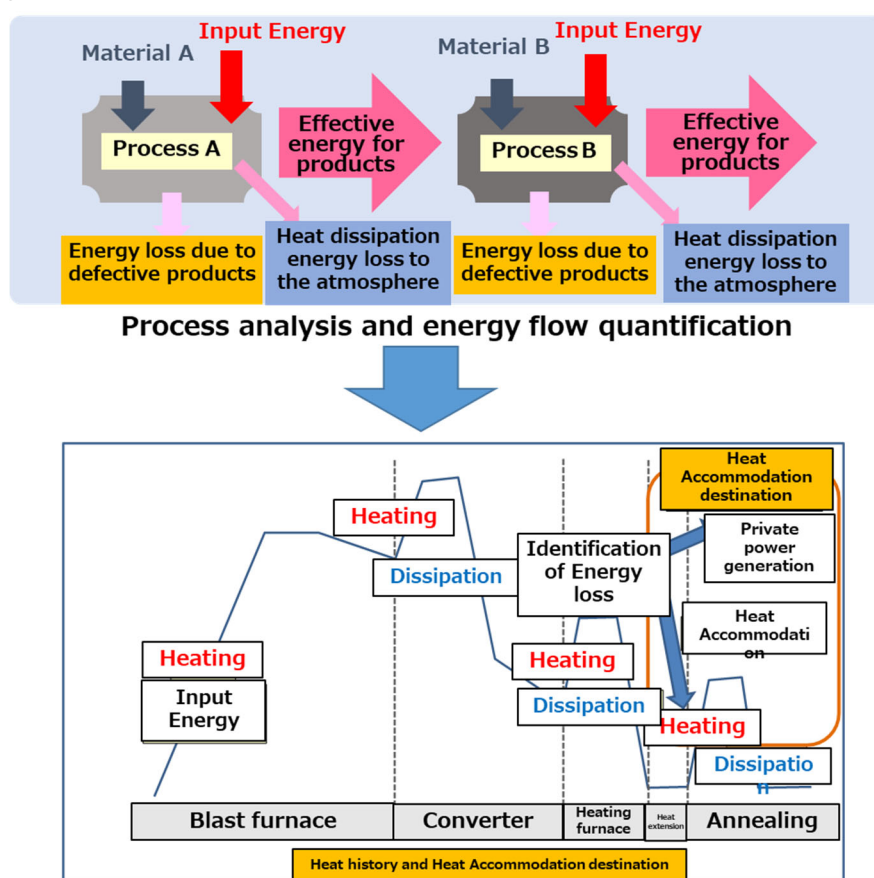


Figure 2-4 Image of analysis by developing energy-saving support tools for iron/steel works

✓ Promoting ISO 14404 application

ISO 14404 ("Calculation method of carbon dioxide emission intensity from iron and steel production"), which was established under Japanese leadership, is an international standard which contributes to energy saving and CO<sub>2</sub> reduction in the iron and steel industry. It has now been released up to Series 4. Application of ISO 14404 enables simple evaluation of the energy saving potential of an iron/steel works based on the amounts of energy input and outputs at the works concerned, and makes it possible to

grasp the actual status of energy consumption and CO<sub>2</sub> emissions in iron/steel works and analyze the possibility of energy saving and CO<sub>2</sub> reduction. The aim of this activity is to encourage application of these international standards through seminars, workshops and other activities in the target country.

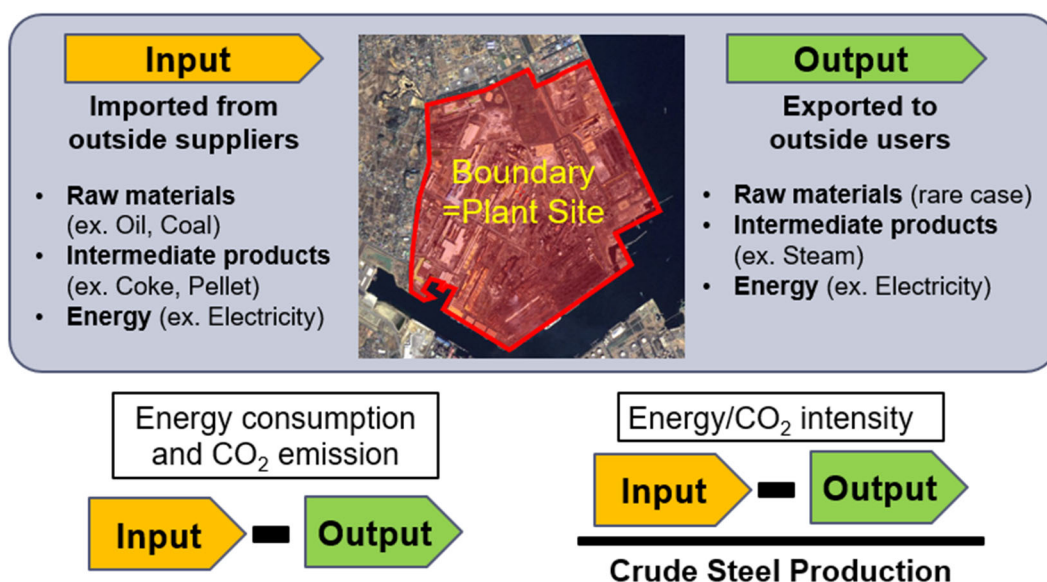


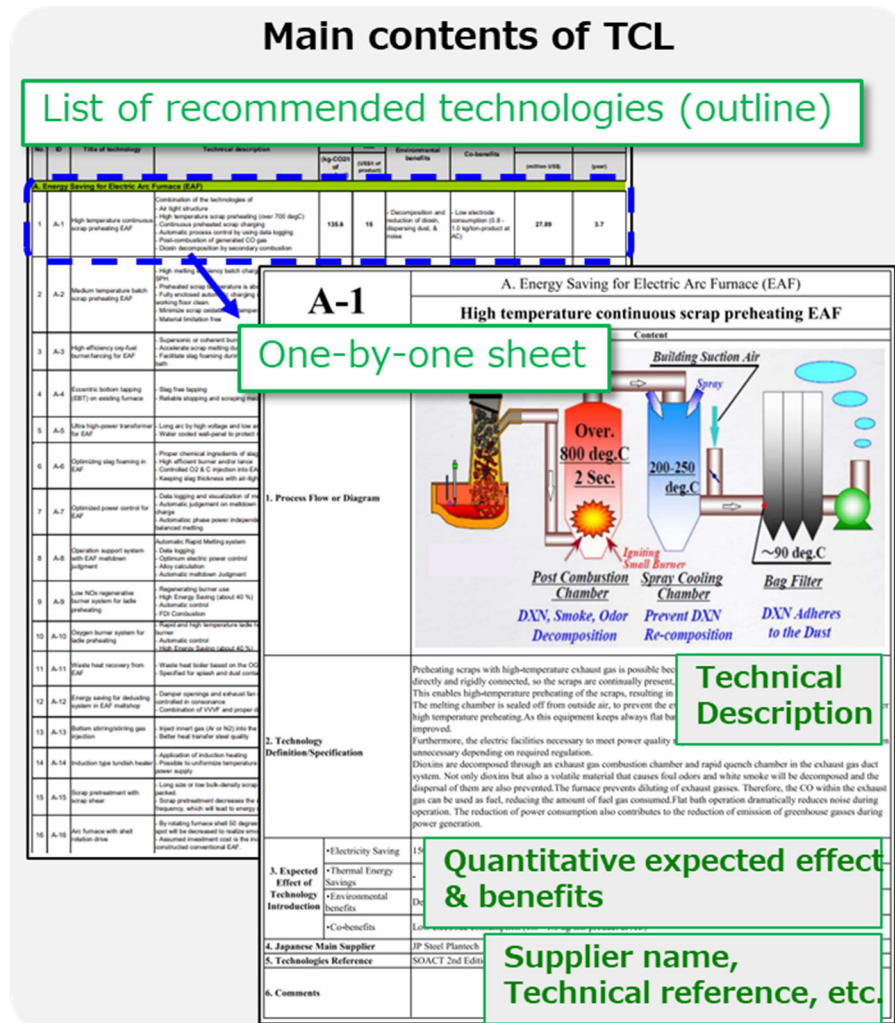
Figure 2-5 Evaluation items of ISO 14404

✓ Promoting TCL formulation and introduction

TCL (Technologies Customized List) is a list summarizing the energy-saving technologies available for application in the iron and steel industry. The content includes an outline of the recommended technologies and their quantitative energy-saving effects, and information on suppliers that can provide the technology. TCLs for India and ASEAN have been issued by the Japan Iron and Steel Federation. These TCLs include a blast furnace edition and electric arc furnace edition, and the information is updated and revised as necessary.

High priority energy-saving technologies which should be introduced at the respective plants in each iron/steel works can be identified by using the TCL.

TCL will be formulated in line with the needs and issues related to energy saving in the target country, and introduction will be promoted through seminars and workshops.



review of the results.

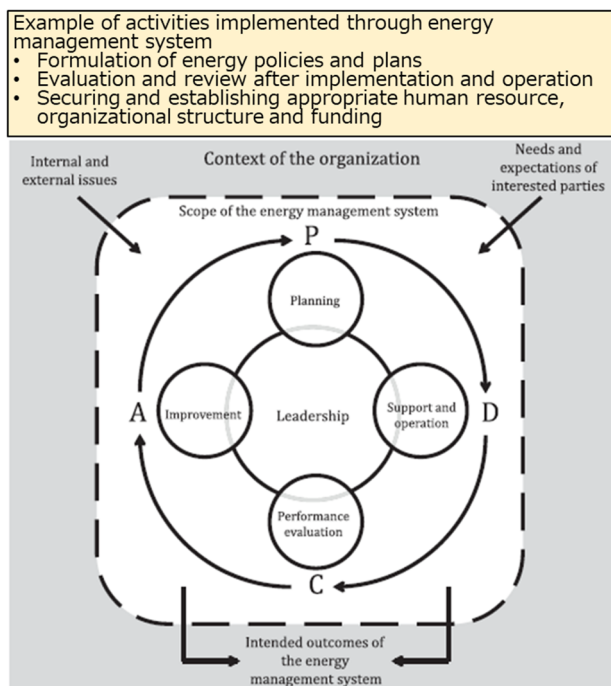


Figure 1 — Plan-Do-Check-Act Cycle

Figure 2-7 Improvement of the management level through the PDCA cycle (ISO 50001)

✓ Public & private sector conferences and workshops

As part of overseas cooperation in eco-solution activities, the Japan Iron and Steel Federation provides information and conducts bilateral information exchanges on energy-saving efforts, technical information, etc. by holding public and private sector conferences and workshops in cooperation with government agencies, the iron and steel association and other related parties in the target countries. The information exchanges and discussions in these conferences and workshops are expected to provide suggestions for future efforts by government agencies, iron/steel works, etc.

By holding conferences (meetings) of this kind with the target countries, it is considered possible to provide information that will contribute to energy saving in the iron and steel industry of the target countries, and to identify additional activity needs through discussions.



Figure 2-8 Past public & private collaborative conferences on the iron and steel industry

In addition, guidance on improving operations at steel plants can be considered as a cooperation activity. Operational improvement does not require large capital investment cost.

The following are examples of the energy saving measures centered on improving operations at steel plants (for EAFs and reheating furnaces). For EAFs, the examples of energy saving methods are shown as below. Basically, the amount and rate of reduction depends on the furnace size, temperatures of furnace and the type of steel produced etc.

- Reduction of heat loss by shortening Tap to Tap Time (TTT)
- Pre-treatment scrap to increase bulk density, thereby shortening TTT by reducing the number of scrap charges
- Closing slag door during smelting process

For reheating furnaces, the examples of energy saving methods are shown as below.

- Air ratio adjustment (e.g. when air ratio is changed from 1.30 to 1.10, then thermal energy consumption declines by 13-14 % at the reheating furnace)
- Air temperature adjustment (e.g. when temperature changes from 300degC to 500degC, then thermal energy consumption declines by about 10%)
- Oxygen enrichment for combustion air (e.g. oxygen is increased from 21% to 39%, then thermal energy consumption declines by 18-19%; while electric consumption increases by generating oxygen)

These are widely known (particularly in Japan) as the operational measures for energy saving. However, in this case, careful study would be necessary because operational know-how has a strong aspect as confidential industrial property of each steel mill, and would be difficult to provide in

view of the global competitive environment of the steel industry.

### **2.1.2 Main Technical Cooperation Activities (Hard)**

The hard aspect of technical cooperation activities centers on transfer of energy saving technologies possessed by the Japanese steel industry. These activities also include identification and designation of target technologies by energy-saving diagnosis and site surveys, support for formulation of plans for technology transfer, follow-up on operation after introduction, and support to promote introduction and ensure that the technologies become firmly established in the target country. In other words, comprehensive support, not limited to simple “sale” of Japanese technologies, is important.

✓ **Diagnosis of iron/steel works (energy-saving diagnosis)**

Iron/steel works in the target country are selected, an energy-saving diagnosis is conducted, and technologies with a high energy-saving effect are proposed in this activity. In making the proposal, the cost effectiveness, etc. is also presented based on a rough estimation of the equipment cost. At the same time, measures which do not require a large capital investment, such as operational improvements, will also be presented.

By receiving this diagnosis, iron/steel works can obtain suggestions for planning and implementing energy-saving measures after the diagnosis based on the recommendations and objective evaluation by experts from Japan. Moreover, although the target of this diagnosis is energy saving, it may also contribute to productivity and quality improvement.

To date, the Japan Iron and Steel Federation has conducted a large number of iron/steel works energy-saving diagnoses in India and the ASEAN countries. In the past, these plant diagnoses were carried out at the site and required a period of about 1 week per iron/steel works, from interviews with local engineers and the site survey to the meeting to report the diagnosis results on the final day. However, during fiscal year 2021, energy-saving diagnoses were performed online on a trial basis, as it was difficult to travel to the site due to the Covid-19 pandemic.

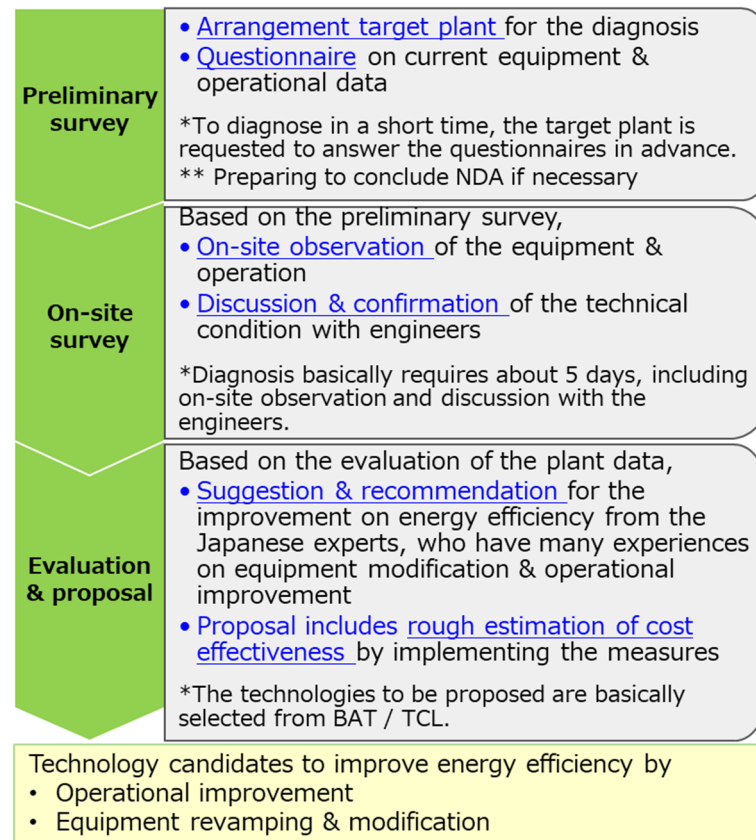


Figure 2-9 High-level process of iron/steel works energy-saving diagnosis

- ✓ Support for detailed plan development (for formulation of detailed equipment introduction plans)

In the past, we conducted follow-up surveys at iron/steel works where the above-mentioned energy-saving diagnoses were carried out to ask whether the technologies proposed after the diagnosis were actually introduced or not. However, several entities commented that the proposed technologies were not introduced because they did not have sufficient manpower to conduct a detailed study on introduction of the technologies, or lacked the capabilities and information necessary for the study.

These issues are generally considered to be a barrier to energy saving, and a simple one-time diagnosis is not an effective solution. An effective solution would involve a kind of “guided” technical support, in which experienced personnel on the Japanese side work together with the target company, guiding their counterparts through the full process from the basic plan to the basic design and detail design. This process would also include acquiring the information necessary for introduction of the proposed technology, and matching with effective equipment manufacturers.

As expected benefits, in addition to giving concrete form to efforts in the planning stage by confirming the energy-saving and CO<sub>2</sub> reduction targets

The diagram illustrates the Energy Management and Control System for a steel plant, showing the flow of materials and energy recovery across various stages of production.

**Legend:**

- Steam Recovery
- ▲ Heat Recovery
- Electric Power Recovery
- ▼ Fuel Saving

**Key Components and Processes:**

- Raw Material Input:** 原料炭 (Raw Material Coal) and コークス炉ガス (Coke Oven Gas).
- Coke Production:** Coal Moisture Control, Coke Oven Gas Holder, Coke Oven Dry Quench, Sintering Machine, and Sinter Cooler Heat Recov.
- Gas Recovery:** LD Gas & Heat Recovery, BF Gas Holder, and Bof Gas Holder.
- Ironmaking:** Blast Furnace (BF) and Converter (BOF).
- Continuous Casting:** Continuous Caster, Hot Slab Charging, and Continuous Annealing.
- Rolling:** Continuous Rolling, Hot Rolling, Cold Rolling, and Annealing Furnace.
- Energy Recovery:** Hot Stove Waste Heat Recovery, Efficient Heating Furnace, and Continuous Annealing.
- Control System:** Energy Management And Control System.

The diagram highlights the integration of energy recovery systems throughout the production process, from raw material handling to final product delivery.

## Equipment Renewal and Energy Consumption Reduction Plan



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iron/steel works of target countries. Rather than technologies that are not yet at the practical stage, such as hydrogen reduction steelmaking, for which technology development is currently underway in Japan, if there are any energy-saving technologies (transition technologies) that have already been commercialized and have a proven track record in Japan and are not yet widespread in the target country, such technologies are actively transferred. In the long term, however, the introduction of technologies, including the demonstration of new technologies that will be put to practical use in the Japanese steel industry, will be an option to achieve ambitious decarbonization targets. Updating in line with the technological innovation of recent years is also assumed, as implementation and use of AI, IoT and other digital transformation (DX) technologies can also contribute to energy saving.

- ✓ Survey and support for utilization of unused energy (waste heat and byproduct gas)

Because the processes in an iron/steel works generate large amounts of waste heat and byproduct gases such as blast furnace gas (BFG) and basic oxygen furnace gas (BOF gas), a large energy-saving effect can be achieved by effectively utilizing this energy. This is considered to be an effective support when the effective use of such energy is not advanced in the target country. The content of this activity would include a survey to determine how much potential for utilization of unused energy exists in the total steel production process, and based on the results, and a study of how that potential can be utilized most efficiently.

As a benefit of this activity, the target iron/steel works will be able to understand the usable potential of currently unused energy, that is, waste heat and byproduct gases, in the works through recommendations based on an analysis by experts from Japan.



### **2.1.3 Major Financial Cooperation Activities**

In financial cooperation activities, it is necessary to remember the importance of eliminating financial hurdles, especially in technical cooperation activities that center on technology transfer. In particular, this is considered to be an effective and necessary measure for small and medium-scale iron/steel works with limited financial resources.

- ✓ Use of JCM (bilateral crediting mechanism) and other financial assistance systems

If the target country has concluded a JCM agreement with Japan, the introduction of equipment using the subsidy system, such as application of the JCM equipment subsidy project in the capital investment plan, is expected to resolve and alleviate the financial issue, which is the biggest barrier to the introduction of energy-saving technologies in developing countries.

When the target country has not concluded a JCM agreement, encouraging participation through government agencies will make it possible to study the introduction of energy-saving equipment by using a JCM equipment subsidy project.

### **2.1.4 Main Policy Cooperation Activities**

The content of policy cooperation is likely to be initiatives related to energy conservation and carbon neutrality in the entire industry, not only in the steel industry but also through a wide range of government agencies and public institutions. Therefore, the formation of a Japanese organization will be an issue in the formation of cooperative programs.

- ✓ Support for formulation of energy-saving and carbon-neutral policies

This activity consists of surveys, studies, analysis and other activities that contribute to policy development, formulation of policy measures and study of concrete measures for achieving targets related to energy saving and carbon neutrality. This includes identification of issues in existing systems in the target country and elimination of issues by revision of laws, systems, etc.

- ✓ Supporting for response to energy saving, cap-and-trade (C&T) and other systems of neighboring countries

When it is necessary to respond to international systems for energy saving and decarbonization in neighboring countries and regions that are main markets for the iron and steel industry of the target country, this activity

supports actions responding to those systems by the iron and steel industry.

- ✓ Support for formulation of energy saving and carbon neutrality roadmaps  
This activity consists of study, investigation, analysis, etc., for the formulation of mid to long-term targets and policies for promoting energy conservation and carbon neutrality and roadmaps for their achievement as government policy. Since the iron and steel industry has a wide base of supporting industries, it is difficult to achieve decarbonization only if energy saving and CO<sub>2</sub> reduction are limited to the iron/steel works alone (SCOPE 1). Therefore, it is important to formulate a comprehensive roadmap for low carbon and decarbonization which also includes realizing low carbon in purchased energy and resources (SCOPE 2) and in the means of transportation (SCOPE 3). Where a roadmap already exists, this may also include identification of problems in the current condition in the existing roadmap, and proposed revisions of the roadmap to include measures for solving those problems.
- ✓ Energy saving incentive policies  
This activity supports studies, surveys and other work for improving incentive policies, such as subsidies to promote diffusion of energy-saving measures, in conjunction with the energy conservation system of the target country. When the target country is a non-JCM country, this may also include promoting JCM participation.
- ✓ Capacity building for policymakers  
As capacity building for persons engaged in policymaking in government agencies, including the above, this activity would include intergovernmental exchanges, training by inviting policymakers to Japan, etc.

#### **2.1.5 Arrangement of Assumed Target Sectors of Support in the Proposed Menus**

In addition to the study and arrangement of the proposed Technology, Finance and Policy cooperation menus described above, the focus of support in the respective target sectors was also arranged as follows. Technical support activities mainly target private-sector companies and related organizations, while financial support is assumed to take the form of cooperation with the related companies and organizations through government agencies, and policy support is cooperation with government agencies and public organizations aimed at capacity building and improvement of policy recommendations.

Table 2-2 Arrangement of main target sectors of support in the proposed menus

	Technology (Software / Hardware)	Finance	Policy
• Governmental organizations	○	◎	◎
• Public organizations (National organizations etc.)	○		○
• Nonprofit & private organizations (for energy conservation, iron & steel association, etc.)	◎		○
• Private companies	◎	○	
Steel companies	◎	○	
Scope 2/3 companies except for steel companies	○		

## 2.1.6 Prerequisites for cooperation programs

As prerequisites for considering the cooperation programs to be applied to this project, the main forms of cooperation that JICA could offer and their outlines are summarized in Table 2-3.

The differences of the forms of cooperation can be broadly categorized in terms of the recipient/target of support and the method of support.

In principle, the Finance and Investment Cooperation is provided with repayment obligations, and the target is the government of the country concerned in the case of ODA Loans, and is mainly corporations that intend to expand business in the country in the case of Private-Sector Investment Finance. In the Grants, cooperation is provided to the government of the country concerned without repayment obligation. The Technical Cooperation project is a combination of JICA's three cooperation tools: dispatch of experts, acceptance of trainees, and provision of equipment, and governments of the countries concerned are the main recipients. Then, the Small and Medium Enterprises (SMEs) and SDGs Business Support project provides financial and other means of cooperation to Japanese SMEs in their overseas expansion. In addition, blended finance is also provided in collaboration with international organizations and private companies.

When considering cooperation programs, it is important to take into account the situation of the steel industry in the countries concerned of this project. In many cases, the main body of the steel industry in each country has shifted to the private sector. For example, in Turkey, which will be discussed later, state-owned companies have been privatized. Therefore, while the recipient/target of support will be the national government and/or the private sector of the country concerned, it is necessary to recognize that there are certain limitations on how to support these entities in the current form of cooperation.

In this project, which focuses on the implementation of energy-saving technologies in the steel industry through the cooperation of Japanese companies and governments, the options for cooperation programs include Technical Cooperation projects to support the governments of the countries concerned in formulating policies and systems for energy-saving in the steel industry, and Private-Sector Investment Finance and SMEs and SDGs Business Support project to support the business development of Japanese companies. Further, given the relatively large size of the amount, ODA loans may be an option depending on the scale of the initial investment required for energy efficiency improvement and conservation, but the situation of iron/steel works in the country must be confirmed before working on the details.

Table 2-3 Forms of cooperation of JICA and their overview

Forms of cooperation		Overview
Finance and Investment Cooperation	ODA Loans	Cooperation projects that lend to the governments, etc. of developing countries/regions the funds necessary for the implementation of development projects or the achievement of plans concerning the economic stability of said countries/regions.
	Private-Sector Investment Finance	Cooperation projects that provide loans and investments necessary for the implementation of development projects to corporations, etc. in Japan or developing countries/regions.
Grants		Cooperation projects through grant aid (with no repayment obligations) provided to the government of a developing countries/regions for the primary purpose of developing such country/region.
Technical Cooperation Project		Cooperation projects that develop human resources who will be the leaders of economic and social development in developing countries/regions by utilizing knowledge, technology, and experience of Japan for the main purpose of development in those countries/regions.
SMEs and SDGs Business Support project		Cooperation projects that use the excellent technologies, products, and ideas possessed by Japanese companies to solve problems faced by developing countries and help companies expand their business overseas, which in turn helps to revitalize the Japanese economy.

## 2.2 Framework of the analysis

From the subsequent sections, we propose a cooperation program that is tailored to the situation in each country. For this purpose, this work identifies the goals, challenges, and gaps of the stakeholders related to the steel industry by identifying the national goals, the situation of the steelmaking business market, and the parties concerned in each of the countries concerned. It is assumed that the cooperation program should be implemented as a means to consider the essential needs of the steel industry in the country concerned based on the results of this work, and to resolve the identified issues and gaps. In view of this analysis procedure, information on the local situation in each country, which is the basis of the analysis, was collected according to the framework shown in the table below.

We decided to extract issues related to low-carbonization and decarbonization based on the local situation in each country, and to gain insights that will contribute to the consideration of cooperation programs. In the consideration of cooperation programs, the importance of each cooperation program is weighted by taking into account the motivation of each country's government and the relevant national companies for energy efficiency and conservation, as well as the consistency with Japan's cooperative development policy. In examining the feasibility of the cooperation programs and their priority, it is important to confirm whether countries and businesses have the foundation to accept the cooperation. Therefore, this study was conducted to understand the foundation from the perspective of motivation and gaps. Specifically, we inferred the motivation of the government in terms of the economy and climate change measures, and of business operators in terms of energy efficiency and conservation and the market environment, based on their existing plans and future visions. By contrasting this future direction with the results of the current analysis, we estimated the difference (gap) between the said future and the future that each entity has.

In addition, as JICA has already presented individual cooperation programs to each country, it is required to consider cooperation programs that do not contradict the current cooperation programs so that the governments of each country that already know the programs will not be confused with the additional cooperation contents. For this reason, we confirmed and discussed the position of this project that contributes to energy efficiency and conservation by referring to the national cooperation and development policies and cooperation and development plans.

In the survey, consideration was given to obtaining quantitative information as much as possible, as it is important to give specificity to the cooperative program. However, due to the characteristics of this survey, which is mainly a

desktop study, there are limits to the information that can be accessed. Therefore, in situations where quantitative information is limited, we supplemented it with qualitative information based on reliable sources. Further, consideration was given to ensure concreteness by citing the contents and results of previous surveys conducted by the research team outside of this work.

Cooperation programs need to take into account the situation of the counterpart government and its relationship with Japanese entities. However, it is difficult to take these factors into account in this chapter, which organizes and discusses the results mainly through desk study. Therefore, based on the assumption that direct approaches will be made to each country in the future, the actual short-term activities in the image of the Technical Cooperation project shown in Figure 2-2 are organized and presented based on the information currently available. Long term goals will be discussed and organized based on the actual approach to the government and short-term activities to determine future direction.

Table 2-4 Framework for analyzing the local situation in each country

Item	Contents of survey	Purpose
Overview of the steel industry	Summarize the market size and demand for steel production, domestic supply and demand, imports and exports, etc.	To analyze the situation of the private sector and other parties involved in the steel industry, by studying the supply and demand situation in the country and external pressures.
Overview of major steel companies	Outline the steel companies in the country, the equipment they have installed, and their energy consumption and carbon dioxide emissions, separating blast furnaces and electric furnaces wherever possible.	To understand the level of technology from multiple perspectives such as energy, carbon dioxide, and equipment.
Energy-saving, low-carbon, and decarbonization-related policies and systems in each country	Summarize the contents of the NDC and the efforts being made in the steel industry, both public and private.	To identify decarbonization awareness and steel industry-related opportunities and barriers in the country in light of the Paris Agreement.

## 2.3 Turkey

### 2.3.1 Analysis of current situation (level of facility capacity, technology and energy management of major companies, policies and institutions, etc.)

Based on the literature review, the current status of the steel industry in Turkey was analyzed, including the capacity of major steel companies and the actual production of crude steel. In addition, regulations and promotion policies and systems related to industry, energy saving and environment in Turkey were analyzed.

#### (1) Overview of the Turkish Steel Industry

Turkey's crude steel production is the world's 8<sup>th</sup> largest (33.7 million tons) as of 2019 and has fluctuated between 30 million tons and 40 million tons. The ratio of crude steel production is 32.2% for blast furnace steel and 67.8% for electric furnace steel. The supply and demand of steel in Turkey is shown in Figure 2-12.

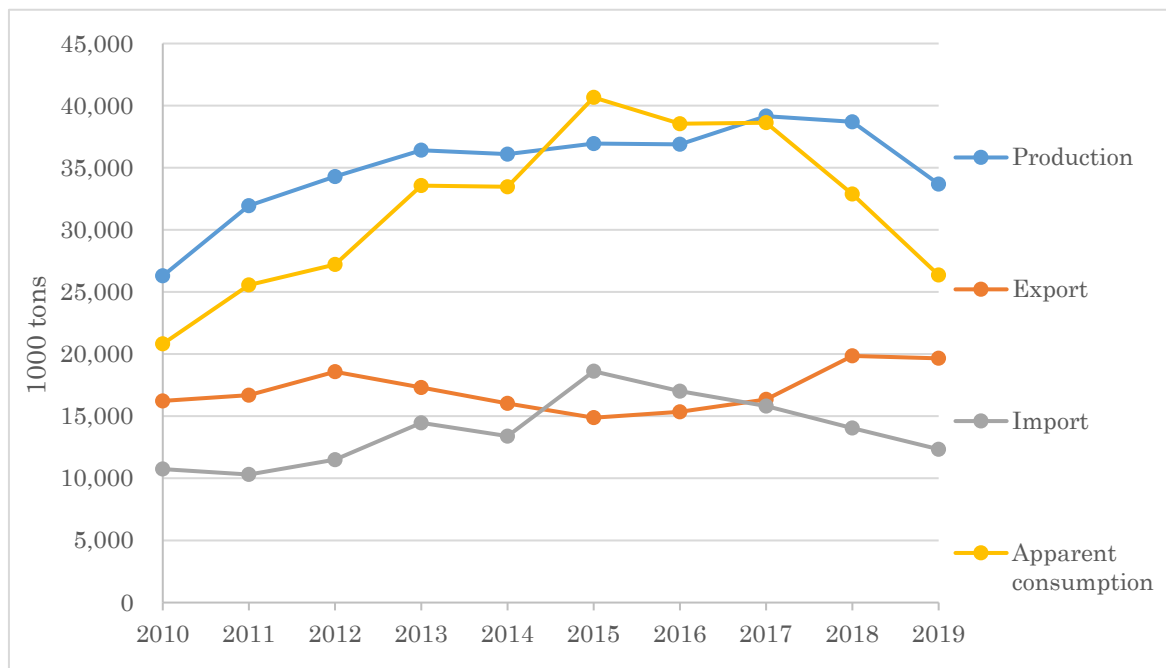


Figure 2-12 Supply and Demand of Steel Products in Turkey

Source: Compiled by NSRI based on World Steel Association Steel Statistical Yearbook 2020

The percentage of the value of exports from Turkey to each region in 2018 is shown in Figure 2-13. The EU accounted for the largest share at 40%, followed by Africa and the Middle East at 29%. In terms of products, exports of hot-rolled steel sheets are the largest for EU, while exports of hot-rolled steel bars (including reinforcing bar steel) are the largest for Africa and the Middle East (Table 2-5 ). Looking at the destinations of hot-rolled steel sheets in detail,

exports to Italy, Spain, Belgium, Portugal, and the United States are large, while exports of hot-rolled steel bars to Yemen, Israel, the United States, and Hong Kong are large (Table 2-6).

According to a report<sup>33</sup> by Steel Recycling Research Inc., as of 2018, Turkey imports scrap from developed countries such as the EU, North America, CIS, and Russia, and exports reinforcing bar steels mainly to developing countries in the Middle East, Asia, Africa, and Latin America. Reinforcing bar steels are generally manufactured in electric furnaces, and Turkey's electric furnace plants are thus responsible for the international circulation of steel, and are called the recycling plant of the world.

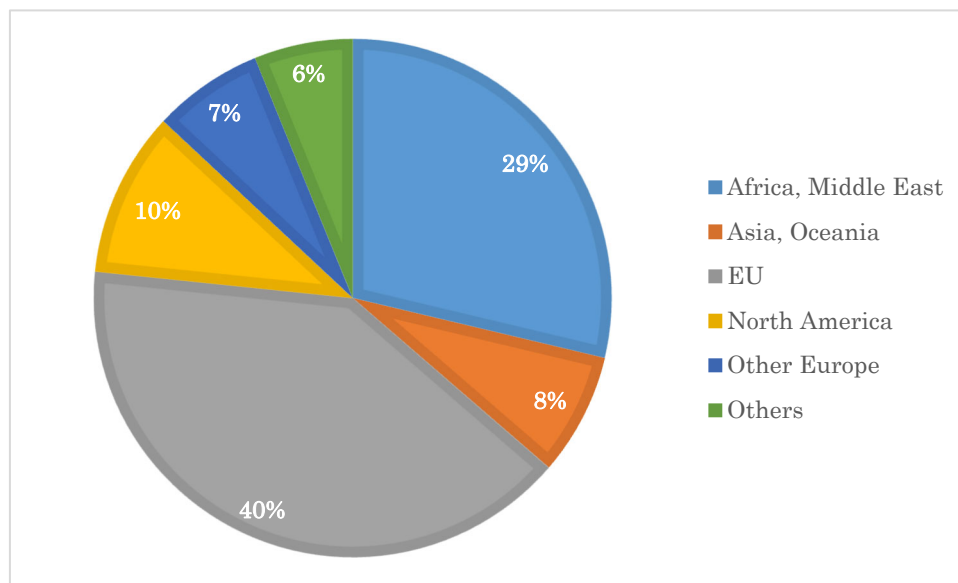


Figure 2-13 Percentage of Turkey's Export Value by Region

<sup>33</sup> Turkey, World's Largest Importer of Steel Scrap (Steel Recycling Research Inc., 2019, <http://srr.air-nifty.com/home/files/190701.pdf>)

Table 2-5 Value of exports from Turkey to each region by category in 2018 (US\$)

合計 / Trade Value (US\$)	地域名						
品目	Africa, Middle East	Asia, Oceania	EU	North America	Other Europe	Others	総計
Cast-iron pipe	144,292,024	14,413,408	22,077,632	457,496	24,923,528	98,208	206,262,296
Non-alloyed steel, Cold steel bar	199,944,192	52,886,304	149,609,240	48,879,912	82,652,992	45,496,248	579,468,888
Non-alloyed steel, Cold-rolled steel sheets (600 mm or more)	233,717,992	8,693,600	1,218,248,696	975,530,208	22,797,944	18,122,896	2,477,111,336
Non-alloyed steel, Hot steel bar	11,434,058,232	4,876,881,376	3,824,830,664	2,870,169,664	896,161,160	3,024,902,504	26,927,003,600
Non-alloyed steel, Hot-rolled steel sheets (600 mm or more)	1,978,399,584	102,575,176	14,608,000,048	1,613,621,008	608,971,200	148,896,928	19,060,463,944
Non-alloyed steel, Plating/coating (600mm or more)	1,526,396,640	15,279,384	3,738,536,256	1,352,380,552	1,166,625,672	103,025,424	7,902,243,928
Non-alloyed steel, Semi-finished products	1,967,784,368	1,301,418,936	131,862,880		100,706,056	254,503,680	3,756,275,920
Non-alloyed steel, shaped steel	4,480,235,240	491,609,240	1,501,496,616	363,807,968	731,167,376	1,338,193,080	8,906,509,520
Non-alloyed steel, Steel plate and strip (less than 600mm)	96,947,696	4,752,872	155,749,160	16,369,152	28,670,568	11,449,672	313,939,120
Non-alloyed steel, Steel sheet and strip Plating/coating (less than 600mm)	153,820,152	4,433,512	147,883,464	48,003,024	140,536,744	32,282,920	526,959,816
Non-alloyed steel, steel wire	767,898,360	51,921,888	991,421,416	37,472,376	321,757,464	143,034,368	2,313,505,872
Non-alloyed steel, Wire rod	2,668,522,504	516,980,208	3,962,991,848	230,865,040	110,651,680	762,494,336	8,252,505,616
Other alloy steel, ingots and semi-finished products	21,987,520	1,816,432	800,168,320	4,551,528	100,669,128	1,220,512	930,413,440
Other alloy steel, Shaped and rebars	263,191,608	44,222,688	956,069,400	229,569,848	79,027,864	275,155,592	1,847,237,000
Other alloy steel, Steel plates (600 mm or more)	109,868,600	11,463,592	889,166,208	27,690,720	5,780,816		1,043,969,936
Other alloy steel, Steel plates (less than 600 mm)	11,045,048	3,200,512	250,359,264	496,232	7,090,136		272,191,192
Other alloy steel, steel wire	58,223,520	5,915,736	156,353,528	7,435,216	93,829,616	8,983,704	330,741,320
Other alloy steel, Wire rod	2,629,904	128,888	304,464,592			20,634,984	327,858,368
Railroad track and accessories	183,183,688	36,638,232	103,773,552	8,967,536	54,521,696	351,872	387,436,576
Seamless steel pipe	125,081,960	41,051,536	102,989,960	5,918,416	99,342,480	1,670,576	376,054,928
Stainless steel, ingots and semi-finished products	86,040		459,696	12,960	3,834,184		4,392,880
Stainless steel, Shaped and rebars	62,962,032	5,010,144	24,603,528	5,954,144	19,462,616	264,600	118,257,064
Stainless steel, Steel plates (600 mm or more)	146,953,952	37,949,472	1,470,287,360	4,679,312	297,425,672	17,036,944	1,974,332,712
Stainless steel, Steel plates (less than 600 mm)	15,123,728	2,509,952	91,687,352	677,312	46,392,416	2,435,480	158,826,240
Stainless steel, steel wire	2,374,760	2,462,744	5,089,328	3,424	7,307,112	1,347,728	18,585,096
Stainless steel, Wire rod	58,576		609,304				667,880
Steel sheet pile, Welded steel	48,496,520	2,173,704	6,279,896	13,760	7,535,312		64,499,192
Welded steel pipe / riveted pipe, etc. (Circular cross section, outside diameter over 406.4 mm)	500,992,912	67,646,928	808,833,080	1,336,580,952	125,952,888	48,587,408	2,888,594,168
Welded steel pipe / riveted pipe, etc.(Others)	2,154,765,008	92,658,328	4,753,425,616	1,372,790,864	1,842,903,840	38,853,712	10,255,397,368
総計	29,359,042,360	7,796,694,792	41,177,327,904	10,562,898,624	7,026,698,160	6,299,043,376	102,221,705,216

Source: United Nations Trade Statistics, compiled by NSRI

Table 2-6 Turkey's major exporters of hot-rolled steel sheet and hot-rolled steel bars

Non-alloy steel Hot-rolled steel sheets (600 mm or more)			Non-alloy steel Hot-rolled steel bars		
No	Country	Total/ Trade Value (US\$)	No	Country	Total/ Trade Value (US\$)
1	Italy	6,415,186,512	1	Yemen	3,395,319,296
2	Spain	3,429,478,768	2	Israel	3,279,974,144
3	Belgium	1,721,535,904	3	Singapore	1,567,630,032
4	Portugal	1,179,402,552	4	USA	1,507,664,672
5	USA	924,663,264	5	China, Hong Kong SAR	1,448,433,208
6	Canada	620,122,800	6	Canada	1,361,979,984
7	Greece	612,421,272	7	Ethiopia	1,005,540,272
8	Egypt	499,534,912	8	Romania	935,267,576
9	Bulgaria	442,185,008	9	Malaysia	826,732,608
10	United Kingdom	431,287,568	10	Netherlands	824,988,848

Source: United Nations Trade Statistics, compiled by NSRI

## (2) Overview of Major Steel Companies in Turkey

In Turkey, there are 3 blast furnace manufacturers and 28 electric furnace manufacturers. 10 are in the area around Iskenderun near the Syrian border, 8 are in the Marmara region in the northwest, 5 are in the Black Sea region, and 8 are in the area around Izmir in the west.



Figure 2-14 Steel production sites in Turkey

Source: Turkish Steel Producers Association (<http://celik.org.tr/en/harita/>)

According to the Turkish Steel Producers Association<sup>34</sup>, the steel industry's share of Turkey's total energy consumption is 7.5% and its share of industrial consumption is about 22.9 %. The Turkish steel industry has developed a roadmap for the development of energy efficiency projects and has reduced its energy consumption per ton of crude steel by about 18-20% since the 1980s through continuous improvement of technology. Specifically, the industry has reduced its environmental impact by increasing the use of high-efficiency, low-carbon natural gas instead of fuel oil and diesel as fuel for arc furnaces, crucible heating, tundish heating, and rolling mill annealing furnaces.

Outline and facilities of major steel works with the top three highest crude steel production capacity in integrated blast furnace and electric furnace are shown in Table 2-7, Table 2-8 and their locations are shown in Figure 2-17.

< Blast Furnace Integrated >

The steel industry in Turkey has developed around the 3 state-owned blast furnace companies, Erdemir, Isdemir, and Kardemir (all now privatized). The blast furnaces in Turkey may have a large energy intensity due to the old

<sup>34</sup> <http://celik.org.tr/en/cemtas-celik-makina-sanayi-ve-ticaret-a-s/>

operation period of the facilities. In addition, some energy efficiency and conservation equipment such as CDQ and TRT have been introduced, but they are not yet sufficiently widespread, and there seems to be potential for energy saving. However, it is necessary to confirm the diffusion rate through field surveys. Byproduct gases from blast furnaces and converter furnaces are effectively used to provide the necessary energy, but it is necessary to confirm through field surveys or hearings whether gas holders and boilers are being used to control gas emission.

Erdemir was established in 1960 and privatized in 2006. Erdemir is very familiar with Japan as it imported a large amount of steel products from Japan during the state-run period. The former Nippon Kokan (NKK) also exported blast furnace equipment and dispatched engineers from its steel division to support operations. The Japanese steel equipment manufacturers have continued to install equipment to Turkey. The company has also been active in reducing CO<sub>2</sub> emissions, regularly calculating and monitoring greenhouse gas emissions per ton of crude steel and reporting them to the government, as well as training employees on greenhouse gas emissions. Under the direction of the R&D Center, the company has established the Emissions and Waste Research Platform (ESWRP-EMKAR), which is working to reduce CO<sub>2</sub> emissions by reducing the use of fossil fuels (coal) through the use of biomass, reducing the use of primary raw materials, indirectly reducing emissions through the recycling of ferrous and carbon-based waste, and improving energy efficiency throughout the organization. The Erdemir Group is also working to reduce CO<sub>2</sub> emissions. In addition, the Erdemir Group has obtained ISO 50001 certification, and through energy efficiency projects, has achieved energy savings amounting to 455,300,952 kWh per year, reducing the emission of 214,620 tons of CO<sub>2</sub> and realizing economic savings equivalent to 170,885,256 Turkish Lira (about 1.6 billion yen)<sup>35</sup>. As a result of its proactive efforts to save energy and CO<sub>2</sub>, the company's "The Basic Oxygen Furnace (BOF) Gas Recovery and Increasing Usage" project was awarded the 2<sup>nd</sup> prize in the "Large-Scale Companies Sustainable Production" category, during the second round of "Efficiency Project Awards" organized by the Ministry of Science, Industry and Technology of the Republic of Turkey in 2015.<sup>36</sup>

Isdemir was founded in 1970, privatized and acquired by Erdemir in 2002.<sup>37</sup> According to JICA's data (2004), Isdemir has been implementing no-cost and low-cost measures to reduce energy consumption with the cooperation of the

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<sup>35</sup> Integrated Annual Report

2020([https://www.erdemir.com.tr/Sites/1/upload/files/2020\\_Integrated\\_Report-4864.pdf](https://www.erdemir.com.tr/Sites/1/upload/files/2020_Integrated_Report-4864.pdf))

<sup>36</sup> <https://www.erdemir.com.tr/sustainability/environment/environmental-awards/>

<sup>37</sup> In this project, studies were conducted in integrated blast furnace and electric furnace iron/steel works under the cooperation of EIE and JICA. In this project, studies were conducted at integrated blast furnace and electric furnace iron/steel works in cooperation with EIE and JICA, and measures were taken to reduce energy consumption.

Directorate General of Electricity Resources Research and Development (EIE) and JICA. They have achieved improvement of the coke-making energy intensity by 14%, the blast furnace coke ratio by 1%, the steel bar heating furnace intensity by 10%. The converter induced draft fan (IDF) electricity intensity is also improved. The effects of these measures amount to 780 million yen per year. The company won the top prize in the "Reducing Energy Intensity in Metal Industry Sector" category sponsored by the Directorate General of Renewable Energy, and also won 9 awards in the "Increasing Energy Efficiency in Industry Projects" category of the "Energy Efficiency in the Industry Project Competition" sponsored by the Ministry of Energy and Natural Resources of the Republic of Turkey between 2002 and 2015. The company also works with NGOs related to climate change and is the Vice President of TOBB - Environment and Climate Change Committee and the Interprovincial Committee of the Turkish Steel Producers Association. The company is also a member of the Greenhouse Gas Reduction Task Force established by the Ministry of Environment and Urban Development.

Kardemir was established in 1937 and privatized in 2002. In 2020, 6 million tons of CO<sub>2</sub> greenhouse gas emissions were emitted within Kardemir's scope of operations. In parallel with the 9% increase in production, greenhouse gas emissions, especially in the scope 1, have increased compared to the previous year (Figure 2-16 ). On the other hand, greenhouse gas emissions per ton of crude steel produced decreased from 2.4 to 2.3 CO<sub>2</sub>e/ton (Figure 2-15). In addition, energy efficiency research has reduced CO<sub>2</sub> emissions by 136,276 tons per 2020, and a total of 579,912 tons of CO<sub>2</sub> emissions have been reduced since 2017 (Figure 2-16).

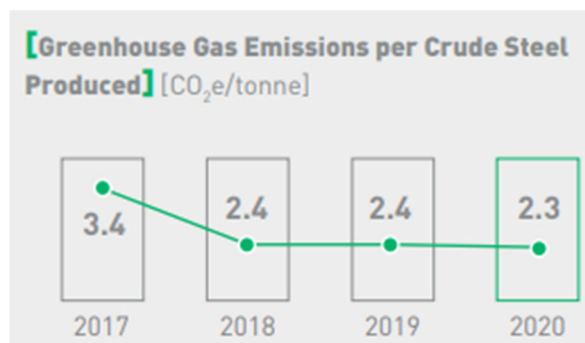


Figure 2-15 GHG gas emissions per ton of crude steel produced

Source: Kardemir Sustainability Report 2020

([https://www.kardemir.com/dosyalar/sayfalar/1339/03092021/2021090315555121\\_sayfalar\\_1339\\_03092021.pdf?v=c02ebf9b\\_c703\\_07bf\\_68ae\\_25ac990022ed](https://www.kardemir.com/dosyalar/sayfalar/1339/03092021/2021090315555121_sayfalar_1339_03092021.pdf?v=c02ebf9b_c703_07bf_68ae_25ac990022ed))

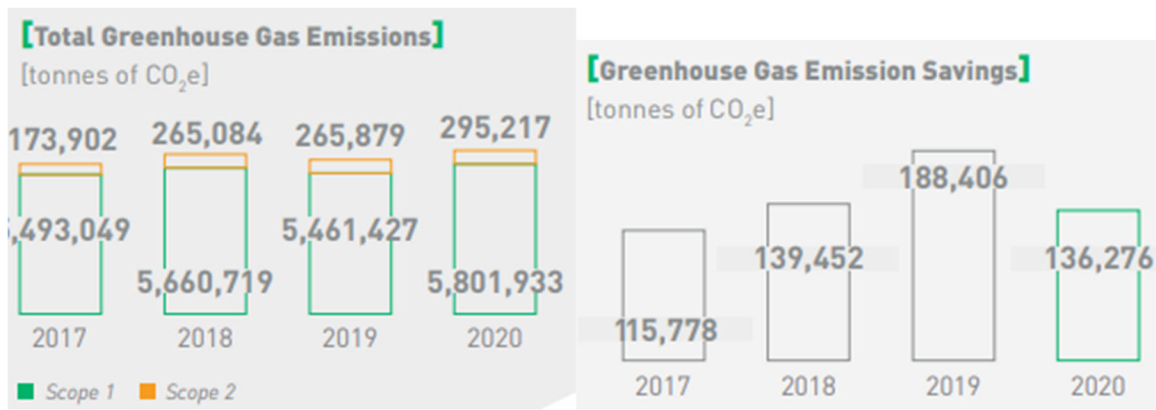


Figure 2-16 GHG gas emissions (left) and GHG gas emission reductions (right)

Source: Kardemir Sustainability Report 2020

([https://www.kardemir.com/dosyalar/sayfalar/1339/03092021/2021090315555121\\_sayfalar\\_1339\\_03092021.pdf?v=c02ebf9b\\_c703\\_07bf\\_68ae\\_25ac990022ed](https://www.kardemir.com/dosyalar/sayfalar/1339/03092021/2021090315555121_sayfalar_1339_03092021.pdf?v=c02ebf9b_c703_07bf_68ae_25ac990022ed))

#### <Electric furnace>

Icdas Celik is the largest electric furnace to bar wire manufacturer in Turkey, with a rolling mill in Istanbul and an electric furnace to rolling mill in Karabiga. Icdas Celik was awarded the "Düşük Karbon Kahramanları Ödülü (Low Carbon Hero Award)" by the Sustainable Production and Consumption Association (SPCA) in 2018 for its production of construction steel with low greenhouse gas emissions.<sup>38</sup> The company uses high energy efficient production technology in compliance with the best available technology reference document issued by the EU and the amount of greenhouse gas emissions from its rolling mill is 78 kg CO<sub>2</sub>/ton-steel.

Habas Group was established in 1956 and started production of industrial and medical gases, invested in the steel sector and started crude steel production in Aliaga in 1987, bar rolling in 1992. Its current crude steel production capacity is 4.5 million tons, making it the 2<sup>nd</sup> largest electric furnace manufacturer in Turkey.

Colakoglu Metalurji is an electric furnace manufacturer established in 1945. The company installed a rolling mill for flat products and the world's largest electric furnace at that time (315 tons) to incorporate the latest technology. The company's energy management department consists of personnel from all departments who are familiar with energy management issues and oversee the implementation of all energy-related processes from procurement to usage according to the ISO 50001 energy management system standard. It also keeps a close eye on changes in energy-related technologies and incorporates them in terms of manufacturing processes to achieve energy reduction targets in line with energy policies. On the environmental front, the company has invested in flue

<sup>38</sup> Icdas Celik's website (<https://www.icdas.com.tr/News.aspx?year=2018&lang=tr-TR>)

gas and wastewater filtration systems, as well as fresh water production, which has been certified by the Ministry of Environment. The company has also listed the following environmental goals for the year 2020.

- Reduce the amount of hazardous waste generated by iron/steel works
- Reduce greenhouse gas emissions by reducing electricity consumption at production plants
- Reduce greenhouse gas emissions by reducing the amount of natural gas used in production plants
- Improve waste recovery rates
- Improve the frequency and severity of accidents

Table 2-7 Overview of major iron/steel works in Turkey

No	Company name	Office	Crude steel production capacity (thousand tons/year)	Upper process	Main Products	National/Foreign	Information on saving CO2 and energy	Notes
1	Erdemir	Eregli	3,850	Blast Furnace Integrated	Thick plate, hot and cold rolled, tinplate, hot-dip galvanized steel sheet (CG steel sheet)	Local, Privatized in 2006	<ul style="list-style-type: none"> <li>• There are two pulverized coal blowers (PCI) for blast furnaces.</li> <li>• Installed TRT in four blast furnaces in Erdemir /Isdemir from 2014 to 2016.</li> <li>• Reduction of 214,620tCO2 by 2020 through energy efficiency PJ</li> </ul>	• Erdemir Group (Oyak 49.29%, Erdemir treasury shares 3.08%, listed shares 47.63%, ArcelorMittal 12.08%, golden shares (Turkish Privatization Commission) 20 shares)
2	Isdemir	Iskenderun	5,250	Blast Furnace Integrated	Slabs, billets, wire rods, hot rolled products	Local, Privatized in 2002	<ul style="list-style-type: none"> <li>• One CDQ, two TRTs, and three or four PCIs are available.</li> <li>• TRTs were installed in four blast furnaces in Erdemir /Isdemir from 2014 to 2016.</li> <li>• In the 2000s, field surveys and improvements were carried out in cooperation with EIE and JICA.</li> </ul>	• Erdemir Group (Erdemir 95.07%)
3	Kardemir	Karabük	2,800	Blast Furnace Integrated	Steel rebars, shaped steel, wire rod	Local, Privatized in 2002	<ul style="list-style-type: none"> <li>• Electricity self-sufficiency in 2013 (by-product gas power plant in operation, made in China).</li> <li>• There is one PCI unit.</li> <li>• In 2020, 6 million tons of CO2, but by improving energy efficiency were emitted planning to reduce CO2 emissions by 136,276 tons.</li> </ul>	<ul style="list-style-type: none"> <li>• Kardemir Group (Cag Celik I&amp;S 25%, employees 51%. (25% of Cag Celik I&amp;S, 51% of employees; US investment firm Arrowstreet Capital has acquired more than 10% of shares)</li> <li>• Cooperation with Karabük University in the fields of environment, energy and efficiency.</li> </ul>
4	Icdas Celik	Karabiga	4,700	Electric furnace	Steel rebars	Local	Awarded the Düşük Karbon Kahramanları Ödülü (Low Carbon Hero Award) by the SPCA in 2018 for producing construction steel with low greenhouse gas emissions	
5	Habas	Aliaga	4,500	Electric furnace	Steel rebars, wire rods, hot rolled	Local		
6	Colakoglu Metalurji	Gebze	3,000	Electric furnace	Steel rebars, wire rods, hot rolled	Local	Environmental goals for 2020 include reducing greenhouse gas emissions by reducing electricity consumption and natural gas consumption.	

Source: Compiled by NSRI from various sources.

Table 2-8 Facilities of major iron/steel works in Turkey

No	Company Name	Number of units (start of operation year)						
		Blast Furnace	Converter	Coke Ovens	Sintering Furnace	Electric Furnace	Heating Furnace	DR
1	Erdemir	2 units (65, 78)	3 units (95, 94, 93)	3 units (64, 64, 78 )	1 unit (72 )	—	3 units (65, 78, 92)	—
2	Isdemir	4 units (75, 79, 85, 11)	3 units (07, 07, 08)	6units (75, 77, 85, 86, 07, 07)	2 units (08, 11)	Plan for steel products	2 units (08, 08)	—
3	Kardemir	5 units (39, 50, 62, 11, 14)	3 units (98, 98, 14)	5 units (68, 68, 52, 52, 14)	3 units (62, 87, 14)	—	?	—
4	Icdas Celik	—	—	—	—	3 units (03, 09, 12) ※175, 220, 100tEF	2 units (01, 03)	—
5	Habas	—	—	—	—	2 units (87, 17) ※130tEF	?	—
6	Colakoglu Metalurji	—	—	—	—	5 units (69×4 units, 06) ※45tEF × 4, 315tEF	New heating furnace to be installed in 2022	—

Source: Compiled by NSRI from various sources.

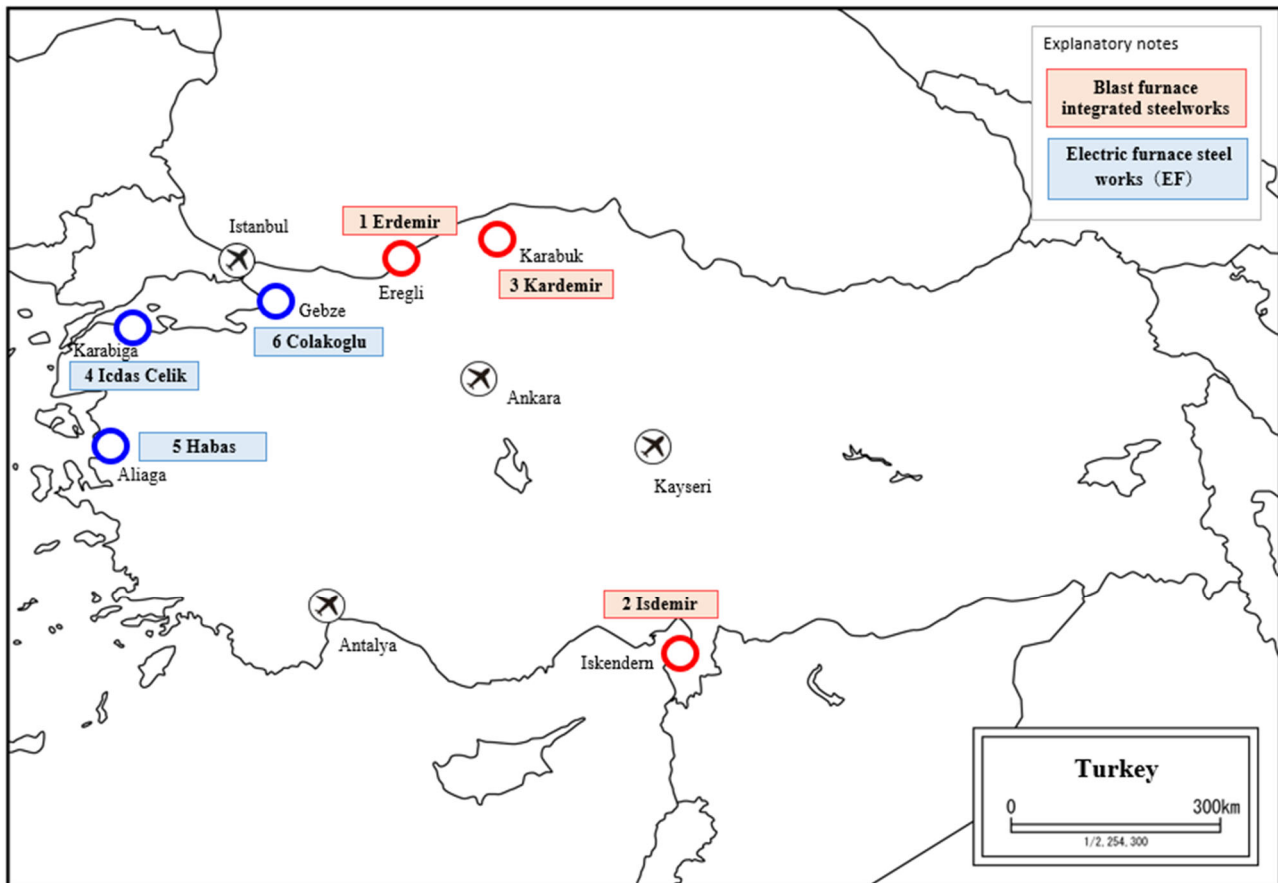


Figure 2-17 Location of major iron/steel works in Turkey

Source: Compiled by NSRI from various sources.

(3) Energy-saving, low-carbon, and decarbonization-related policies and systems in Turkey

The following is an overview of NDCs in Turkey.

- Turkey is classified as a developed country (Annex I country, greater burdens will be required for greenhouse gas emission reductions, etc.) under the United Nations Framework Convention on Climate Change (UNFCCC), and was the only G20 country that did not ratify the Paris Agreement, claiming that the burden was too heavy.
- However, on October 6<sup>th</sup>, 2021, the Turkish parliament unanimously approved the ratification of the Paris Agreement and set a goal of achieving net zero emissions by the year 2053 as NDC.
- However, while Turkey proceeded with the ratification process as an Annex I country classification, the statement approved by the parliament states that “Turkey, as a developing country, will implement the agreement as long as it does not undermine Turkey's right to economic and social development”.

It can be said that by ratifying the Paris Agreement and joining the discussions

at COP26 held from end of October 2021, Turkey have demonstrated to the international community that they want to bring in funds for climate measures from overseas.

The following climate change measures have been taken in Turkey.

- Regulations on Measures to Promote the Rational Use of Energy by Industrial Organizations" (enacted in 1995)
- Energy Efficiency Law (enacted in 2007)
- Energy Efficiency Strategy 2012-2023 (Passed in 2012)
- National Energy Efficiency Action Plan 2017-2023 (Passed in 2017)
- Verimlilik Arttırıcı Projelerin (VAP, Efficiency Improvement Project) based on the Energy Efficiency Law<sup>39</sup>
- TEYDEB Project (supported by TÜBİTAK)<sup>40</sup>
- Energy efficiency support from TTGV (Turkish Technology Development Fund)

The Turkish National Energy Conservation Center (EIE/NECC) <sup>41</sup> of the General Directorate of Electric Power Resources Research and Development has established an energy manager system to promote energy conservation in factories with large plants that consume more than 2,000 TOE (tons of oil equivalent) of energy. The system is based on the "Regulations on Measures for the Promotion of Energy Consumption Rationalization by Industrial Organizations" (enacted in 1995), which requires major plant companies to assign energy managers to save energy. The collection of emission performance data from iron/steel works has been carried out systematically and scientifically, and the figures have been verified. In addition, the members of the Turkish Steel Producers Association use the PDCA cycle to monitor energy consumption monthly/annually in accordance with the energy policy developed, set targets to reduce energy consumption, identify the causes of deviations from the targets and take the necessary measures, and continue to make improvements. In terms of data collection, the Turkish Steel Producers Association seems to be playing an important role.

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<sup>39</sup> T.C. Enerji ve Tabii Kaynaklar Bakanlığı, Ministry of Energy and Natural Resources, Turkey ([https://enerji.gov.tr/evced-enerji-verimlilik-destekleri-verimlilik-artirici-\(proje-destekleri\)](https://enerji.gov.tr/evced-enerji-verimlilik-destekleri-verimlilik-artirici-(proje-destekleri)))

<sup>40</sup> THE SCIENTIFIC AND TECHNOLOGICAL RESEARCH COUNCIL OF TURKEY The main body responsible for managing, funding and conducting research in Turkey.

<sup>41</sup> EIE: General Directorate of Electrical Power Resources Survey & Development Administration, NECC: National Energy Conservation Center, NECC: National Energy Conservation Center, National Energy Conservation Center of Turkey

The Turkish steel industry is using VAP and TEYDEB projects under the Energy Efficiency Law to save energy and reduce CO<sub>2</sub> emissions<sup>42</sup>. In addition, TTGV's energy efficiency support and other resources are being used to finance the projects.

VAP is a program started by the Turkish Ministry of Energy and Natural Resources in 2011. Projects that prevent or minimize unnecessary energy use through the use of energy-efficient equipment and systems, insulation, etc., and recover waste energy are considered VAP, and companies with annual energy consumption of 500 TOE or more are eligible to receive a grant of up to 30% of the project cost.

TEYDEB aims<sup>43</sup> to contribute to the improvement of the competitiveness of private sector organizations and the diffusion of R&D culture by supporting research in the form of technology development and innovation activities, in line with Turkey's Science and Technology Innovation Policy. TÜBİTAK and TTGV have been working on projects eligible for TUBITAK incentives, including TÜBİTAK and TTGV will subsidize projects and research related to the following activities: concept development, technical and technological feasibility studies, laboratory concept-to-design conversion studies, design and sketching studies, prototyping, construction of pilot facilities, test production, patent and licensing studies, and elimination of post-sale problems arising from product design. TTGV provides grants and loans for projects and research on activities related to design and sketching research, prototyping, construction of pilot facilities, test production, patent and licensing research, and elimination of post-sale problems arising from product design. In addition, TTGV provides interest-free long-term loans<sup>44</sup> for projects related to technology development, renewable energy, energy-saving technologies, and environmental impact reduction.

In addition, on February 10, 2022, the Turkish Industrial Development Bank (TSKB), which focuses on green transformation in Turkey's development, signed a US\$ 220 million loan agreement with JBIC. The loan is a continuation of the US\$ 150 million loan obtained by TSKB from JBIC in March 2015. Through this loan, TSKB plans to provide funds for investments in renewable energy and energy efficiency to reduce GHG emissions in Turkey. The scope of the loan has been expanded to include high-efficiency compressors and other equipment for steel mills and spinning mills, where Japanese technology is expected to be utilized. Therefore, it is expected that the loan will be utilized in the future in

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<sup>42</sup> <http://celik.org.tr/en/cemtas-celik-makina-sanayi-ve-ticaret-a-s/>

<sup>43</sup> <https://teydeb.tubitak.gov.tr/teydebanasayfa.htm>

<sup>44</sup> The maximum loan amount is 50% of the total project amount, the maximum loan per project is US\$1 million, and the repayment period is one year after the implementation of the project,<sup>4</sup> subject to a grace period of one year.  
([https://joi.or.jp/modules/investment/custom/documents/TUR\\_Incentive.pdf](https://joi.or.jp/modules/investment/custom/documents/TUR_Incentive.pdf))

terms of funds for this project.

Alliances, national frameworks, etc. are described below.

In 1996, the European Coal and Steel Community (ECSC) agreement was signed between the EU and Turkey, which allows Turkey to import and export steel products to and from all EU member countries without tariffs in principle. In compliance with the agreement, the Turkish government has abolished subsidies for the steel industry to the EU.

Under this context, the introduction of a carbon border adjustment measure (CBAM) is currently under consideration in the EU. The border adjustment tax would first require steel, cement, aluminum, fertilizer, and electricity sectors to meet the same CO<sub>2</sub> emission control costs as EU products. In the steel sector, Russia, China, Turkey, Ukraine, India, and other countries have expressed concerns about carbon border adjustment measures.

Mr. Abdulkadir BEKTAS of the Turkish Ministry of Energy and Natural Resources has published a paper<sup>45</sup> on the impact of CBAM on the Turkish steel industry and measures to deal with it. In the paper, the following points are discussed.

- Europe is Turkey's most important import/export partner, and CBAM will have a significant impact on trade between Turkey and Europe.
- Energy-intensive sectors such as steel, cement, glass, and aluminum will be severely affected.
- Determine what measures can be taken to ensure that the steel industry is not affected by this.
- Measures should include trying to implement low-carbon development policies and reducing energy-related emissions in the steel sector.
- Analyze the actual status of emissions from the steel industry and other factors
- It is essential to present and implement the latest technologies to improve the energy efficiency of the steel sector.

The above paper concludes that impact of CBAM on the steel industry cannot be overlooked, but it should be noted that the statistical data used in the paper is calculated based on the IPCC 2006 Guideline, which differs greatly from the methodology and resulting figures based on the World Steel Association's calculation methodology (basically the ISO 14404 series), that is widely used in the global steel industry. For example, with regard to energy-derived CO<sub>2</sub> emissions, the ratio of steel industry emissions (4.20

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<sup>45</sup> “The Impact of European Green Deal on Turkey’s Iron and Steel Industry: Decomposition Analysis of Energy-Related Sectoral Emissions” (2021.3, Celal Bayar University Journal of Science)

million t-CO<sub>2</sub> in 2018) to Turkey's overall emissions (521 million t-CO<sub>2</sub>/y in 2018) is assumed to be 0.8%. According to this, since crude steel production in 2018 was 37.3 million t-s, the intensity is 0.11 t-CO<sub>2</sub>/t-s, which is an unusually low value. It is presumed that coking coal and other materials are counted as non-energy-derived CO<sub>2</sub> (IPPU). In any case, it is assumed that there will be little impact on the qualitative conclusion that CBAM will have a significant impact on the Turkish steel industry, of which Europe is the largest trading partner. (See also 1.3.1 for CBAM developments.)

As for energy saving and CO<sub>2</sub> reduction, with the cooperation of EIE (Electricity and Natural Resources Research and Development Directorate) and JICA, a survey was conducted <sup>46</sup>at the beginning of the year 2000 in integrated iron/steel works and electric furnace iron/steel works, and a number of measures have been taken to reduce energy consumption. <sup>47</sup>

### **2.3.2 Extraction of issues (technical, financial, policy, etc.) related to low and decarbonization**

In Turkey, energy intensity may be large due to the long operation period of the old equipment. In addition, the byproduct gas from blast furnaces and converter furnaces is effectively used in integrated iron/steel works in Turkey to provide the necessary energy. However, it is necessary to confirm through field surveys or interviews, etc., how the gas holders and boilers are used to suppress gas emission. In addition, some energy-saving facilities such as CDQ and TRT have been introduced, but they are not sufficiently widespread and seem to have potential for CO<sub>2</sub> emission reduction. The diffusion rate needs to be confirmed through field surveys, etc.

In addition, the introduction of carbon border adjustment measures (CBAM) is currently under consideration in the EU. The border adjustment tax would first require steel, cement, aluminum, fertilizer, and electricity to have the same cost of compliance with emission regulations as EU products. Turkey's exports to the EU account for 29% of its total steel exports in 2020, so there are concerns about the impact of this measure.

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<sup>46</sup>"Turkey Energy Conservation Project", conducted from August 2000 to July 2005. ([https://www2.jica.go.jp/ja/evaluation/pdf/2008\\_0604267\\_4\\_f.pdf](https://www2.jica.go.jp/ja/evaluation/pdf/2008_0604267_4_f.pdf))

<sup>47</sup> At ISDEMIR (integrated steelworks), the implementation of no-cost and low-cost measures has resulted in an improvement in coke-making energy intensity (14%), blast furnace coke ratio (1%), steel bar heating furnace intensity (10%), and converter furnace IDF power intensity, resulting in an annual benefit of 7.8100 million yen. (JICA, 2004, [https://openjicareport.jica.go.jp/pdf/11803160\\_03.pdf](https://openjicareport.jica.go.jp/pdf/11803160_03.pdf))

### **2.3.3 Consideration and proposal of cooperation programs**

#### **(1) Status of the country supported**

##### **a) Motivations and gaps in Turkish government**

From the perspective of climate change, as mentioned above, the NDC has an ambitious goal of achieving net zero emissions by 2053, which shows a high level of motivation. In addition, considering the country's willingness to take in climate change funds from abroad, the situation is likely to be willingly accepting cooperation from Japan. On the other hand, we need to keep in mind that in practicing climate change countermeasures, the Turkish government is concerned about coexistence with economic development.

The Eleventh Development Plan (2019-2023) is helpful in understanding the Turkish government's stance on the steel industry in economic development. Here, the direction of the basic metal industry is indicated as "improving the production structure with the aim of improving the quality of manufactured goods," "expanding the types of high value-added products," and "increasing the proportion of production methods using ore". Particularly in the steel industry, the four clear policies are to "expand export volume and export markets," "prevent the import of low-quality steel," "improve the domestic supply chain based on the quality and size of steel grades used in strategic sectors such as defense, railroads, mega projects, and nuclear power generation," and "guarantee the supply of input resources. Taken together, it can be observed that Turkey considers the securing of stability in the production of steel, which is the foundation of development, as an issue/challenge, and that it is trying to expand and improve the quality of production by positioning the steel industry itself as a major external industry. This can be seen as a sign of Turkey's recognition of its position as the world's recycling plant.

On the other hand, what is particularly important in this 11th Development Plan is that the matters relating to climate change countermeasures are not mentioned in these directional documents. Therefore, it is possible that the Turkish government has little awareness of the link between fostering and strengthening the steel industry and combating climate change, or has not envisioned a technology or roadmap that would allow these two to coexist. Therefore, bridging this gap is considered to be an important factor in intergovernmental cooperation.

##### **b) Motivation and gaps in Turkish steel producers**

As mentioned above, it can be inferred that steelmakers in Turkey are generally proactive in energy conservation and CO<sub>2</sub> reduction, and motivation to respond to cooperation is considered to have been fostered. In addition, it may be

relatively easy to gain their trust for cooperation since they have experience in the past through training programs to enhance their capabilities in factory diagnosis. At the same time, since the three former state-owned blast furnaces have old equipment and may have large energy intensity, there is room for support. Considering that the energy intensity of the electric furnace method is 8.8 GJ/t crude steel in Turkey, there is ample room for energy conservation.

(2) Compatibility with the Japanese cooperation and development policy

The development cooperation policy of Japan for Turkey lists priority areas such as "support for the creation of a strong social infrastructure to support the economy," "strengthening of cooperation with the private sector," and "strengthening of cooperation as a development partner," and advocates human resource development in the industrial sector and sectoral support utilizing the strengths of Japanese companies, human resources, and technology. On the other hand, while the business development plan mentions the importance of improving energy efficiency (energy conservation) in the resources and energy sector, there is no specific cooperation program planned specifically for the steel industry. Therefore, this project is expected to strengthen this cooperation policy and increase the depth of cooperation programs.

On the other hand, JICA implemented an energy efficiency and conservation project in the 2000s and has been supporting factory audit technology mainly cooperated with the Energy Efficiency and Conservation Center (NECC), and the target sector includes the steel industry. The purpose of this project is to support the formulation of energy efficiency and conservation laws and provide capacity building and education on energy efficiency and conservation technologies for EIE/NECC(the Turkish National Energy Center of the General Directorate of Electricity Resources Research and Development) staff. However, this project is not specific to iron and steel manufacturing, but is intended for energy efficiency and conservation in a wide range of industries, including cement factories, etc. Therefore, the technical details of this project are different from the contents of cooperation specific to iron and steel manufacturing assumed in this report. The Energy Efficiency and Conservation Center of Turkey originally belonged to the EIE, but the EIE itself was closed in 2011 and changed to the "Directorate General of Renewable Energy" in 2012. Furthermore, in 2018, with the transition to a presidential system, the "Directorate General for Renewable Energy" was closed, and renewable energy operations were transferred to the "Directorate General for Energy-related Operations", while energy efficiency-related operations were transferred to the "Directorate General for Energy Efficiency and Environment", which was established in 2019. In light of these facts, the previous cooperation program for Turkey's energy-related ministries should be

updated for the Directorate General for Energy Efficiency and Environment, which has undergone significant changes, and it should be noted that it requires a different form of cooperation than the previous program, given the changes in organizational structure.

### (3) Proposal of cooperation programs for the country

The table below summarizes the short-term cooperation programs based on the above points. These assume Technical Cooperation projects as the basic form of cooperation. Since it was inferred that the motivation of both the government and the private sector is high in Turkey, it is preferable to take a top-down approach starting with a survey of the government's views and perceptions, and a bottom-up approach starting with a concrete understanding of the actual situation and room for energy efficiency and conservation in the private sector to estimate the overall situation of the country and to reflect it in the government's policies in parallel. In particular, it is likely that governments will find it easier to accept assistance by contrasting it with the content of the extensive energy conservation cooperation programs JICA conducted in the 2000s.

Table 2-9 Cooperation programs proposed for Turkey

Cooperation program	Scope	Importance & policy for cooperation
Policy building capacity improvement, policy recommendation ➤ Implementation of periodic statutory reporting system, etc. for energy conservation ➤ Support for formulating energy conservation/decarbonization promotion policies and roadmap development ➤ Support for implementation of energy efficiency and conservation incentive system	Government	Extremely important and high priority. In order to strengthen the government's policy toward the steel industry in an integrated manner in terms of combating climate change and strengthening the economy, the government should start by promoting the importance of energy conservation as the link between the two. Once the policy direction has been set, the implementation of a roadmap and incentive system to support it

Cooperation program	Scope	Importance & policy for cooperation
		should be supported. Existing incentive programs (e.g., energy efficiency support projects based on the Energy Efficiency Act) are already in place, but further institutional and financial reinforcement is expected by clarifying the actual status of their public offerings and private company's barriers.
<p>Energy efficiency and conservation assessment at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ BAT feasibility study</li> <li>➤ Survey on potential for utilization of unused energy (exhaust heat, by-product gas, etc.)</li> </ul>	Private business organizations & private business operators	<p>Extremely important and high priority.</p> <p>It is important to grasp the possibility that there is a large room for energy conservation as a reality. Understanding the utilization potential of unused energy of multiple companies will ensure the reliability of BAT's proposals.</p> <p>In addition, it is desirable to conduct this cooperation at the same time as the diagnosis, because listening to the issues of fundraising from governmental projects in conjunction with the diagnosis will lead to a review of the existing system in the above-mentioned "improvement of policy-making capacity and policy recommendations.</p>
Support for developing a roadmap for CO <sub>2</sub> reduction in	Government & private business	It should be implemented in the

Cooperation program	Scope	Importance & policy for cooperation
<p>the steel industry</p> <ul style="list-style-type: none"> <li>➤ Administration of public-private meetings and seminars for industry players</li> <li>➤ Top management level capability improvement (ISO 50001, ISO 14001)</li> <li>➤ Support for developing supply chain CO<sub>2</sub> reduction roadmaps</li> </ul>	<p>operators (Japanese government/Japanese private business operators)</p>	<p>context of, or in parallel with, improving policy-making capability and policy recommendations.</p> <p>At present, there is the possibility that the government's policies are not systematically organized, and in addition, the relationship between industry players and the government is not clear. In particular, it is necessary to be cautious about holding public-private meetings when the government's policies are not yet organized, as it may cause confusion among industry players.</p>
<p>Support for planning the implementation of eco-processes and pilot equipment</p> <ul style="list-style-type: none"> <li>➤ Support for detailed planning</li> <li>➤ Support for matching with equipment manufacturers, etc.</li> <li>➤ Support for consideration of financing methods</li> </ul>	<p>Private business operators</p>	<p>Since the country has been active in energy conservation in various projects relating to the energy manager program and energy laws, this could be an important cooperation program in terms of supporting those efforts.</p>
<p>Improvement of decarbonization and energy conservation support tools for iron/steel works.</p> <ul style="list-style-type: none"> <li>➤ ISO 14404 promotion</li> <li>➤ TCL formulation and promotion</li> <li>➤ BAT preparation and promotion</li> <li>➤ Energy balance modeling tool</li> <li>➤ Improvement measures</li> </ul>	<p>Government &amp; private business organizations</p>	

Cooperation program	Scope	Importance & policy for cooperation
identification tool		

#### <Turkey's Administrative System>

The system of government in Turkey shifted from a parliamentary to an intrinsic presidential system, in which the president solely employs the executive power granted from the constitution, after the elections held on June 26, 2018. An overview of the constituent ministries is shown in the figure below. Also, the ministries and departments that may be relevant to energy conservation in the steel sector are listed below. For these ministries and departments, further detailed research is needed on their more detailed roles, as information on detailed assignment of planning, institutional design, implementation, etc. could not be obtained from the relevant websites. Since the Ministry of Environment and Urbanization was changed to the Ministry of Environment, Urbanisation, and Climate Change on October 29, 2021, the notation differs from that in the figure. The possible C/P in this case is most likely the Department of Energy efficiency and environment of the Ministry of Energy and Natural Resources or the General Directorate of Industry of the Ministry of Industry and Technology. However, as mentioned above, note that it is necessary to go through confirmation of institutional and other sharing of responsibilities.

- Ministry of Environment, Urbanization and Climate Change
  - General Directorate of Environmental Impact Assessment, Permission and Inspection
  - Directorate General of Environmental Management
- Ministry of Energy and Natural Resources
  - General Directorate of Energy Affairs
  - Department of Energy efficiency and environment
- Ministry of Industry and technology
  - General Directorate of Industry
- Ministry of Trade

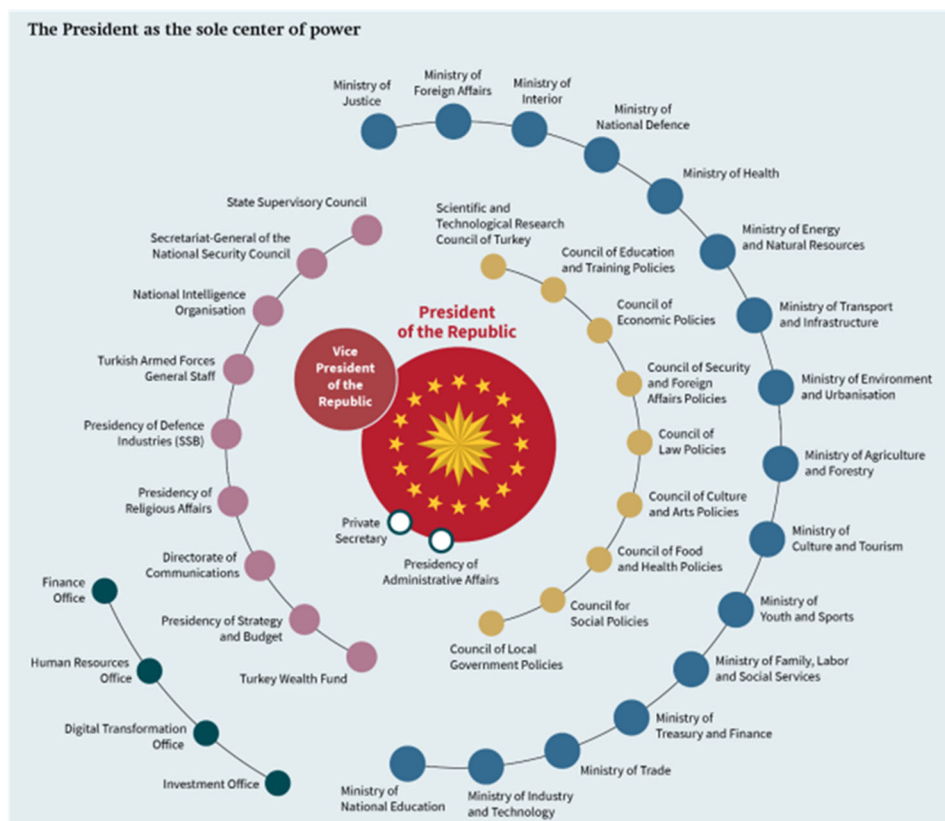


Figure 2-18 Administrative System of Turkey

Resource : SWP Research Paper “Turkey’s Presidential System after Two and a Half Years” ([https://www.swp-berlin.org/publications/products/research\\_papers/2021RP02\\_Turkey\\_Presidential\\_System.pdf](https://www.swp-berlin.org/publications/products/research_papers/2021RP02_Turkey_Presidential_System.pdf))

## 2.4 Vietnam

### 2.4.1 Analysis of current situation (level of facility capacity, technology, and energy management of major companies, policies and institutions, etc.)

#### (1) Overview of Vietnam's Steel Industry

Vietnam is the world's 14<sup>th</sup> largest producer of crude steel (20.1 million tons) as of 2019, with blast furnace steel accounting for 55.8% and electric arc furnace steel 28.2% of total crude steel production. In Vietnam, Formosa Ha Tinh Steel (FHS), one of the first and largest integrated blast furnace iron/steel works in Southeast Asia, has been operating since 2017, and several other integrated blast furnace iron/steel works are in operation. The growth of steel production has been remarkable in recent years (Figure 2-19). 40% of the final products manufactured are long products used in construction materials (Table 2-10). In 2019, Vietnam imported steel the most from China (35%), followed by India and Japan (Table 2-11). The largest export destination is ASEAN (62%), followed by China (6%) and the United States (5%)(Figure 2-20 ).

Vietnam is one of the 11 countries that are parties to the Comprehensive and

Progressive Agreement on Trans-Pacific Partnership (CPTPP), and the Free Trade Agreement with the European Union (EVFTA) has been in effect since August 2020. While the issuance of these free trade agreements is expected to further expand the steel market, the increase in steel imports may have an impact on steel prices and local companies.

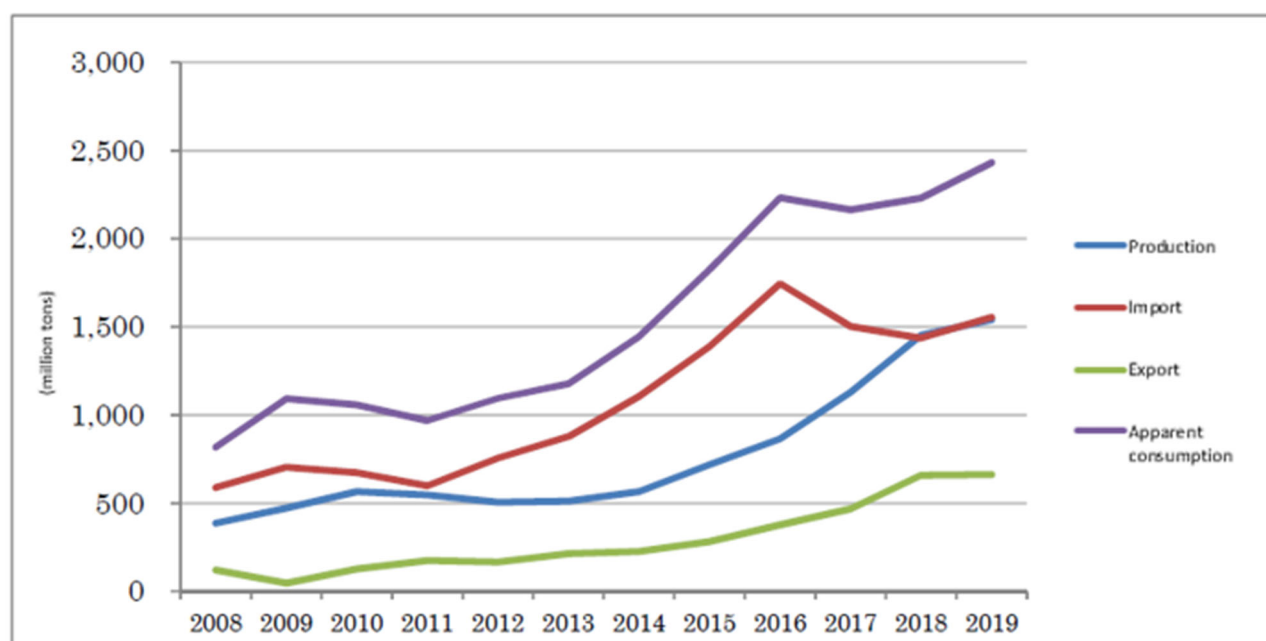


Figure 2-19 Vietnam Steel Supply and Demand

Source: Prepared by the National Survey Institute (NSRI) from SEASIS Statistical Yearbook

Table 2-10 Iron and steel production in Vietnam (thousand tons)

Products	2017	2018	2019
Total of finished steel production	22,101	25,602	26,334
Hot-rolled sheets & strips	1,378	3,439	4,130
Cold-rolled products	3,825	3,867	3,947
Metallic & color coated	4,667	4,710	4,470
Welded steel pipe	2,307	2,493	2,516

Source: SEASIS, Vietnam Iron and Steel Association

Table 2-11 Countries exporting steel products to Vietnam

Country	2019		Share (%)	
	Volume	Value	Volume	Value
Total	14,555,064	9,507,800	100.00%.	100.00%.
China	5,143,330	3,299,900	35.34%.	34.71%.
India	2,213,766	1,100,500	15.21%.	11.57%.
Japan	2,084,461	1,358,300	14.32%.	14.29

Source: SEASIS, Vietnam Iron and Steel Association

### Top 10 largest destinations for steel exports of Vietnam in 2019

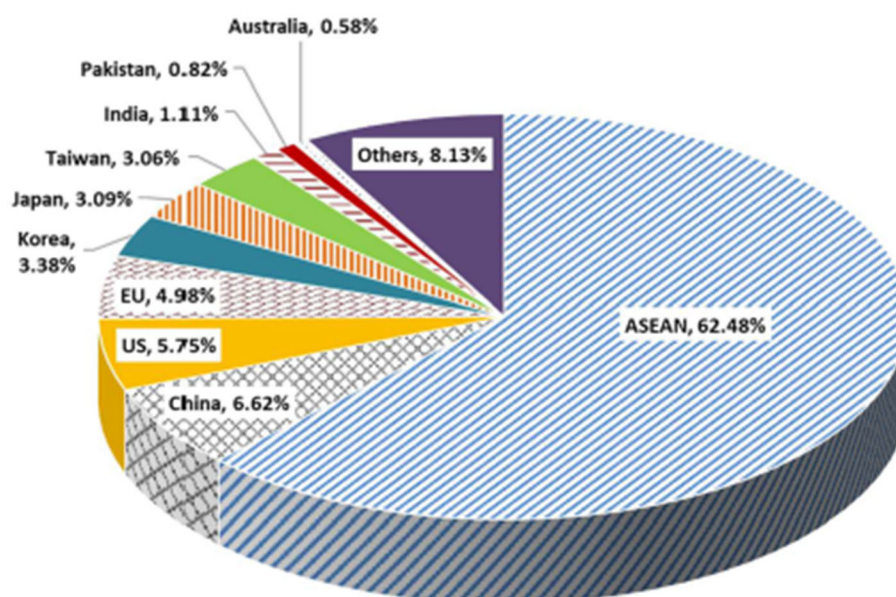


Figure 2-20 Export Destinations of Steel Products from Vietnam

Source: Industry and Trade Information Center, Ministry of Industry and Trade, Vietnam; Vietnam Steel Association; SEAISI.

#### (2) Overview of Major Steel Companies in Vietnam

In Vietnam, there are several blast furnace manufacturers (Viet Nam Steel, Formosa Ha Tinh Steel, Hoa Phat Steel JSC, Van Loi Group) and electric furnace manufacturers (18 Vietnam Iron and Steel Association members).

Outline of major iron/steel works with high crude steel production capacity in blast furnaces and electric furnaces, and their facilities are shown in Table 2-12, Table 2-13 and their locations are shown in Figure 2-21.

Formosa Ha Tinh Steel is a foreign-owned integrated blast-furnace steel works. Their first blast furnace started operation in May 2017 and the second blast furnace was put into operation on May 2018. The company is said to be considering further expansion. The company is led by Taiwan's Formosa Plastics Group, and is partly owned by Taiwan's China Steel and JFE Steel.

Hoa Phat Steel JSC is a local company with iron/steel works in northern and central Vietnam. By recovering and reusing heat and exhaust gas for power generation, the company is saving 1 trillion dong (approximately 5 billion yen) per year and reducing greenhouse gas emissions<sup>48</sup>. In addition, 80% of the company's electricity needs are covered by its own power generation through

<sup>48</sup> Hoa Phat's Annual Report 2020 (<https://file.hoaphat.com.vn/hoaphat-com-vn/2021/04/annual-report-2020-eng.pdf>)

waste heat recovery, including the introduction of CDQ, but the company was not recovering and using coke oven gas when the survey team members visited in 2018.

In Vietnam, in the 2000s, local companies with a certain level of scale, such as Hoa Phat Steel JSC, entered the market and introduced state-of-the-art equipment (hardware) at the time of their entry. However, according to the Vietnam Iron and Steel Association, they are still lacking the software to use the equipment properly and are not able to achieve full performance in terms of productivity and energy efficiency.<sup>49</sup> When the members of the survey team visited in the past, they found some issues such as the lack of interest in energy management among the local staff.

Pomina Steel was established in 1999, and has purchased advanced equipment from suppliers such as Techint, SMS-Concast, Siemens-VAI, etc. For electric furnaces, the company has introduced Consteel, a scrap preheating electric furnace. The company plans to start up a small blast furnace with a production capacity of 200,000 tons/year in a 2020 to utilize the hot metal in the electric furnace and to supply the generated gas to a newly built power generation facility.

Nghi Son Iron and Steel is a subsidiary of Vietnam American Steel (VAS). The company is using Tenova's Consteel to reduce the power consumption of its electric furnaces to less than 350 kWh/ton<sup>50</sup>.

Posco Yamato Vina Steel is 51% owned by Posco (South Korea) and 49% by Daiwa Kogyo (Japan), while Tung Ho Steel Vietnam is 100% owned by Tung Ho Steel (Taiwan).

Southern Steel Company is wholly owned by the state-owned Viet Nam Steel. Its main source of iron is imported scrap, and its main product is deformed steel bars. According to the information obtained from past visits by the survey team, new large-scale equipment has been installed, but its performance has not been fully realized and there is room for improvement in terms of production volume and operation technology. According to the information obtained from past visits by the survey team, the executives are proactive in energy conservation and CO<sub>2</sub> reduction.

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<sup>49</sup> From the report on the 26 fiscal year 2015 project to promote the diffusion of technologies to combat global warming (feasibility study on the JCM project by introducing energy-saving technologies to the Vietnamese steel industry) (JFE Techno Research, JFE Steel, 20153).

<sup>50</sup> <http://steelbuilder.vn/en/project/nghi-son-iron-and-steel-factory/>

Table 2-12 Overview of major iron/steel works in Vietnam

No	Company name	Office	Crude steel production capacity (thousand tons/year)	Upper process	Main Products	National/Foreign	Information on saving CO2 and energy	Notes
1	Formosa Ha Tinh Steel (Formosa HTS)	Vung Ang, Ha Tinh Province	7,000	Blast Furnace Integrated	Hot rolled, bar wire (Thick plate, cold rolled, CG, electromagnetic)	Foreign capital (Taiwan and Japan) 9.50%	CDQ, TRT (2017) Introduction	Formosa Plastics (Taiwan) 72.75%? CSC (Taiwan) 20.45%? JFE Steel 4.09%? and 5% of local companies in Vietnam.
2	Hoa Phat Steel JSC	Hai Duong Province Kinh Mon	1,650	Mini BF-LD	Rebar, thick plate	Local		Hoa Phat Group
3	Hoa Phat Steel JSC	Quang Ngai Province Dung Quat Economic Development Zone	2,000	Blast Furnace Integrated	Steel bars, (hot rolled)	Local		Hoa Phat Group
4	Pomina Steel	Ba Ria-Vung Tau Province Phu My and others	1,600	EF	Rebar, cold rolled, CG, color	Local ? ※No definitive information		Shareholder Thép Việt (under VN Steel?)
5	Nghi Son Iron and Steel (NSI)	Thanh Hoa Province	1,000	EF	Rebar	Local ? ※No definitive information		The parent company is Vietnam American Steel (VAS)
6	Posco Yamato Vina Steel	Ba Ria-Vung Tau Province Phu My	1,000	EF	Rebar, shaped steel	Foreign capital		The shares were acquired 51% by POSCO and 49% by Yamato Group (Japan)
7	Tung Ho Steel Vietnam	Ba Ria-Vung Tau Province Phu My	1,000	EF	Billet	Foreign capital		Towa Steel (Taiwan) 100%.
8	Southern Steel Company	Phu My industrial zone 1, Vung Tau Province	1,000	EF	Steel rebar	State-owned (part of Vietnam Steel)	Scrap preheater made by DANIELI (poor operating condition) Equipment arrangement is consistent with electric furnace-CC-heating furnace, and direct rolling orientation	New, large scale facilities, but are not performing to their full potential There are problems in terms of production volume and operation technology

Source: Compiled by NSRI from various sources.

Table 2-13 Facilities of Major iron/steel works in Vietnam

No	Company Name	Number of units (start of operation year)						
		Blast Furnace	Converter	Coke Ovens	Sintering Furnace	Electric Furnace	Heating Furnace	DR
1	Formosa Ha Tinh Steel (Formosa HTS)	2 units (17, 18)	3 units (17, 17, 18)	5 units (15, 18)	2 units (17)	—	?	—
2	Hoa Phat Steel JSC	3 units (10, 14, 16)	4 units (10, 14, 14, 16)	1 unit	1 unit (14)	—	?	—
3	Hoa Phat Steel JSC	2 units (19, 19)	2 units (19, 19)	8 units (19)	1 unit (19)	—	?	—
4	Pomina Steel	—	—	—	—	1 unit (07) ※60tEF 1 unit (14) ? ※Location may vary	?	—
5	Nghi Son Iron and Steel (NSI)	—	—	—	—	1 unit (Not in work ?)	?	—
6	Posco Yamato Vina Steel	—	—	—	—	1 unit (15)	?	—
7	Tung Ho Steel Vietnam	—	—	—	—	1 unit (12)	?	—
8	Southern Steel Company	—	—	—	—	1 unit (06) ※85tons	80ton/h walking hearth furnace	—

Source: Compiled by NSRI from various sources.

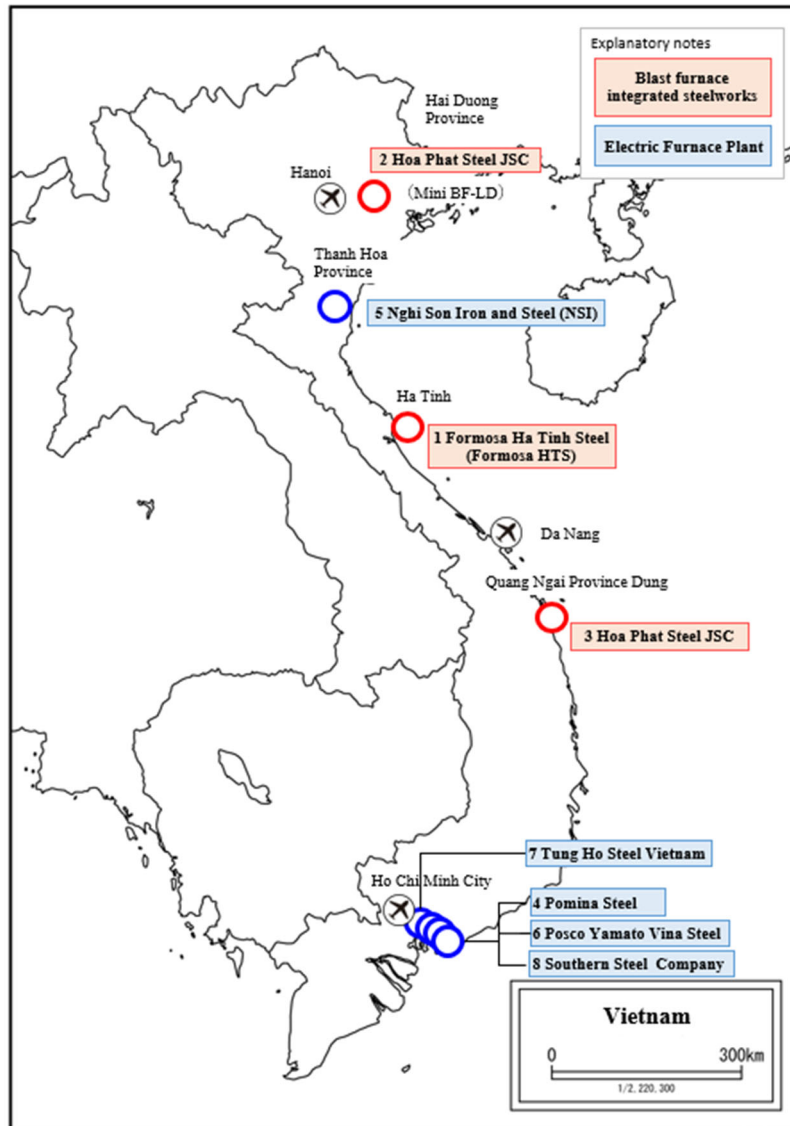


Figure 2-21 Location of major iron/steel works in Vietnam

Source: Compiled by NSRI from various sources.

(3) Energy-saving, low-carbon, and decarbonization-related policies and systems in Vietnam

An overview of NDC in Vietnam (in September 2020) is as follows.

- By 2030, reduce GHG emissions by 9% (83.9 million t-CO<sub>2</sub>) through domestic efforts (compared to BAU, base year is 2014).
- Reduce GHG emissions by 27% (250.8 million t-CO<sub>2</sub>) if international assistance is obtained.
- The reduction rate for "industrial processes" is set at 0.8% (7.2 million t-CO<sub>2</sub>) with domestic efforts alone and 0.9% (8 million t-CO<sub>2</sub>) with international assistance.

The following climate change related measures have been taken in Vietnam<sup>51</sup>.

- The National Target Program to respond to Climate Change (NTP-RCC) (2008 and 2012): Provides a basic framework for climate change action. The Ministry of Natural Resources and Environment (MONRE) is responsible for coordination and implementation.
- Support Program to Respond to Climate Change (SP-RCC) (2010): A platform for the coordination of foreign assistance, supported by the World Bank, Japan International Cooperation Agency (JICA), and the French Development Agency.
- National Climate Change Strategy (2011): Sets out a long-term policy for the period up to 2050, and sets numerical targets for climate change mitigation measures in each sector. Energy-saving measures by the "industrial production and construction" sector include "increasing the contribution of industrial production through the use of advanced technology and adding 42-45% of value to industrial production by 2020", "promoting technological innovation toward advanced technology", "using advanced technology and equipment at a rate of 20% by 2020", and "increase the contribution of industry using state-of-the-art technology by at least 80% by 2050". The Ministry of Natural Resources and Environment (MONRE) is in charge.
- Green Growth Strategy (2012): Numerical targets have been proposed for the reduction of greenhouse gas emissions, green production, and the promotion of green lifestyles and sustainable consumption. The Ministry of Planning and Investment (MPI) and the Ministry of Finance (MOF) are in charge.
- Environmental protection tax (2012annual): levied on fossil fuels.

Laws and regulations in the field of energy efficiency and conservation have been developed at an earlier stage than climate change-related policies, as follows.<sup>51</sup> The Ministry of Industry and Trade (MOIT) is in charge of energy conservation policies.

- Regulations on conservation and energy saving (2003)
- National Strategic Program on Energy Saving and Energy Use (2006)
- Laws related to energy conservation (2010)
- National target program in energy conservation (2012 to 2015): Targets for curbing energy consumption, including intensity targets in the steel, cement, and textile industries, were presented.
- Energy Efficiency Master Plan (Vietnam Energy Efficiency Program

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<sup>51</sup> See IGES, "Vietnam's Climate Change Mitigation Measures: Current Status and Future Challenges."

(VNEEP)) (2006, 2011, 2019): Phase III is currently underway covering the period from 2019 to 2030. In the steel sector, the targets are to reduce energy consumption by 3-10% by 2025 and 5-16% by 2030, depending on the type of product and manufacturing technology<sup>52</sup>.

- Resolution on the direction of the National Energy Development Strategy from 2021 to 2030, looking forward to the year 2045 (2020): The energy development policy of Vietnam was presented, including the promotion of renewable energy and energy conservation. It is mentioned that sanctions, mandatory standards and regulations on energy efficiency will be implemented for sectors and products with high energy consumption.<sup>53</sup>

In November 2020, the "Amended Law on Environmental Protection" was adopted, requiring the Ministry of Natural Resources and Environment (MONRE) to design a national emissions trading market (ETS) and MRV system.<sup>54</sup> The target sectors have not been determined, but as a technical preparation, Vietnam has been working with the World Bank's Market Readiness Partnership (PMR) since 2013 to develop pilot markets in the steel, solid waste, and electricity sectors. According to a document by MONRE,<sup>55</sup> a tentative roadmap shows that the introduction of a voluntary pilot ETS market and detailed design of a mandatory emissions trading market will come in 2026-2027, and the implementation of a mandatory domestic emissions trading market will start from 2028.

Regarding a policy related to the steel industry, the Ministry of Industry and Trade of Vietnam had started to prepare the "Vietnam Steel Industry Development Master Plan (2015~2025)", but the plan was abolished in 2019.

The energy intensity of Vietnam's industrial sector is said to be higher than the global benchmark for energy intensity. The low energy efficiency is due to the use of outdated technology, and investment in energy efficiency will improve the competitiveness of the steel sector and reduce CO<sub>2</sub> emissions. According to a World Bank study in 2016, investment in energy conservation in iron/steel works can reduce energy consumption by a cumulative total of about 45,000

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<sup>52</sup> Prime minister, "Decision on approval of the National Energy Efficiency Program for the period of 2019-2030." Available at: [http://gizenergy.org.vn/media/app/media/the-signed-version-of-VNEEP\\_ENG\\_GIZ.pdf](http://gizenergy.org.vn/media/app/media/the-signed-version-of-VNEEP_ENG_GIZ.pdf)

<sup>53</sup> Central Committee of the Communist Party of Vietnam, "On Orientations of the Viet Nam's National Energy Development Strategy to 2030 and outlook to 2045." Available at: <http://vepg.vn/wp-content/uploads/2020/03/CPCs-Resolution-55.NQ-TW-on-Energy-Development-Strategy-to-2030-and-outlook-to-2045.pdf>

<sup>54</sup> ICAP (International Carbon Action Partnership) website: <https://icapcarbonaction.com/en/news-archive/730-new-law-in-vietnam-creates-mandate-for-ets>

<sup>55</sup> MONRE (2021), "PMR East Asia and Pacific Regional Webinar on Carbon Pricing - from Readiness to Implementation" <https://www.thepmr.org/system/files/documents/Luong%20Quang%20Huy%20presentation.pdf>

GWh between 2015 to 2030.<sup>56</sup> Against this backdrop, the needs and potential for energy conservation and CO<sub>2</sub> emission reduction in Vietnam's steel sector are considered to be high.

#### **2.4.2 Extraction of issues (technological, financial, policy, etc.) related to low-carbon and decarbonization**

In promoting the introduction of energy efficiency and conservation technologies, the lack of human resources with expertise, the lack of energy management systems, and the lack of capacity to implement energy efficiency and conservation measures are among the issues that need to be addressed.

On the other hand, Southeast Asia, including Vietnam, has been facing an oversupply of steel due to China's capital investment in steel and imports of cheap steel from neighboring countries such as China and Iran (Figure 2-22). This has been an issue for some time. Local companies are facing fierce competition, and many of them cannot afford to invest in energy conservation. With the acceleration of the world's decarbonization, Southeast Asia is seen as having lower costs than other countries and regions for climate change measures, such as carbon taxes, and could be a target for investment, including steel, so there is no prospect of easing the overcapacity. In addition to the use of policies and systems that promote capital investment, such as JCM's equipment subsidy programs, it would be effective to consider and implement measures that contribute to the improvement of productivity and added value (cost reduction, etc.) as well as the realization of energy conservation.

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<sup>56</sup> The World Bank (2016) "Exploring a Low-Carbon Development Path for Vietnam."

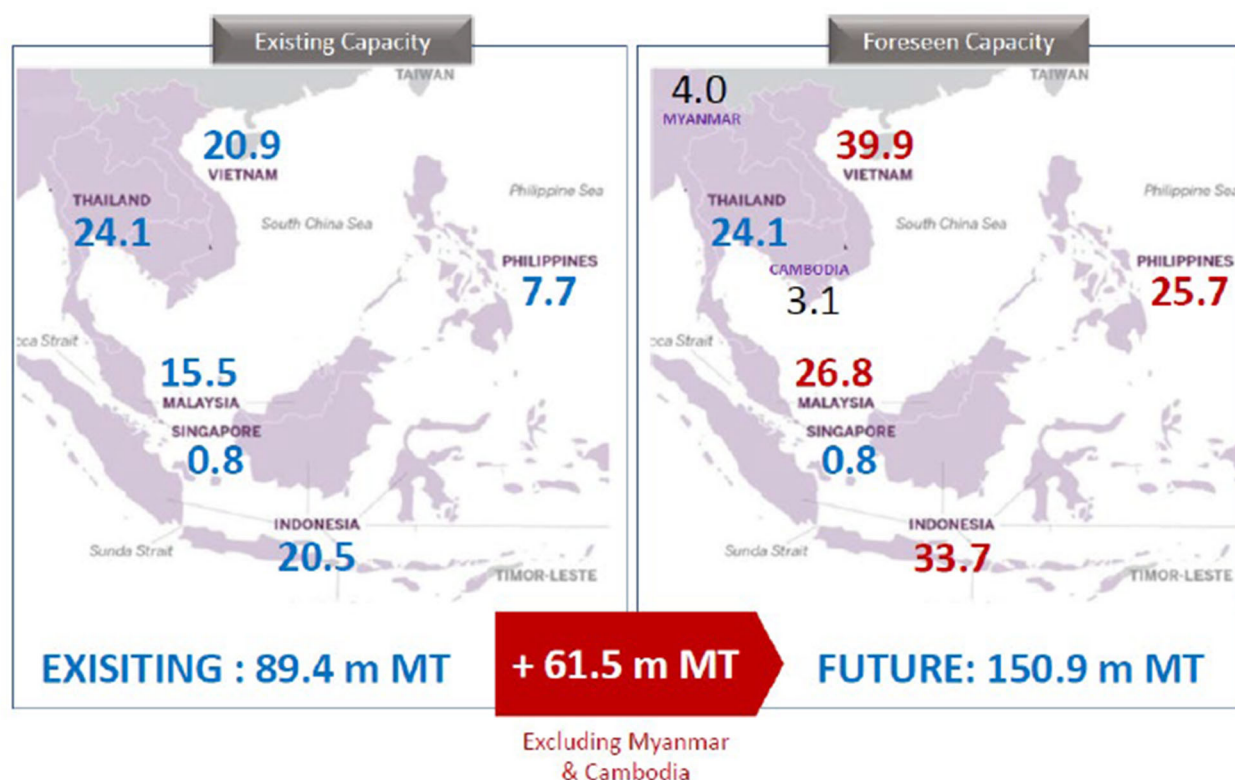


Figure 2-22 Outlook for Capacity Expansion in the ASEAN Region

Source: SEAISI e-conference materials (2020), partially processed by NSRI.

### 2.4.3 Consideration and proposal of cooperation programs

#### (1) Status of the country supported

##### a) Motivations and gaps in Vietnamese government

In terms of climate change, specific motivation can be observed in the National Climate Change Strategy, which clearly states the introduction of state-of-the-art technology in industrial production, and the Green Growth Strategy, which advocates the reduction of greenhouse gas emissions. In addition, the Energy Conservation Master Plan also states specific energy consumption reduction figures for the steel sector, and there is a high possibility that support will be gained for encouraging the achievement of these goals through well-defined cooperation.

Further, the "Industrial Development Strategy through 2025, vision toward 2035" indicates that emphasis will be placed on three types of industries until 2025, including steel manufacturing, specifically steel plate, shaped steel, and alloy steel. It indicates that investment will be made in the development of steel production for mechanical engineering. Thus, the motivation has already begun to materialize.

On the other hand, according to "Vietnam 2035 Toward Prosperity, Creativity, Equity, and Democracy (World Bank Group, Ministry of Planning and Investment

of Vietnam, 2016)", Vietnam's iron and steel industry uses twice as much energy per product as the global average due to the use of old technology. Not only does this represent a significant gap with the goals, but it also represents a need for urgent action to improve energy efficiency, as it actually contributes to worsening air pollution.

#### b) Motivation and gaps in Vietnamese steel producers

As mentioned above, it can be inferred that steel companies in Vietnam are generally proactive in energy conservation and CO<sub>2</sub> reduction. This is also reinforced by the fact that the executives of Southern Steel Company were proactive in energy conservation and CO<sub>2</sub> reduction.

However, in contrast to this motivation, the market environment is severe and forms a large gap for the future, which clearly identifies the room for support in this project. Specifically, local companies, exposed to international competition, cannot afford to invest in energy efficiency and conservation, and despite this, energy development policies have introduced sanctions and mandatory standards for energy efficiency improvement. In addition, the survey team has obtained information on the following detailed gaps in its previous surveys. It can therefore be said good foundation has been laid for relatively smooth implementation of this project.

- Soft measures are lagging behind the implementation of state-of-the-art hardware.
- Hoa Phat Steel JSC did not reclaim coke oven gas.
- Local staff are not highly interested in energy management.

#### (2) Compatibility with the Japanese cooperation and development policy

In the Development Cooperation Policy, "Growth and Competitiveness Enhancement" has been specified as a priority area for Vietnam. Strengthening industrial competitiveness is advocated here, with the objective of contributing to the enhancement of international competitiveness.

In the business deployment plan, a large number of infrastructures such as ports, airports, highways, railroads, and power plants are scheduled to be developed to support Vietnam's efforts to become an industrialized country in the above priority areas, indicating that the country is trying to form the foundation for industrial development. In contrast, there are few plans for supporting the production of the steel materials used to create these facilities and equipment. Therefore, although depending on the timeline, support through this project may lead to the underpinning of other large-scale development projects, thereby creating a synergistic effect of development cooperation.

(3) Proposal of cooperation programs for the country

The following table summarizes the cooperation programs based on the above points.

Table 2-14 Cooperation programs proposed for Vietnam

Cooperation program	Scope	Importance & policy for cooperation
<p>Policy building capacity improvement, policy recommendation</p> <ul style="list-style-type: none"> <li>➤ Implementation of periodic statutory reporting system, etc. for energy conservation</li> <li>➤ Support for formulating energy conservation/decarbonization promotion policies and roadmap development</li> <li>➤ Support for implementation of energy efficiency and conservation incentive system</li> </ul>	Government	Extremely important. After sharing the fact that energy conservation is effective not only as a measure against global climate change but also as a local environmental measure, we should start by discussing a roadmap on how to achieve specific goals in the policy of promoting energy conservation and decarbonization.
<p>Energy efficiency and conservation assessment at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ BAT feasibility study</li> <li>➤ Survey on potential for utilization of unused energy (exhaust heat, by-product gas, etc.)</li> </ul>	Private business organizations & private business operators	This is very important, but should be done based on a survey on the position of private business organizations. It is desirable to not only collect information on the actual situation of local iron/steel works to enhance the survey conducted by the survey team, but also to contact and collect information from private business organizations and individual business operators from the perspective of extracting detailed issues and challenges of the Vietnamese steel industry, which is

Cooperation program	Scope	Importance & policy for cooperation
		exhausted due to exposure to the international market environment.
<p>Support for developing a roadmap for CO<sub>2</sub> reduction in the steel industry</p> <ul style="list-style-type: none"> <li>➤ Hold public-private meetings and seminars for industry players</li> <li>➤ Top management level capability improvement (ISO 50001, ISO 14001)</li> <li>➤ Support for developing supply chain CO<sub>2</sub> reduction roadmaps</li> </ul>	Government & private business operators (Japanese government/Japanese private business operators)	The results of this study did not lead to the conclusion that a roadmap is urgently needed due to the current situation in Vietnam. For this reason, it is desirable to conduct a detailed study and summarize the intentions of private business organizations and the government, and then specify the steps that should be taken before the roadmap is formulated.
<p>Support for planning the implementation of eco-processes and pilot equipment</p> <ul style="list-style-type: none"> <li>➤ Support for detailed planning</li> <li>➤ Support for matching with equipment manufacturers, etc.</li> <li>➤ Support for consideration of financing methods</li> </ul>	Private business operators	It is important but not a priority. Based on the results of the survey, we believe that the local environment is ready for the project to move forward, but it may cause conflicts among the parties involved if the intentions of the government and private business organizations are not heard before the implementation planning.
<p>Development of tools to support decarbonization and energy conservation at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ Promotion of ISO 14404</li> <li>➤ TCL formulation and promotion</li> <li>➤ BAT preparation and</li> </ul>	Government & private business organizations	The program should be carried out after the implementation of policy building capacity improvement and policy recommendation. This is because without the

Cooperation program	Scope	Importance & policy for cooperation
<p>promotion</p> <ul style="list-style-type: none"> <li>➤ Energy balance modeling tool</li> <li>➤ Improvement measures identification tool</li> </ul>		<p>direction of the government, specific issues will not be addressed and the effectiveness of this program, which provides tools to achieve these challenges, will not be enhanced.</p>

## 2.5 Indonesia

### 2.5.1 Analysis of current situation (level of facility capacity, technology, and energy management of major companies, policies and institutions, etc.)

#### (1) Overview of the Indonesian Steel Industry

Indonesia is the world's 26<sup>th</sup> largest producer of crude steel (6.4million tons) in 2019 with blast furnace steel accounting for 41% and electric arc furnace steel 59%. Indonesia's steel production is on the rise due to the start of operations at large integrated blast furnace iron/steel works (Figure 2-23). On the other hand, the Indonesian steel industry is struggling with price competitiveness against imported steel products. The Indonesian government has announced that it will reduce industrial energy prices and ease restrictions on scrap imports in order to support local manufacturers' operations, and has also introduced restrictions on steel import licenses, including a registration system for importers of steel products. In terms of supply and demand by product type, demand for long products and flat products is almost equal, with infrastructure construction being the main purchaser, followed by automobiles.

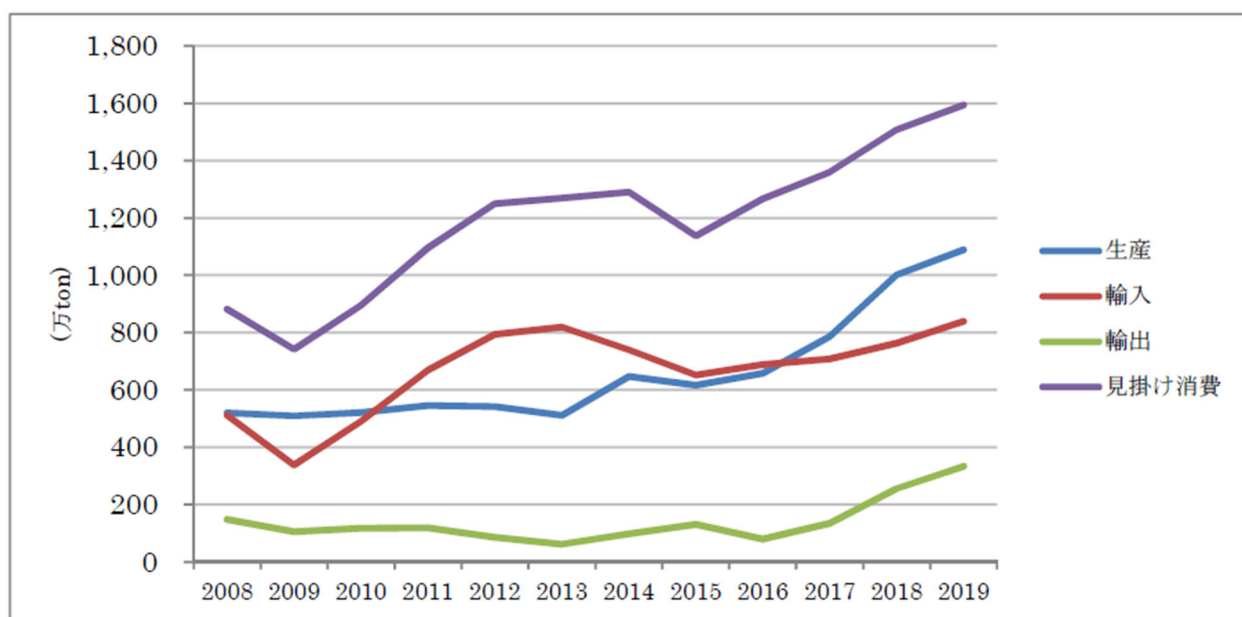


Figure 2-23 Supply and Demand for Steel Products in Indonesia

Source: Prepared by the National Survey Institute (NSRI) with reference to SEAISI Statistical Yearbook.

Indonesia is projected to be the world's 4<sup>th</sup> largest economy by 2050,<sup>57</sup> and steel consumption is expected to increase in line with economic growth. There are plans to invest in additional capacity of more than 20 million tons per year in the future, and it is said that large-scale capital investment is needed to develop the capacity of the steel industry in the long term (Figure 2-24).

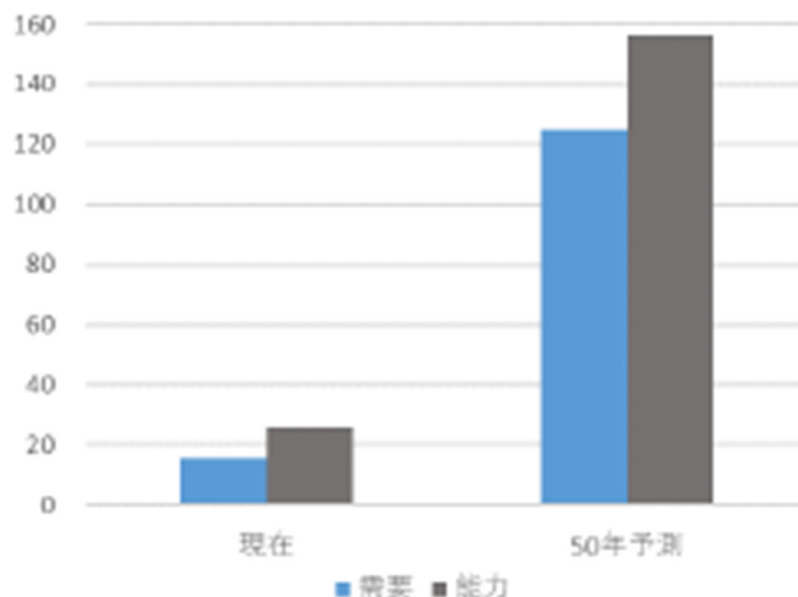


Figure 2-24 Indonesia's steel demand and capacity forecast (million tons)

Source: Made by NSRI based on data from the Indonesian Steel Association.

<sup>57</sup> PwC (2017Year), "The World in a 2050: Will the shift in global economic power continue?"

## (2) Overview of Major Steel Companies in Indonesia

There are about 20 steelmakers in Indonesia, but only a few of them, such as Krakatau Steel, Krakatau Posco, and Gunung Raja Paksi, have blast furnaces, while the rest are steel manufacturers with electric furnace or re-rolling manufacturers.

Outline of major iron/steel works with high crude steel production capacity in blast furnaces and electric furnaces, and their facilities are shown in Table 2-15, Table 2-16 and their locations are shown in Figure 2-25.

Krakatau Steel is a state-owned company, but has been running at a loss for many years. There is talk of privatization, but there seems to be no one willing to undertake it. The company uses iron ore pellets and iron scrap as raw materials to produce sponge iron by direct reduction using natural gas, and then produces slabs and billets in an electric furnace. A new blast furnace with a capacity of 1.2 million tons was put into operation in 2019, but due to the influx of inexpensive billets and other materials from overseas, it was suspended in December 2019, and is scheduled to start operation in the 3<sup>rd</sup> quarter of 2022. Hot metal was planned to be injected directly into the existing electric furnace.

Krakatau POSCO is a joint venture between Krakatau and POSCO (South Korea), established in 2010.

Gunung Raja Paksi was established in 1986, and acquired Gunung Garuda, Indonesia's only manufacturer of large shaped steel, in 2019. The company, which was owned by an overseas Chinese family, was listed on the stock exchange at the same time as the merger. The company is competitive because it produces products that are not produced by other domestic companies, such as thick plates, ERW pipes, and cold-rolled steel sheets. The company has plans to build a new blast furnace, but the timing of its operation is unclear due to the influence of the COVID-19 pandemic. The company is also active in new technology initiatives, and in 2008 installed a thermal storage burner in its heating furnace under the NEDO energy conservation model project, implemented by current Nippon Steel Engineering. In addition, at the webinar "Carbon Neutral in Steel industry policies & challenges" organized by the Indonesian Iron and Steel Industry Association (IISIA) on October 21<sup>st</sup>, 2021, the company discussed emission trading, setting up green zones in cooperation with universities, and implementation waste management as short-term carbon neutral measures. In addition, they mentioned the Indonesian steel industry needs to improve energy efficiency, use clean energy, and introduce CCUS in the future.

Ispat Indo mainly produces wire rods from imported scrap and DRI, and is the largest wire rod manufacturer in Indonesia. Its energy intensity is low due to poor market conditions and low production volume. On the other hand, according to the information obtained from past visits by the survey team, the engineers

are highly motivated and excellent, and the executives are also active in energy conservation and CO<sub>2</sub> reduction. The company has been designated by the Indonesian Ministry of Industry as a model company for promoting energy efficiency and conservation, and has been dispatching staff to Japan and accepting Japanese survey groups on an ongoing basis.

Table 2-15 Overview of major iron/steel works in Indonesia

No	Company name	Office	Crude steel production capacity (thousand tons/year)	Upper process	Main Products	National/Foreign	Information on saving CO2 and energy	Notes
1	Krakatau Steel	Cilegon	3,075	DR-Blast furnace	Wire, hot and cold rolled	State-owned company		Krakatau Hot metal is fed directly into the existing electric furnace.
2	Krakatau Posco	Cilegon	3,000	Blast furnace - converter	Thick plate, slab	Semi-governmental, semi-private 70% foreign investment (Korea)		Krakatau/POSCO ※Krakatau 30%, POSCO(Korea)70% ?
Planning?	Dexin Steel Indonesia	Central Sulawesi states Morowali	3,500	Integrated steelworks with blast furnaces for ordinary steel	Rebar, wire (wire rod is already in operation)	Foreign capital (China) 80%		Delong Holding / Aoyama Group. (Delong HD) 45%, Shanghai Dingxin Investment (a subsidiary of Aoyama Iron & Steel) 43%, Indonesia Morowali Industrial Park (IMIP) 12%.
3	Gunung Garuda	Citibung Bekasi, West Java Province	350	Blast furnace, electric furnace	Shaped steel	Local (conglomerate) Unconfirmed if Chinese capital is involved.		Gunung Steel
4	Aoyama Group (①Sulawesi Mining Investment (SMI) ②PT Indonesia Guang Ching Nickel and Stainless Steel Industry(GCNS) ③PT Indonesia Tsingshan Stainless Steel(ITSS))	Morowali, Central Sulawesi Province	3,000	Electric furnace	Hot rolled, stainless steel cold rolling	Including foreign capital (China and Japan)		(1) Joint venture between Aoyama Steel (China) and local company Bintang Delapan Gr (2) Shanghai Dingxin Investment (Group) 55% (sister company of Aoyama Holding (China)), local company Bintang Delapan Gr 45 (3) Mainly owned by Aoyama Steel (China), partly owned by Hanwa Kogyo (Japan)
5	Gunung Raja Paksi	Citibung Bekasi, West Java Province	1,200	Electric furnace (blast furnace and converter under construction)	Rebar, hot and cold rolled, shaped steel, tube	Local (conglomerate) Unconfirmed if Chinese capital is involved.		Gunung Steel ※From 2019, Shaogang Songshan will be involved in the operation. ※The company has signed an agreement with China's Baowu Group and is planning technical cooperation.
6	Ispat Indo	Surabaya	700	Electric furnace	Wire	Foreign capital	Engineers are motivated and excellent. Head company of Indonesian electric furnace company when they visited Japan. Poor market conditions and low production resulted in poor intensity.	ArcelorMittal
7	Jakarta Prima Steel	Pulogadung, Jakarta	670	Electric furnace	Rebar	Local (conglomerate) Not sure if Chinese capital is involved.		Baja Manunggal

Table 2-16 Facilities of major iron/steel works in Indonesia

No	Company Name	Number of units (start of operation year)						
		Blast Furnace	Converter	Coke Ovens	Sintering Furnace	Electric Furnace	Heating Furnace	DR
1	Krakatau Steel	1 unit (19)	—	1 unit (17)	1 unit (19 ?)	10units(79×4, 81or83×4 units, 94×2 units)	2 units (83)	3 units (83, 79, 93) One unit was deactivated in 2001?
2	Krakatau Posco	1 unit (13)	1 unit (13)	2unit (13)	1unit (13)	—	?	—
Planning?	Dexin Steel Indonesia	1 unit (20)	2 units (20)	2 units (20)	2 units (20)	—	?	—
3	Gunung Garuda	1 unit (19) ? ※Possibly the same PJ as Gunung Raja Paksi	—	—	—	1 unit (91)	?	—
4	Aoyama Group (①Sulawesi Mining Investment (SMI) ②PT Indonesia Guang Ching Nickel and Stainless Steel Industry(GCNS) ③PT Indonesia Tsingshan Stainless Steel(ITSS))	—	—	—	—	① ② 1 unit each, rotary kiln electric furnace process (RKEF, Nickel pig iron (Ni10%)) in 2003 and 2004 respectively ③ 1 unit (17 years) rotary kiln electric furnace process (Ni10-12%)	—	—
5	Gunung Raja Paksi	—	—	—	—	1 unit (16)	?	—
6	Ispat Indo	—	—	—	—	1 unit (78) ※80ton	78 ton/h walking hearth furnace	—
7	Jakarta Prima Steel	—	—	—	—	4 units (87×3, 92)	?	—

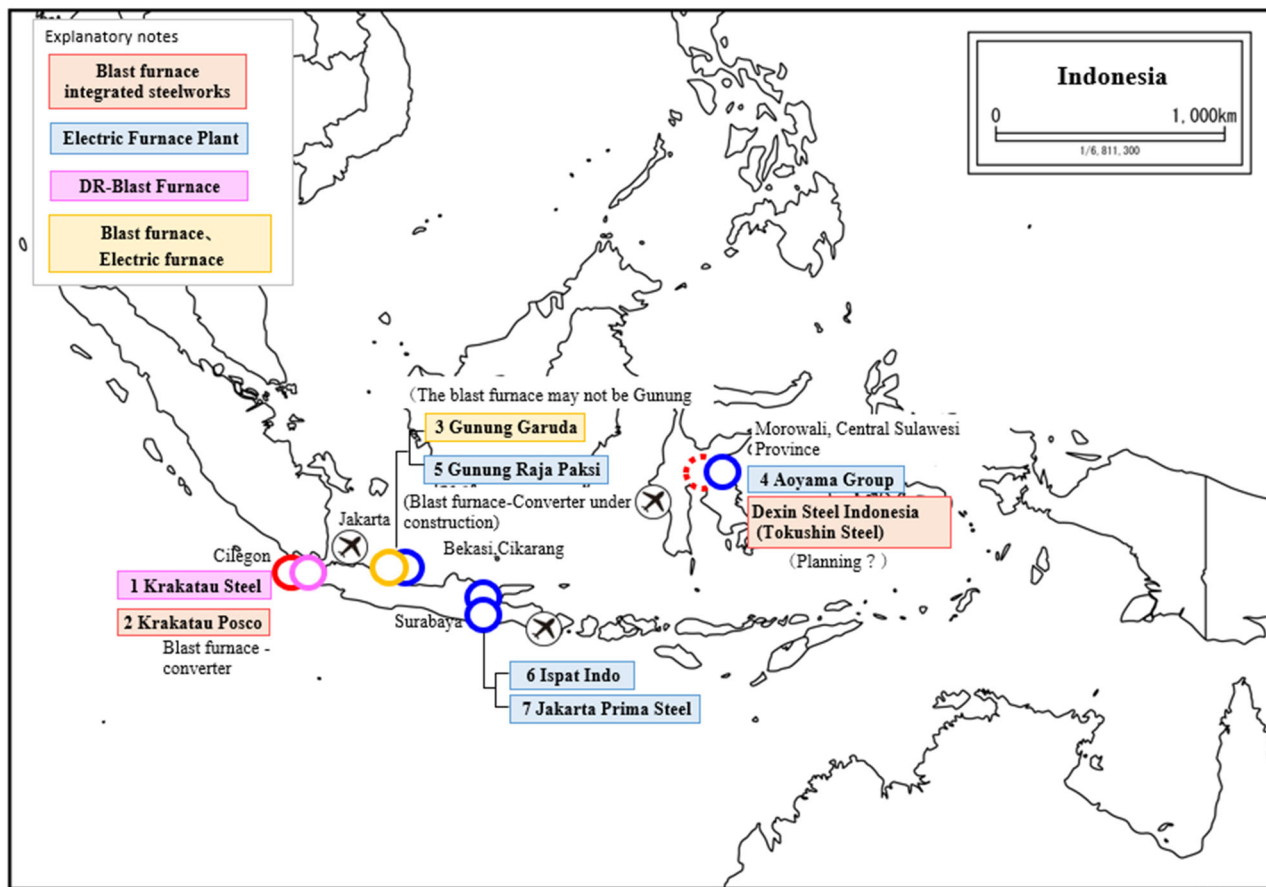


Figure 2-25 Location of major iron/steel works in Indonesia

Source: Compiled by NSRI from various sources.

(3) Energy-saving, low-carbon, and decarbonization-related policies and systems in Indonesia

An overview of NDC in Indonesia (in July 2021) is as follows.

- By 2030, reduce GHG emissions by 29% through domestic efforts (compared to BAU, 2030 BAU: 2.87 billion tons)
- Reduce GHG emissions by 41% if international assistance is obtained.
- In the Industrial Processes and Product Use (IPPU) sector, where the iron and steel industry is classified, the target for emission reduction is 0.10% (3 million t-CO<sub>2</sub>) with domestic efforts alone, and 0.11% (3.25 million t-CO<sub>2</sub>) with international assistance. In the iron and steel industry, CO<sub>2</sub> capture, improvement of smelting processes and promotion of scrap utilization are proposed as countermeasures.

The Indonesian government has pledged to become carbon neutral by 2060, and Indonesia's largest power company PLN has pledged to phase out fossil fuels by 2060 in order to achieve carbon neutrality.<sup>58</sup>

<sup>58</sup> NIKKEI ASIA, May 28, 2021, "Indonesia aims to dump coal plants for carbon neutrality by 2060" Available at: <https://asia.nikkei.com/Spotlight/Environment/Indonesia-aims-to-dump->

The following climate change-related measures have been taken in Indonesia<sup>59</sup>.

- National Medium Term Development Plan (RPJMN 2020-2024): As a basis for national development, climate change mitigation and low-carbon development have been identified as one of the priorities. It sets a goal to reduce greenhouse gas emissions by 27.3% by 2024, and sets the rate of reduction for greenhouse gas emissions for each sector, including energy and land.<sup>60</sup>.
- National Energy Policy (KEN, 2014): Policy for a stable supply of energy and sustainability. It aims to promote the spread of renewable energy and energy conservation.
- National Master Plan for Energy Conservation (RIKEN, 2014): Establishes a plan to realize the national energy policy. The goal is to improve the energy intensity by 1% every year up to 2025.
- Decree of the Minister of the Environment on MRV for climate change mitigation actions (2013)
- National Action Plan for Climate Change Adaptation (RAN-API, 2013)

According to the National Master Plan for Energy Conservation (RIKEN, 2014), the energy efficiency and conservation target for the industrial sector is to reduce the energy consumption by 17% compared to BAU by 2025, but the target for each technology is unknown. In order to achieve the target in the industrial sector, an energy management system has been introduced, which requires businesses with annual energy consumption of more than 6,000 toe to implement energy efficiency and conservation programs and conduct periodic energy efficiency and conservation audits.<sup>62</sup> However, the rate of submission of energy efficiency and conservation implementation status reports is low at 38%. There are no policies targeting only the steel industry, but the MP3EI Master Plan of the National Economic Policy partially mentions the steel industry. However, there is no specific plan for the future, and the plan only describes the recognition of issues and abstract directions.

As for other measures, the Indonesian government has announced the introduction of a carbon tax. Starting in 2022, coal-fired power plants will be taxed at the rate of 30Rp (US\$ 0.0021) per kilogram of CO<sub>2</sub> emissions in excess of a predetermined limit. The government plans to introduce a carbon tax for all sectors from 2025 onwards, along with the introduction of a carbon trading

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coal-plants-for-carbon-neutrality-by-2060

<sup>59</sup> See IGES, "Vietnam's Climate Change Mitigation Measures: Current Status and Future Challenges."

<sup>60</sup> JETRO website:

<https://www.jetro.go.jp/biz/areareports/special/2021/0401/0c7b9b158f232a1a.html>

market.<sup>61</sup>

Indonesia's industrial sector energy intensity is large compared to other countries, and it is estimated that there is 20%-30% energy saving potential.<sup>62</sup> In addition, the UN-led Technology Needs Assessment (TNA) was conducted to identify the energy efficiency and conservation technology needs in Indonesia. In the iron and steel sector, 23 priority technologies have been identified (1st priority:8, 2nd priority:8, 3rd priority:7). In the report published in 2012, the regenerative burner system, which is a widespread energy-saving technology in the steel sector, was listed as a target technology to be promoted.

### **2.5.2 Extraction of issues (technical, financial, policy, etc.) related to low-carbon and decarbonization**

In promoting the introduction of energy efficiency and conservation technologies, the lack of human resources with expertise, the lack of energy management systems, and the lack of capacity to implement energy efficiency and conservation measures are among the issues that need to be addressed.

On the other hand, Southeast Asia, including Indonesia, has been facing an oversupply of steel due to China's capital investment in steel and imports of cheap steel from neighboring countries such as China and Iran (Figure 2-22). This has been an issue for some time. Local companies are facing fierce competition, and many of them cannot afford to invest in energy conservation. With the acceleration of the world's decarbonization, Southeast Asia is seen as having lower costs than other countries and regions for climate change measures, such as carbon taxes, and could be a target for investment, including steel, so there is no prospect of easing the overcapacity. In addition to the use of policies and systems that promote capital investment, such as JCM's equipment subsidy programs, it would be effective to consider and implement measures that contribute to the improvement of productivity and added value (cost reduction, etc.) as well as the realization of energy conservation.

### **2.5.3 Consideration and proposal of cooperation programs**

#### **(1) Status of the country supported**

##### **a) Motivations and gaps in the Indonesian government**

From the perspective of climate change, the government's expectations

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<sup>61</sup> Reuters, October 13, 2021, "Indonesia needs \$200 bln annual investment in 2021-2030 to decarbonize-govt." Available at: <https://www.reuters.com/business/environment/indonesia-needs-200-bln-annual-investment-2021-2030-decarbonise-govt-2021-10-13/>

<sup>62</sup> Ministry of Economy, Trade and Industry (METI), "29FY2006 Project to Contribute to the Promotion of Energy Conservation Measures and the Introduction of Renewable Energy in Emerging Countries, etc. (Project to Study Measures to Promote Energy Conservation and Renewable Energy in Indonesia) Report" (Commissioned by the Institute of Energy Economics, Japan)

regarding greenhouse gas reduction for the steel industry are extremely uncertain and may be of little interest. Specifically, improvements in the refining process are mentioned in the NDC but it does not go so far as to state specific target figures. In addition to that, the National Energy Conservation Master Plan (Rencana Induk Konservasi Energi Nasional (RIKEN), 2014) does not impose any targets or measures specifically for the steel industry, and it is expected that there is no prospect of government intervention in the steel industry from the perspective of climate change, as shown by abstract references in the MP3EI.

From the perspective of industrial promotion, it can be assumed that the government is interested in improving production capacity but gives relatively low priority to energy conservation. As mentioned above, Indonesia's steel production is on an upward trend, and demand is expected to grow in the future, and the government has been proactive in improving production capacity by providing specific figures for investment in additional capacity. On the other hand, investment in technology to improve production processes is not mentioned, and the willingness to do so cannot be detected, thus it is assumed to be a relatively low priority. This is evident from the fact that the Long-Term National Development Plan (2005-2025), the government's main growth strategy, does not specifically mention the steel industry.

There are no detailed plans for the steel industry, and energy efficiency and conservation programs must start with strengthening enforcement of the program, and the introduction of a carbon tax is only the discussion for the future, with a target year of 2025. Therefore, it can be inferred that they are currently concentrating on capacity building and have low motivation for energy efficiency and conservation as a whole.

In addition, although energy conservation programs and other measures have been implemented, their enforcement is inadequate, and it is predicted that there is a lack of resources and capacity within the government. Taken together, the government is interested in strengthening the capacity of the steel industry, but does not have the time or interest to look at aspects such as climate change regulations and encouraging efficiency improvements in existing facilities. This may be partly due to the lack of government capacity for planning and implementation. Therefore, it can be inferred that the motivation of the government regarding energy efficiency and conservation is currently low, and it is assumed that fundamental measures such as starting from strengthening the government's capacity are necessary to complement it.

#### b) Motivations and gaps in Indonesian steel producers

As mentioned above, the Indonesian steel industry itself is advocating energy

efficiency in the future, which suggests that the industry is positive about the introduction of this technology. In particular, Gunung Raja Paski and Ispat Indo have responded to technical cooperation from Japan in the past, and the barrier to proposals from Japan is considered to be the lowest.

On the other hand, Krakatau Steel is a company that has been incurring losses at a level that makes it difficult to privatize. Other than the new blast furnace in 2019, there may be a need for improvements in its processes. However, it should be noted that the government's level of interest will have a real impact on the implementation of the demonstration because it is currently state-owned.

Therefore, it will be easier to foster cooperative relationships with Indonesian steelmakers who not only have needs for the support from Japan, but also seem to be highly motivated.

## (2) Compatibility with the Japanese cooperation and development policy

In the development cooperation policy, "support for improving international competitiveness" is indicated as one of the medium-term goals, and development related to railroads and logistics/transportation is the main focus, and the construction of power plants is also included in the development cooperation plan. Therefore, it is considered that there is a need for the supply of steel to support these activities, as in Vietnam.

On the other hand, the statement in the medium-term goal indicates that it is important to develop the infrastructure necessary to improve the competitiveness of the private sector, and it is considered that the country is in a preparatory phase to realize the improvement of the competitiveness of the private sector.

Therefore, it is assumed that this initiative, while complementing the above medium-term goals, is not out of line with the main objectives of the Cooperative Development Policy, as it is a step ahead in terms of improving the competitiveness of steelmakers.

## (3) Proposal of cooperation programs for the country

As for cooperation with Indonesia, the first step is to make the country pay attention to energy efficiency and conservation, and it will take a lot of effort to put the steel industry, which has yet to occupy a significant position in the nation's industry, on the agenda. Despite the fact that there are state-owned steel companies that can relatively easily implement cooperation programs based on G to G, the lack of capacity of the local government makes it difficult to stress the importance of the project. We have no choice but to take a bottom-up approach, with the government's capacity building and the private sector as the main players, but in either case, we must keep in mind that the government's intentions

may be a bottleneck and may take time. The following table summarizes the cooperation programs based on the above points.

Table 2-17 Cooperation programs proposed for Indonesia

Cooperation program	Scope	Importance & policy for cooperation
<p>Policy building capacity improvement, policy recommendation</p> <ul style="list-style-type: none"> <li>➤ Implementation of periodic statutory reporting system, etc. for energy conservation</li> <li>➤ Support for formulating energy conservation/decarbonization promotion policies and roadmap development</li> <li>➤ Support for implementation of energy efficiency and conservation incentive system</li> </ul>	Government	<p>This will be an important but long-term cooperation that requires patience. The government's current measures include lowering the price of industrial energy, which supports local businesses in the exact opposite direction of energy conservation. Therefore, we need to start by encouraging a fundamental change in mindset and getting people interested in energy efficiency and conservation. Capacity building of the government is important.</p>
<p>Energy efficiency and conservation assessment at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ BAT feasibility study</li> <li>➤ Survey on potential for utilization of unused energy (exhaust heat, by-product gas, etc.)</li> </ul>	Private business organizations and private business operators	<p>This is very important. Since it is effective to present the detailed situation of local companies in order to encourage the government to change its mindset, the project should be promoted at an early stage, targeting state-run iron/steel works. On the other hand, since the activities of private business organizations are unclear, cooperation will be smoother if the</p>

Cooperation program	Scope	Importance & policy for cooperation
		roles and responsibilities of these organizations and their power relationships with individual businesses are researched and understood in the early stages of the project, in order to work on the industry as a whole.
<p>Support for developing a roadmap for CO<sub>2</sub> reduction in the steel industry</p> <ul style="list-style-type: none"> <li>➤ Hold public-private meetings and seminars for industry players</li> <li>➤ Top management level capability improvement (ISO 50001, ISO 14001)</li> <li>➤ Support for developing supply chain CO<sub>2</sub> reduction roadmaps</li> </ul>	Government & private business operators (Japanese government/Japanese private business operators)	The work should be proceeded based on or in parallel with the cooperation program of the policy building capacity improvement/policy recommendation, however, depending on the situation of the government, it may take a long time to reach this program. In order to solve this problem, it is desirable to establish a cooperative relationship with private business organizations as soon as possible and foster a system that enables bottom-up dialogue with the government.
<p>Support for planning the implementation of eco-processes and pilot equipment</p> <ul style="list-style-type: none"> <li>➤ Support for detailed planning</li> <li>➤ Support for matching with equipment manufacturers, etc.</li> <li>➤ Support for consideration of financing methods</li> </ul>	Private business operators	Important, but low priority. As it is not in line with the current direction of the government itself, it should be considered after the cooperation program of policy building capacity improvement and policy recommendation.
Development of tools to support	Government &	It is desirable to

Cooperation program	Scope	Importance & policy for cooperation
decarbonization and energy conservation at iron/steel works ➤ Promotion of ISO 14404 ➤ TCL formulation and promotion ➤ BAT preparation and promotion ➤ Energy balance modeling tool ➤ Improvement measures identification tool	private business organizations	implement them after the implementation of policy building capacity improvement and policy recommendation. This is because, without the direction of the government, specific issues will not be addressed and the effectiveness of this program, which provides tools to accomplish those issues, will not be enhanced.

## 2.6 Thailand

### 2.6.1 Analysis of Current Condition (Equipment Capacity, Technologies and Energy Management Level of Main Companies, Policies and Systems, etc.)

#### (1) Overview of the steel industry in Thailand

The steel industry in Thailand consists mainly of electric arc furnace iron/steel works (hereinafter, EAF mills), which produce crude steel from scrap as the raw material, and so-called “rolling-only” mills, which produce final products by hot-rolling imported steel materials. There are no blast furnace-route integrated iron/steel works in Thailand. The EAF mills have steelmaking and hot-rolling facilities, and some also have cold-rolling and coating facilities, depending on the works. Rolling-only mills have hot-rolling, cold-rolling and coating facilities.

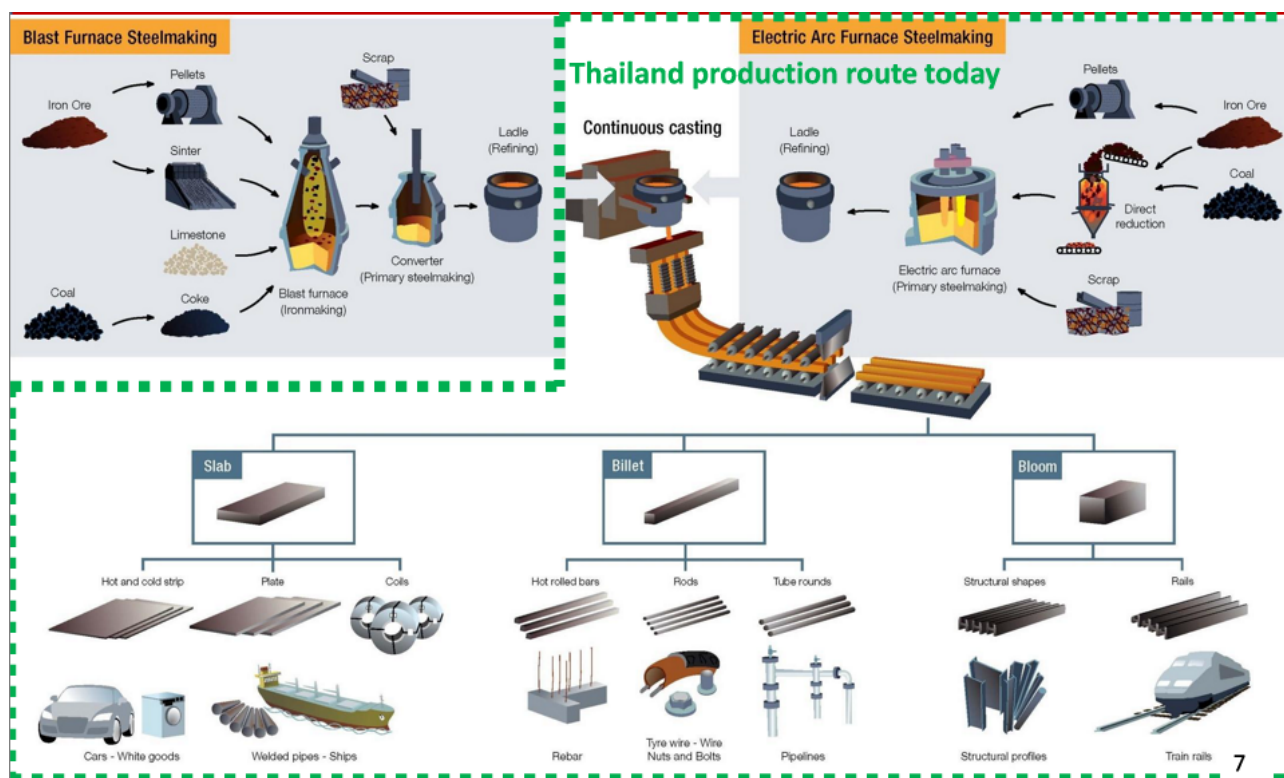


Figure 2-26 Overview of production routes in the Thai steel industry

Source: ISIT, Energy Efficiency in the Thai Steel Sector : ISIT' s Efficiency Action Plan

Growth of demand for steel products in Thailand has slowed since 2013, and production volume has also been flat since 2014. Since 2010, the volume of imports has exceeded domestic production, and local manufacturers, except those affiliated with foreign companies, have been placed in a difficult management situation.

By demand sector, infrastructure construction is the largest. The Thai government has announced an infrastructure investment plan totaling 2 trillion baht (approximately 7 trillion yen) over an 8 year period beginning in 2015. Development plans include large volume transportation systems (elevated railways and high speed railways) in the Bangkok metropolitan area.

In 2019, a decline in steel consumption due to a slowdown in the construction industry and slump in automobile production had become apparent. At that point, severe restrictions were imposed on movement and economic activity from March 2020 in response to the spread of the Covid-19, resulting in a further increase in negative growth in 2020.

It should be noted that demand for flat products (steel sheets) is large in Thailand due to the concentration of the auto industry.

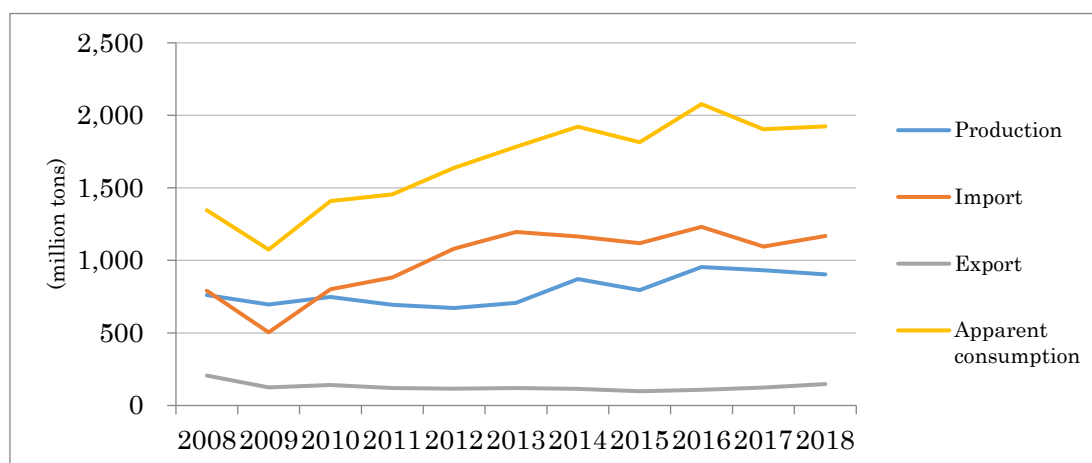


Figure 2-27 Transition of steel supply and demand in Thailand

Source: WSA Steel Statistical Yearbook

Table 2-18 Steel supply and demand in Thailand by product type (2017)

(thousand tons)											
	Production	Component ratio	Against apparent consumption	Import	Component ratio	Against apparent consumption	Export	Component ratio	Against production	Apparent consumption	Component ratio
Strip steel	3,950	38.2%	72.9%	2,610	21.2%	48.1%	560	56.5%	14.1%	5,420	27.8%
Steel plate	210	2.0%	31.7%	500	4.1%	77.6%	0	0.4%	1.9%	650	3.3%
Hot-rolled steel sheet	2,720	26.3%	42.3%	4,480	36.4%	69.7%	10	1.0%	0.4%	6,430	33.0%
Cold-rolled steel sheet	1,960	18.9%	61.8%	1,130	9.2%	35.8%	110	10.6%	5.4%	3,160	16.2%
Galvanized steel sheet	890	8.6%	41.8%	1,590	12.9%	74.5%	60	5.6%	6.2%	2,140	11.0%
Tinplate	130	1.3%	34.7%	240	1.9%	61.0%	0	0.2%	1.5%	390	2.0%
Steel pipe	N.A.*	-	-	740	6.0%	-	220	22.1%	-	N.A.*	-
Others	470	4.6%	36.1%	1,030	8.3%	78.1%	30	3.5%	7.3%	1,310	6.7%
Total	10,330	100.0%	53.0%	12,320	100.0%	74.7%	990	100.0%	9.6%	19,490	100.0%

\* There is no statistics on Thailand Steel Pipes, and apparent consumption is not also calculated.

Source: SEASIS YEARBOOK

\*Total apparent consumption includes next process, and is not based on final productions.

Source: WSA Statistical Yearbook

Because the steel industry in Thailand consists mainly of EAF plants and rolling-only plants, as described above, there is a large potential for energy saving in the hot-rolling process and electric arc furnace process in the Thai steel industry as a whole. In particular, it is thought that prioritizing energy saving in the electric arc furnace process is an effective strategy.

## (2) Overview of main steel companies in Thailand

The structure of the Thai steel industry in 2019 is shown in Figure 2-28. For long products, the main EAF mills were Millcon, Tata Steel Manufacturing (Thailand), NTS, SYS (Siam Yamato Steel), BISW (The Bangkok Iron/steel works), etc., and crude steel production was 15 million t/y or less. Iron/steel works with induction furnaces (IF) included SKY, Chou, Linan, and SINGHA THAI, and crude steel production was 13 million t/y or less.

Flat products are produced by G Steel and its affiliate, GJ Steel. However, the

scale of production is small compared with flat products, at no more than 2 million t/y.

By end users, construction accounted for about 60% of demand, and Thailand's construction industry market is tending to expand. The next largest sector after construction is automobiles and automotive parts, at approximately 20% (2019).

### Thailand steel industry structure 2019

Steelmaking		Finishing & Coating		Forming & Fabrication	End Users
<b>Long Product</b>					
<b>Melting&amp;Casting</b>	<b>Hot-Forming</b>	<b>Cold-Forming</b>		<b>Coating</b>	<b>&gt;1,000 Mills</b>
<b>EAF ~ 15 Mills</b> <ul style="list-style-type: none"> <li>• Millcon</li> <li>• TATA</li> <li>• NTS</li> <li>• SYS</li> <li>• BISW</li> <li>• Etc.</li> </ul> <b>IF ~ 13 Mills</b> <ul style="list-style-type: none"> <li>• SKY</li> <li>• Chow</li> <li>• Linan</li> <li>• SINGHA THAI</li> <li>• Etc.</li> </ul> <b>Prod : 3 mT (excl. IF)</b> <b>Im : 2.6 mT</b> Oman 29% Russia 18% Iran 17% <b>Ex : 0.1 mT</b> Philippines 79% Taiwan 18% Cambodia 2% <b>Demand: 6 mT</b>	<b>Bar ~ 34 Mills</b> <ul style="list-style-type: none"> <li>• TATA</li> <li>• Millcon</li> <li>• BISW</li> <li>• BSIRSM</li> <li>• Etc.</li> </ul> <b>HR section ~ 7 Mills</b> <ul style="list-style-type: none"> <li>• SYS (Heavy Section)</li> <li>• Triumph</li> <li>• ZUBB</li> <li>• TATA</li> <li>• Etc.</li> </ul> <b>Bar &amp; HR Section</b> <b>Prod : 4 mT</b> <b>Im : 0.9 mT</b> Japan 42% China 39% S.Korea 10% <b>Ex : 0.7 mT</b> Malaysia 17% Cambodia 15% Laos 12% <b>Demand: 4.2 mT</b> <b>Piercing</b> <b>Seamless pipe</b> ~ 2 Mills • Boly Pipe • WSP Pipe <b>Prod : N/A</b> <b>Im : 0.1 mT</b> <b>Ex : 0.2 mT</b>	<b>Cold drawn bar &amp; Steel Wire</b> <b>Low carbon steel</b> ~ 50 Mills • TYCN • Kriangkai • Chiaopao • Bangkok Fastener • Etc. <b>High carbon steel</b> ~ 12 Mills • TWP • Bangkok Steel Wire • Siam Wire • Thana Inter • Etc. <b>Stainless steel</b> ~ 10 Mills • Menam • Thai Seisen • SKJ Metal • ABP Stainless • Etc. <b>Cold drawn bar</b> <b>Prod : N/A</b> <b>Im : 0.1 mT</b> Japan 22% China 11% <b>Ex : 0.02 mT</b> Myanmar 29% Laos 23% Indonesia 15% <b>Steel Wire</b> <b>Prod : N/A</b> <b>Im : 0.3 mT</b> China 51% Malaysia 17% Japan 13% <b>Ex : 0.1 mT</b> Taiwan 23% United Kingdom 10% Indonesia 8%		<b>Galvanized</b> ~ 20 Mills • TWP • Sin Thani • Etc. <b>Bronze coated</b> ~ 2 Mills • Slam Michelin • Rayong Wire • Etc. <b>Prod : N/A</b> <b>Im : 0.04 mT</b> China 77% Malaysia 13% S.Korea 6% <b>Ex : 0.02 mT</b> Singapore 16% Indonesia 15% India 10%	<b>Construction</b> <b>60.63%</b> <b>Automobiles and parts</b> <b>20.27%</b> <b>Electrical Appliances</b> <b>7.53%</b> <b>Machinery and Industrial Products</b> <b>5.94%</b> <b>Packaging</b> <b>4.64%</b> <b>Other</b> <b>0.99%</b>
<b>Flat Products</b>					
<b>Melting&amp;Casting</b>	<b>Hot-Forming</b>	<b>Cold-Forming</b>	<b>Welded Pipe</b>	<b>Coating</b>	
<b>EAF ~ 2 Mills</b> <ul style="list-style-type: none"> <li>• G Steel</li> <li>• GJS</li> </ul> <b>Prod : N/A mT</b> <b>Im : 1.5 mT</b> Russia 35% Japan 32% Ukraine 16% <b>Ex : 0.001 T</b> Myanmar 99% Laos 1%	<b>HRC</b> ~ 4 Mills • G Steel • GJ Steel • SSI • Prime steel <b>Prod : 3 mT</b> <b>Im : 1.7 mT</b> Japan 58% S.Korea 12% Vietnam 7% Myanmar 38% Laos 29% Vietnam 11% <b>Demand: 4.7 mT</b> <b>HRP</b> ~ 2 Mills • SPM • LPN <b>Prod : 0.1 mT</b> <b>Im : 0.5 mT</b> China 45% Japan 27% Indonesia 12% Ex : 0.003 mT Singapore 23% India 20% Laos 12% <b>Demand: 0.6 mT</b>	<b>CR-Sheet Steel</b> ~ 4 Mills • NS-SUS • TCRSS • NS BlueScope • Starcore <b>Prod : 2 mT</b> <b>Im : 1.7 mT</b> Japan 49% S.Korea 36% China 6% <b>Ex : 0.1 mT</b> USA 29% Belgium 12% S.Korea 19% <b>Demand: 3.6 mT</b> <b>CR-Sheet Stainless Steel</b> • POSCO-Thainox <b>Prod : N/A</b> <b>Im : 0.02 mT</b> China 43% Vietnam 27% India 20% <b>Ex : 0.01 mT</b> Myanmar 44% Laos 26% Cambosia 16%	<b>CF-Sections</b> ~ N/A Mills • Neatren • T.S.K. • Pacific • Saha-Thai • Samchal • Etc. <b>Prod : N/A</b> <b>Im : 0.4 mT</b> Vietnam 56% Japan 17% S.Korea 7% <b>Ex : 0.2 mT</b> USA 51% Australia 13% Taiwan 5%	<b>GI</b> ~ 8 Mills • TIW • BSI & RSM • Posco-Tcs • Sangkasi Thai • Etc. <b>Prod : 0.3 mT</b> <b>Im : 1.5 mT</b> China 74% Japan 12% S.Korea 8% <b>Ex : 0.06 mT</b> Laos 23% Vietnam 12% Myanmar 15% <b>Demand: 1.7 mT</b> <b>GA</b> ~ 3 Mills • NS-SUS • JSGT • POSCO-TCS <b>Prod : 1 mT</b> <b>Im : 0.2 mT</b> Japan 59% China 13% S.Korea 16% <b>Ex : 0.03 mT</b> Japan 11% China 12% S.Korea 18% <b>Demand: 1 mT</b> <b>Zn-Al-Mg</b> ~ 1 Mills • NS BlueScope • RSM <b>Prod : N/A</b> <b>Im : 0.1 mT</b> Japan 52% S.Korea 24% China 15% Ex : 0.01 mT Singapore 30% Taiwan 19% Cambodia 15% <b>Demand: 0.6 mT</b> <b>EG</b> ~ 1 Mills • TCS <b>Prod : N/A</b> <b>Im : 0.4 mT</b> China 41% S.Korea 30% Japan 8% Myanmar 78% Vietnam 13% Pakistan 6% <b>Demand : 0.6 mT</b> <b>IP/TF</b> ~ 2 Mills • TTP • STP <b>Prod : 0.2 mT</b> <b>Im : 0.4 mT</b> China 41% S.Korea 30% Japan 8% Myanmar 78% Vietnam 13% Pakistan 6% <b>Demand : 0.6 mT</b>	

Figure 2-28 Structure of the steel industry in Thailand

Source: ISIT Summary of Steel of Industry profile, 201963

An outline of the main steel companies is shown in Table 2-19, and the composition of equipment of the companies is shown in Table 2-20. Figure 2-29 shows the locations of the main iron/steel works of the companies.

G Steel began operation in 1999 and has a new-type plant featuring full direct rolling, in which 2 large-scale electric arc furnaces, a medium-thickness slab continuous caster, a tunnel-type soaking furnace and a hot rolling line are

connected in a single, integrated process. In 2015, the members of a survey team conducted an energy-saving diagnosis of the works and proposed multiple energy saving technologies.

GJ Steel, a subsidiary of G Steel, operates a new, large-scale Consteel furnace. The energy unit consumption of the EAF is satisfactory.

Siam Yamato Steel received financing from Japan's Yamato Kogyo Co., Ltd., and resident Japanese engineers are also stationed there. Because this company has already implemented many energy saving measures, energy efficiency is considered satisfactory. However, the company has shown an extremely proactive stance toward study and implementation of further energy saving measures.

Table 2-19 Outline of main steel companies in Thailand

No	Company name	Office	Crude steel production capacity (thousand tons/year)	Upper process	Main Products	National/Foreign	Information on saving CO2 and energy	Notes
1	G Steel (Formerly Siam Strip Mill, SSM)	Rayong Province SSP Industrial Park	1,800	Electric furnace	Hot rolled	Local G Steel Group (formerly Siam Steel Pipe Group)	Direct-feed rolling mill with direct connection of electric furnace, CC, and heating furnace. The operating rate is poor and are not performing to their full potential.	G Steel Group (formerly Siam Steel Pipe Group) Field survey was conducted in 2015
2	G J Steel(GJS) (Formerly Nakornthai Strip Mill, NSM)	Bo-Win Industrial Park, Chonburi Province	1,500	Electric furnace	Hot rolled	Local		G Steel Group (formerly Siam Steel Pipe Group)
3	Siam Yamato Steel	Map Ta Put, Rayong Province	1,000	Electric furnace	Shaped steel (High production volume and good profitability due to the scarcity of shaped steel in Southeast Asia)	Foreign investment (Japan): over 60%. (Joint venture between Yamato Steel of Japan and a local conglomerate)	Several engineers have been dispatched from Japan, and the operation performance is good	Shareholders Daiwa Kogyo 64.18% (Japan), Siam Cement (Thai royal family) 12.25%. A site survey was conducted in 2017 to encourage the company to form a JCM project.
4	Chow Steel Industries	Kabinburi,	730	Electric furnace	Rebar	Local		

Table 2-20 Equipment composition of main Thai steel companies

No	Company name	Number of units (start of operation year)						
		Blast Furnace	Converter	Coke Ovens	Sintering Furnace	Electric Furnace	Heating Furnace	DR
1	G Steel (Formerly Siam Strip Mill, SSM)	—	—	—	—	2 units (99, 99) ※152tEF	Tunnel Furnace	—
2	G J Steel(GJS) (Formerly Nakornthai Strip Mill, NSM)	—	—	—	—	1 unit (98) ※180tEF	?	1 unit (98) ※ Suspended in 2006?
3	Siam Yamato Steel	—	—	—	—	1 unit (94) ※70tEF	150 ton/h Walking beam furnace	—
4	Chow Steel Industries	—	—	—	—	2 unit (?, 08)	?	—

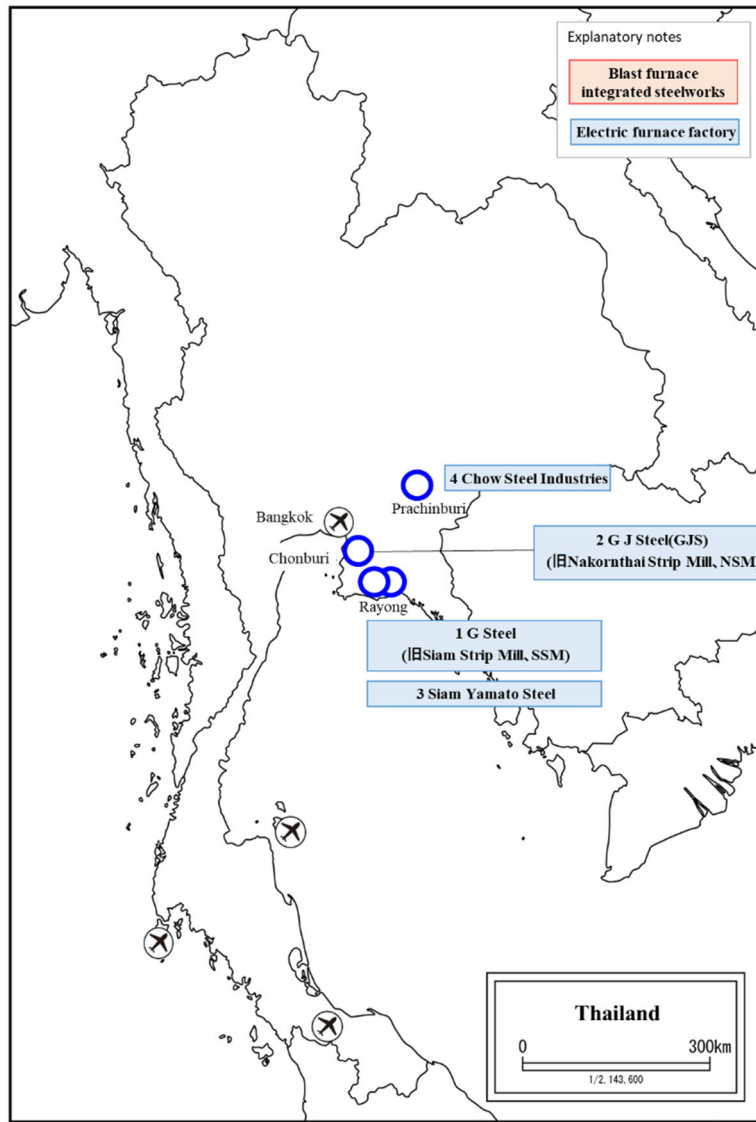


Figure 2-29 Locations of main iron/steel works in Thailand

(3) Energy saving, low carbon and decarbonization-related policies and systems in Thailand

The outline of Thailand's NDC (Nationally Determined Contribution, October 2020) is as follows:

- By 2030, reduce GHG emissions by 20% compared with BAU by domestic efforts alone.  
(BAU baseline year: 2005, 2030 BAU: 555 million t-CO<sub>2</sub>)
- Reduce GHG emissions by 25% in cases where sufficient international assistance is obtained.

In 2011, Thailand's Ministry of Industry launched the "Green Industry Project" to encourage companies to be more environment-friendly and socially responsible. As of the end of January, the number of plants which had received Green Industry

certification exceeded 20,000 companies. The Ministry of Industry, together with Thailand's National Institute for Environmental Studies, issues Green Labels indicating the product was produced in an environment-friendly manner.



Figure 2-30 Thailand's "Green Label"

On March 10, 2021, Thailand's Minister of Industry Mr. Suriya Juangroongruangkit, ordered the Ministry's Department of Industrial Works (DIW) to push all 71,130 factories in the country to obtain Green Industry certification and promote "Green Factories" by 2025. This policy is in line with the Bio-Circular-Green (BCG) economic model being promoted by the Thai government, and is part of the government's "Action Plan to Promote and Develop Enterprises in Green Industry" (2021-2037). The key points of the Action Plan include enhancement of the business efficiency of enterprises and improvement of quality in environmental aspects.

To promote acquisition of Green Industry certification by factories, in 2021 the DIW carried out projects including (1) business support of companies for Green Industry certification, (2) transfer of technologies related to reduction of water consumption and clean production methods and (3) promotion of the sustainability of factories through environmental management and circular economy systems, etc.

In August 2021, Thailand's National Energy Policy Council (NEPC) approved the framework of a new integrated National Energy Plan (NEP)<sup>62</sup>. The framework includes policy guidelines aimed at making a staged transition to clean energy and achieving carbon neutrality by 2065-2070, or over the next 50 years.. The following efforts for realization of a low carbon economy and society will be promoted:

- Increase the share of renewable energy to not less than 50%
- Improve energy efficiency by more than 30% by utilizing modern technologies and innovations
- Restructure the energy industry according to the "4D1E" guideline, as summarized below
  - Decarbonization: Reducing carbon dioxide (CO<sub>2</sub>) in the energy sector

- Digitalization: Use of digital technology in energy system management
- Decentralization: Decentralization of energy generation and infrastructure
- Deregulation: Regulatory updates supporting modern energy policy
- Electrification: Utilization of electricity in place of fossil fuels

The Ministry of Energy has identified the following urgent tasks for the next 10 years (2021-2030).

- ① Establish a National Energy Plan that includes all energy sectors.
- ② Conduct a detailed study over the next 10 years, with the aims of increasing power generation from clean energy and reducing the proportion of purchases of fossil fuel-based power.
- ③ Improve power transmission lines and distribution (electricity sales) infrastructure to be flexible and effective. Ensure electric power security, and prepare for the growth of power generation utilizing renewable energy.

The National Energy Plan (NEP) based on this framework is expected to be established by 2022, and it is foreseen that the new NEP will affect Thailand's steel industry, which is 100% reliant on production by the electric arc furnaces.

Furthermore, because implementation of policies according to Thailand's 20 year National Strategy (2018-2037) is stipulated in the country's Constitution, and the current Twelfth National Economic and Social Plan is also expected to be concluded in September 2022, discussions on the establishment of the Thirteenth Plan, covering the second period, have begun. The draft of the plan proposed by the National Economic and Social Development Council (NESDC) in March 2021 included four transformations and thirteen directions for achieving them. Among the four transformations, the proposal mentions "Transformation to an environment-friendly high value-added economy" and "Transformation from production and consumption that harm the environment to safe, environment-friendly lifestyles." One of the thirteen directions is "Have a circular, low carbon economy."

The governmental agency with jurisdiction over Thailand's steel industry is the Ministry of Industry, and within the Ministry, the Iron and Steel Institute of Thailand (ISIT) has been established to be responsible for the steel industry. Together with the country's domestic steel makers, the Ministry plans to formulate a roadmap for the development of the steel industry with a timeframe of 5 to 10 years.

On the other hand, the system for energy saving, which falls under the jurisdiction of Thailand's Ministry of Energy, has the Energy Conservation Promotion Act B.E.2535 (ECP Act), which was enacted in 1992 as a policy for energy conservation in factories and buildings. Factories and buildings are defined as those which have ① contracted power of 1,000 kW or more, ② total installed transformer capacity of 1,175 kVA or more, and ③ annual consumption of the above-mentioned power of 20 million MJ or more are subject to this act. Factories and buildings in scope are required to implement an energy management system and assign at least one Person Responsible for Energy (PRE), use high efficiency equipment that contributes to energy conservation, prepare and submit an energy conservation activity plan to the Department of Alternative Energy Development and Efficiency (DEDE) every 3 years, and receive approval for the plan based on an audit and analysis of energy consumption before submitting the plan to the DEDE.

In order to strengthen the above-mentioned ECP Act, Thailand also established the ENCON Fund (Energy Conservation Promotion Fund) to encourage energy conservation.

### **2.6.2 Identification of Issues Related to Low Carbon and Decarbonization (Technical, Financial and Policy Aspects)**

Not limited to Thailand, steel makers in the ASEAN countries were experiencing difficulties before the Covid-19 pandemic began in 2019, including low operating rates in the upstream progress due to the effects of capital investment by China and competition with low-cost Chinese and Iranian products. In addition to China and Iran, Thailand also imports a large amount of iron and steel products from the nearby of Indonesia. As shown in Figure 2-22, the ASEAN region is affected by iron and steel-related capital investment by China and an oversupply of steel products due to imports of cheap steel products from China, Iran and other surrounding countries. In this severe competitive environment, investment in energy conservation by local Thai companies is facing strong headwinds, including, for example, low equipment working rates. In addition, since 2020, the Covid-19 crisis has caused a worsening of steel markets in all countries, resulting in a freeze on the capital investment plans of steel companies. In the present condition, there is no room for efforts in connection with energy conservation, either in terms of funding for capital investment or manpower than can be spared for energy conservation projects. Based on this situation, we believe that the use of policies and systems that promote capital investment, such as equipment subsidy programs under the JCM (Joint Crediting Mechanism), etc., and implementation of measures that improve productivity and added value

simultaneously with energy conservation, will be an effective approach in Thailand, as in Vietnam and Indonesia.

### **2.6.3 Consideration and proposal of cooperation programs**

#### **(1) Status of the country supported**

##### **a) Motivations and gaps in the Thai government**

Regarding the climate change perspective, the Thai government's motivation for energy conservation is observed, but it is necessary to refer to future plans to see how this will be reflected in the steel industry. The Thai government's motivation for energy conservation for the industry as a whole is high, because, as mentioned earlier, the National Energy Planning Framework states that energy efficiency is to be improved by at least 30% using modern innovations and technologies. Further, awareness of energy efficiency and conservation is high even outside of the plan, and the ground for acceptance of energy efficiency and conservation technologies is considered to have been formed as the government has not only enforced the Law for the Promotion of Energy Efficiency and Conservation but also organized finances for implementation. On the other hand, the share of steel industry CO<sub>2</sub> emissions in the country's total emissions is low, in the 1% range, and there is a high possibility that it will be low on the government's list of priorities.

It is unclear whether the government will keep a close eye on the steel industry in terms of industrial development. The steel industry is not mentioned in the latest national comprehensive development plan, THE TWELFTH NATIONAL ECONOMIC AND SOCIAL DEVELOPMENT PLAN (2017-2021). In order to mitigate the impact of the recent COVID-19 pandemic, the "Made in Thailand" system has been introduced<sup>64</sup>, which includes a requirement that the percentage of domestic products used in national projects should be at least 60% of the total. Since this domestic product includes steel products, steelmakers will be able to receive various benefits such as loans, but it is important to note that the government is doing this with the intention of increasing domestic production of products, and not with a policy oriented toward product quality or efficiency in the manufacturing process. Another important aspect is that the government does not have a special focus on the steel industry, nor is the government's awareness of the steel industry visible.

This survey did not provide enough information to capture the Thai government's special intentions toward the steel industry. However, with the government's stance up to the present, there is no special awareness of the steel industry, and no motivation to accept energy efficiency and conservation

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<sup>64</sup> <https://www.bangkokpost.com/business/2085399/made-in-thailand-can-earn-bl-77tn>

proposals specific to the steel industry can be found in terms of climate change and industrial promotion. Therefore, the first step is to fully confirm the government's intentions, either by listening to them or by referring to the description related to the steel industry in the comprehensive national energy plan that is expected to be formulated in the future.

#### b) Motivation and gaps in Thai steel producers

In terms of connections with the survey team, Thai steel companies seem to be in a good position to proceed with this project, but a more detailed research is needed to determine whether this project can make a significant contribution to closing the gap in their motivation. G Steel has conducted energy efficiency and conservation audits and proposed energy efficiency and conservation technologies to the survey team in the past, and is considered to have a good relationship with the survey team for the cooperative program, so there is a high possibility of realization. In addition, Siam Yamato Steel is considered to be willing to cooperate with the project because of the investment from Japanese companies, but it should be noted that the degree of contribution from this project may be small because the company has already promoted energy efficiency and conservation measures.

It is assumed that steelmakers have a sense of crisis currently as the growth of domestic steel demand is slowing down and domestic production is also showing sluggish growth. This situation may be one of the reasons why companies such as Siam Yamato Steel are focusing on energy efficiency and conservation, but it is also important to note that they may not have the strength to invest in energy efficiency and conservation and are holding back, given the severe competition from foreign companies such as Chinese manufacturers. Therefore, promoting the introduction of energy efficiency and conservation technologies, including financial ones, through international cooperation may contribute to closing the gap between them, and the ease of starting this project based on existing connections also forms a relatively favorable situation.

#### (2) Compatibility with the Japanese cooperation and development policy

In the development cooperation policy, environmental and climate change issues are addressed as part of sustainable economic development. It also mentions the implementation of third country assistance, and calls for the establishment of a development cooperation model for middle-income countries. Therefore, although the perspective of cooperation targeting only Thailand is concentrated and focused on environment and climate change, the promotion of this project as a touchstone for cooperation with ASEAN countries will not only

strengthen the strategic partnership between Japan and Thailand, but will also have a synergistic effect on cooperation with Vietnam and Indonesia.

The business development plan is expected to involve projects such as "Research on Co-creation of Integrated Climate Change Adaptation Strategy in Thailand" and "Energy Policy", which may lead to a shift from soft and comprehensive cooperation on climate change measures to hard and more detailed cooperation.

### (3) Proposal of cooperation programs for the country

Since the government's intentions were not determined in this survey, it should be clarified first before other aspects. It is extremely unclear whether a cooperation program can be established, even in a situation where the private sector is motivated. In addition, if the approach is to be oriented toward third country cooperation, it may not be persuasive unless the dissemination and deployment steps are conceived and presented based on the situation in other countries. Therefore, it should be noted that although there is potential, we are not in a position to quickly create concrete cooperation projects, and the entire project will be a very long one. The table below summarizes the cooperation programs based on the points mentioned above.

Table 2-21 Cooperation programs proposed for Thailand

Cooperation program	Scope	Importance & policy for cooperation
Policy building capacity improvement, policy recommendation ➤ Implementation of periodic statutory reporting system, etc. for energy conservation ➤ Support for formulating energy conservation/decarbonization promotion policies and roadmap development ➤ Support for implementation of energy efficiency and conservation incentive system	Government	It is possible that a decision can be made based on plans that will be issued in the future, but the first priority is to confirm the government's intentions. In Thailand, where the presence of the iron and steel industry is small, it is highly likely that the importance of energy efficiency and conservation will not be realized unless the importance of energy efficiency and conservation is emphasized with long-

Cooperation program	Scope	Importance & policy for cooperation
		term goals such as cooperation with third countries.
<p>Energy efficiency and conservation assessment at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ BAT feasibility study</li> <li>➤ Survey on potential for utilization of unused energy (exhaust heat, by-product gas, etc.)</li> </ul>	Private business organizations and private business operators	Unless it is confirmed that the government is willing to support iron/steel plants in the first place, or such an attitude is fostered, it is unlikely that the results of this program will be effectively utilized for later cooperation.
<p>Support for developing a roadmap for CO<sub>2</sub> reduction in the steel industry</p> <ul style="list-style-type: none"> <li>➤ Hold public-private meetings and seminars for industry players</li> <li>➤ Top management level capability improvement (ISO 50001, ISO 14001)</li> <li>➤ Support for developing supply chain CO<sub>2</sub> reduction roadmaps</li> </ul>	Government & private business operators (Japanese government/Japanese private business operators)	Since the private sector is motivated, implementation seems feasible. On the other hand, public-private meetings and supply chain CO <sub>2</sub> reduction are impossible without government intervention, which limits the implementation.
<p>Support for planning the implementation of eco-processes and pilot equipment</p> <ul style="list-style-type: none"> <li>➤ Support for detailed planning</li> <li>➤ Support for matching with equipment manufacturers, etc.</li> <li>➤ Support for consideration of financing methods</li> </ul>	Private business operators	Without confirming or fostering the government's positive attitude toward supporting iron/steel works in the first place, it will be difficult to implement this program itself.
<p>Development of tools to support decarbonization and energy conservation at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ Promotion of ISO 14404</li> <li>➤ TCL formulation and promotion</li> <li>➤ BAT preparation and promotion</li> <li>➤ Energy balance modeling</li> </ul>	Government & private business organization	Without confirming or fostering the government's positive attitude toward supporting iron/steel works in the first place, it will be difficult to implement this program itself.

Cooperation program	Scope	Importance & policy for cooperation
tool ➤ Improvement measures identification tool		

## 2.7 Mexico

### 2.7.1 Analysis of Current Condition (Equipment Capacity, Technologies and Energy Management Level of Main Companies, Policies and Systems, Etc.)

#### (1) Overview of the steel industry in Mexico

As of 2019, Mexico ranked 15th in the world in crude steel production by country (18.5 million tons), and 2nd in Latin America following Brazil (32.2 million tons). In terms of the crude steel production ratio, the electric arc furnace (EAF) accounted for approximately 70% of production, while the blast furnace accounted for 30%. The main steel-consuming industries (2014) were construction (61%), automobiles (11%) and industrial machinery (8%).

Mexico's crude steel production ratio is 77.2% by the EAF and 22.8% by the blast furnace. The main end users by industry are construction (approx. 60%) followed by automobiles (approx. 10%). Mexico's steel production is also increasing in response to the successive entry of steel-consuming industries, centering on the automotive industry.

CO<sub>2</sub> emissions in the steel industry are about 45 million tons/year (based on the figures of 2010), or approximately 7% of Mexico's total GHG emissions. Because the main production route is the EAF, the country's unit emissions per ton of crude steel is low, at around 1.6 t-CO<sub>2</sub>/t-steel.

#### (2) Overview of main steel companies in Mexico

In Mexico, iron/steel works are concentrated in the northeastern and central parts of the country. The steel industry has a presence in states corresponding to roughly 40% of Mexico's national land area.

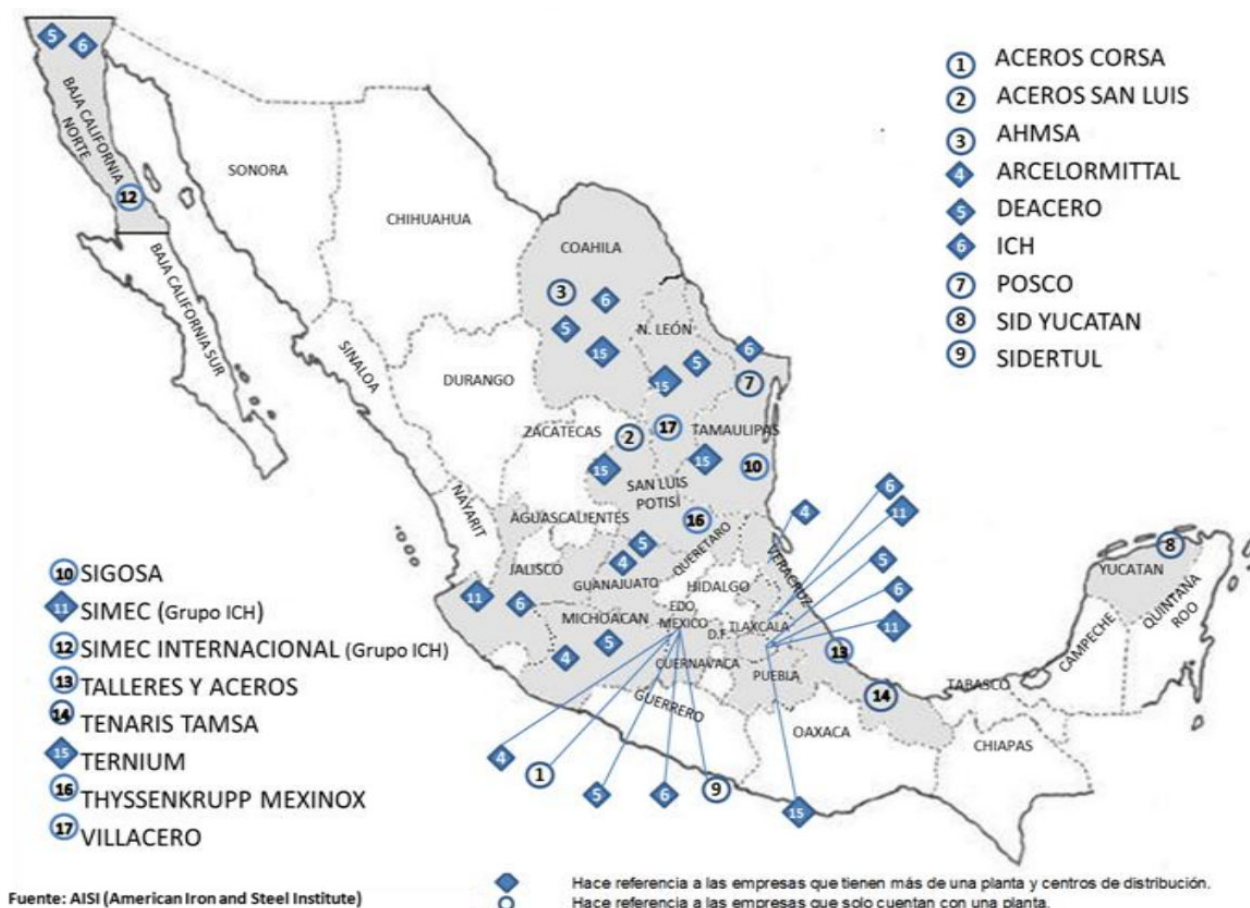


Figure 2-31 Centers of iron and steel production in Mexico

Source: Ministry of Energy (Secretaría de Energía (SENER)), “Sector Siderúrgico en México”

Table 2-22 shows an outline of the main steel companies, and Table 2-23 shows the equipment composition of each company. Figure 2-32 shows the locations of the main iron/steel works.

Ahmsa (Alto Hornos de México) has 5 blast furnaces and mainly produces hot-rolled and cold-rolled coils, plates, tinplate, structural shapes and large-section profiles. Although the company was nationalized during the 1980s, it was acquired and privatized by GAN (Grupo Acerero del Norte) in 1991 following the Gulf War oil price shock. The closure of Monclova No. 6 blast furnace was announced in January 2020. In February GAN studied sale of the company, and negotiations with Ternium, POSCO and Baosteel are reportedly in progress. Due to the age of the facilities, large energy unit consumption is a possibility.

Ahmsa had planned an expansion project with an estimated total cost of US\$ 500 million which was originally scheduled for 2018 but was still on hold as of June 2020. The project includes the construction of a third cold strip mill, and is scheduled to increase the company’s current cold-rolled coil production capacity of 800,000 t/y to 2.3 million t/y. Revamping of No. 3 continuous caster is also

planned, and will increase its production capacity from 2 million t/y to 2.5 million t/y. If completed, this revamp will make it possible to produce slabs with a maximum length of 27.5 meters, maximum width of 74 inches and thicknesses of 8 to 10 inches. The capacity of the hot rolling division will also be increased from 2.8 million t/y to 3.5 million t/y. The project also includes plans to install a new tinplate line, which will increase the equipment capacity from 150,000 t/y to 450,000 t/y.

ArcelorMittal las Truchas has one blast furnace and is a steel manufacturing company in the ArcelorMittal Group which produces steel bars and wire rod material. This company was originally a nationally-owned company called Sicarta, but as in the case of Ahmsa, it was privatized in 1991. Since much of the companies equipment was put into operation in the 1970s, large specific energy consumption is a possibility.

ArcelorMittal Lazaro Cardenas is also a member of the ArcelorMittal Group. This company produces 4 million t/y of steel plates (including slab semi-finished material) using four electric arc furnaces (EAFs).

Ternium Mexico is an EAF mill in the Techint Group (Argentine capital) consisting of Ternium and Tenaris. In August 2021, the company announced the start-up of two walking beam furnaces (capacity: 400 t/h) manufactured by Tenova at a new hot strip mill located in Pesqueria. According to Tenova, these furnaces will hold specific energy consumption to 1.16 MJ/kg while also suppressing NOx emissions to no more than 60 ppm. The furnaces are equipped with Tenova's SmartBurner Monitoring System (SBMS), enabling monitoring and optimization of burner performance, operation and maintenance.

Deacero is a company funded by local capital and is Mexico's largest wire manufacturer. An EAF with a production capacity of approximately 1.5 million t/y has been installed at the company's Ramos Arizpe plant, which also has a total of 8 rolling mills and produces steel bars, wire rod material and merchant bars. In September 2018, the plant started up a rolling mini-mill (production capacity: 500,000 t/y) which produces steel bars and light section steel.

Table 2-22 Outline of main steel companies in Mexico

No	Company name	Office	Crude steel production capacity (thousand tons/year)	Upper process	Main Products	National/Foreign	Information on saving CO2 and energy	Notes
1	Ahmsa	Monclova	5950	Blast furnace - converter, electric furnace	Rebars, shaped steel, wire rod, thick and medium plate, hot and cold rolled, tinplate	Local ? Privatized in 1991		Nationalized in 1980s, privatized in 1991 (acquired by GAN). 78.91% owned by Grupo Acerero del Norte (GAN), 4.02% by management; reportedly considering sale of company in February 2020 (in negotiations with Ternium, POSCO, Baosteel)
2	ArcelorMittal las Truchas (Formerly Sicartsa)	Lazaro Cardenas	1750	Blast Furnace-converter	Rebars and wire rods	Foreign capital		ArcelorMittal Group
3	ArcelorMittal Lazaro Cardenas (Formerly Imexa)	Lazaro Cardenas	4000	DR-electric furnace	slab	Foreign capital (Argentina)		ArcelorMittal Group
4	Ternium Mexico (Formerly Hylsamex)	Monterrey	2300	DR-electric furnace	Heat and cold rolled, CG, color	Foreign capital		Techint Group (Ternium and Tenaris)
5	Deacero	Celaya, Guanajuato	2000	Electric furnace	Rebars and wire rods	Local		Deacero Group Largest wire manufacturer in Mexico

Table 2-23 Equipment composition of main steel companies in Mexico

No	Company name	Number of units (start of operation year)						
		Blast Furnace	Converter	Coke Ovens	Sintering Furnace	Electric Furnace	Heating Furnace	DR
1	Ahmsa	5 units (54, 66, 71, 76, 11)	6 units (74, 76, 83, 13 × 3 units)	5 units (55, 70, 77, 78, 13)	1 unit (68)	1 unit (15) ※150tEF	2 units (67) ?	—
2	ArcelorMittal las Truchas (Formerly Sicartsa)	1 unit (76)	2 units (76, 78) ※120tLD	2 units (76, 76)	—	—	1 unit (76) ?	—
3	ArcelorMittal Lazaro Cardenas (Formerly Imexa)	—	—	—	—	4 units (88 × 4 units)	?	5 units (88, 88, 90, 90, 97)
4	Ternium Mexico (Formerly Hylsamex)	—	—	—	—	2~6 units? (95, 98)	3 units (53, 95, 95)	3 units (83 × 2 units, 97) ?
5	Deacero	—	—	—	—	2 units (98, 06) ※100t, 120t	?	—

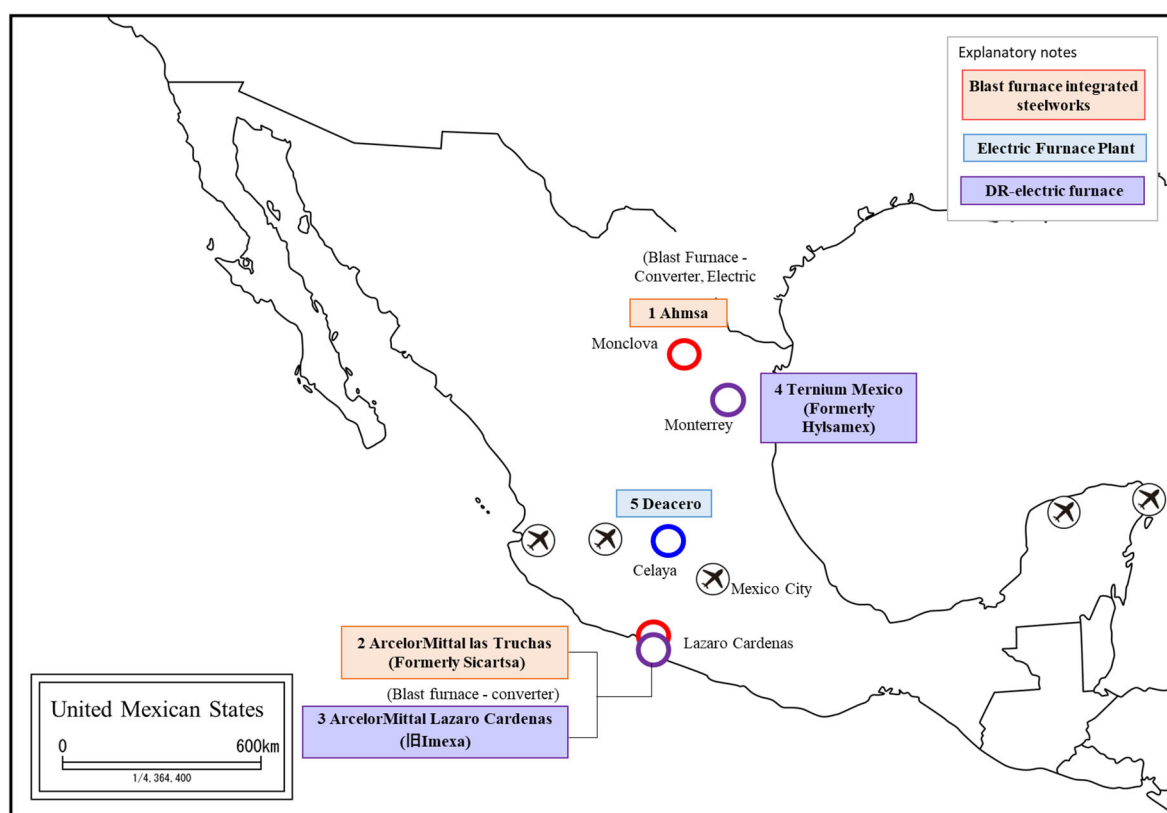


Figure 2-32 Locations of main iron/steel works in Mexico

(3) Energy saving, low carbon and decarbonization-related policies and systems in Mexico

Mexico's GHG reduction goals are laid out in the General Climate Change Law (Ley General de Cambio Climático) enacted in 2012. In addition, in its NDC (Nationally Determined Commitment) of 2020, the country made a commitment to reduce emissions from the predicted value of the BAU baseline by 2030 (BAU refers to the "business as usual" scenario; here, the "BAU baseline" means the predicted amount of emissions based on economic growth in case climate changes measures are not adopted). Concretely, Mexico has stated that it will reduce GHG emissions by 22% and BC (black carbon) emissions by 51% from the levels in 2013, to be achieved by 2030. It is also considered possible to achieve maximum reductions of 36% in GHG and 70% in BC (from 2013, to be achieved by 2030) if financial and technical support and cooperation in capacity building, etc. can be obtained.

According to information published by CANACERO (Mexico's National Chamber of the Industry of Iron and Steel)<sup>63</sup>, the CO<sub>2</sub> emission intensity of the Mexican iron and steel industry was 1.38 t-CO<sub>2</sub>/TAL (as of 2016), which is smaller than China's CO<sub>2</sub> emission intensity of 2.38 t-CO<sub>2</sub>/TAL and the global average of 1.98 t-CO<sub>2</sub>/TAL. CANACERO believes that imports are increasing GHG emissions, having a negative impact on employment, and also causing a loss of foreign currency.

The same information also propose CO<sub>2</sub> emissions of 65 Mt-CO<sub>2</sub>/year for the Mexican steel industry in 2030, which is equivalent to a 14% reduction from the 2030 BAU scenario. To achieve this, the emission intensity of the domestic steel industry is to be improved from 1.38 to 1.28 t-CO<sub>2</sub>/TAL (against the 2016 level). A 14% reduction in emissions is also targeted by substituting domestic production for imported products (9.9 million tons), which have higher emissions, and requiring the use of clean energy. (As of 2016, renewable energy accounted for about 5% of energy consumption in the iron and steel sector.) These measures are expected to generate approximately US\$17 billion in additional investment in the iron and steel industry, and direct/indirect employment of 350,000 persons.

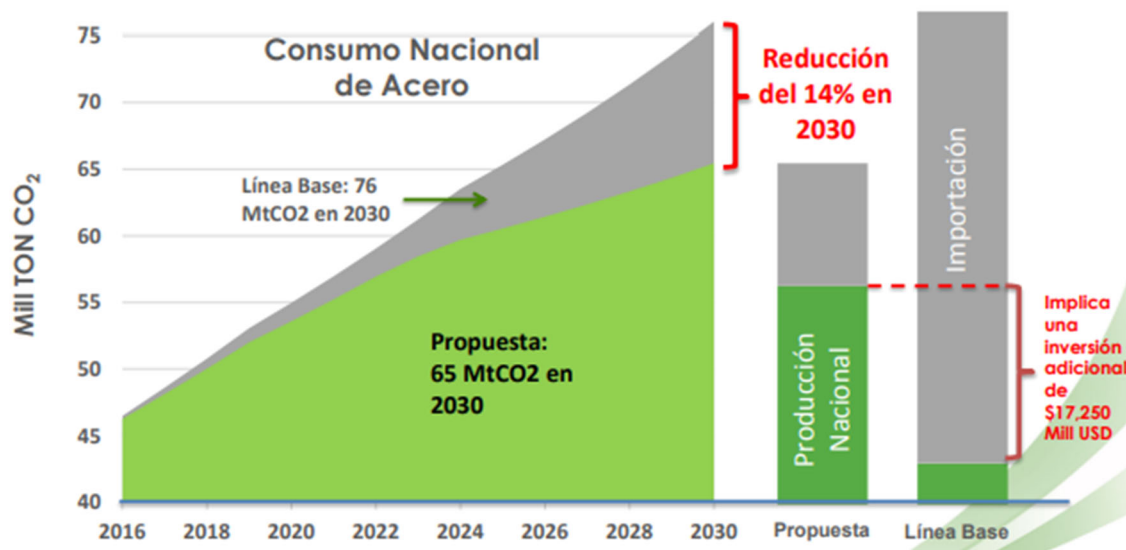


Figure 2-33 Baseline and GHG emissions (materials published by CANACERO, September 2016)

Mexico's strategy for achieving its GHG reduction goals is described in the National Climate Change Strategy (Estrategia Nacional de Cambio Climático. Vision 10-20-40:ENCC). The ENCC was prepared under the leadership of Mexico's Ministry of the Environment and Natural Resources (SEMARNAT) and announced in 2013, and presents two goals for the long term, i.e., 10 years, 20 years and 40 years in the future, and the strategies for achieving them. These policies are mainly reflected in various individual policies, as follows.

Policies related to energy in Mexico are established in the Program for the Energy Sector (Programa Sectorial de Energía; PSE). The PSE specifies the priority goals for the Secretariat of Energy, which has overall responsibility for the energy sector, together with action guidelines for strategies. The period of the current program is from 2020 to 2024. The program describes four low-interest loan programs for the purpose of promoting energy conservation, targeting the sectors of agriculture, industry, transportation, housing, commerce, electric power and the government.

Mexico implemented a carbon tax in 2014, and in 2020, it began Latin America's first attempt at an emissions trading system<sup>65</sup>. This pilot program is applicable to enterprises in the energy and industrial sectors with emissions of approximately 100,000 t-CO<sub>2</sub>/y, and covers roughly 300 enterprises corresponding

<sup>65</sup> Trends in carbon pricing overseas and suggestions for Japan, Institute for International Monetary Affairs (IIMA), 2021.03.11 (<https://www.iima.or.jp/docs/newsletter/2021/n12021.08.pdf>)

to 40% of Mexico's total emissions<sup>66</sup>. Introduction of the full-scale ETS (Emission Trading System) through a pilot phase in 2020-2021 and a transition phase in 2022 is planned. A design aimed at collaboration with other emission trading systems in the future has also been incorporated in the ETS, but concrete collaboration is still in the study stage.

In the United States, which is a main trading partner of Mexico, President Biden made a public commitment to introduce a carbon border adjustment mechanism during the recent election. The US Congress has also been considering a "carbon polluter import fee" since September 2021 based on a financial resolution passed by the Senate on August 11<sup>th</sup><sup>67</sup>. To date, however, it appears that CANACERO has not expressed an opinion on this matter.

### **2.7.2 Identification of Issues Related to Low-Carbon and Decarbonization (Technical, Financial and Policy Aspects)**

Because neither Ahmsa nor ArcelorMittal had introduced CDQ (coke dry quenching) and TRT (blast furnace top pressure recovery turbine) facilities as of 2017, there is room for introduction of energy-saving technologies. However, even before the Covid-19 pandemic, Mexican iron and steel producers had been placed in an extremely difficult situation due to the effects of cheap Chinese materials, and for this reason, some type of financial support will be required for the introduction of energy-saving technologies. In starting cooperation with the Mexican steel industry, it will be important to obtain a consensus in CANACERO, but CANACERO maintains a cautious stance toward the involvement of the Mexican government. Therefore, in addition to JCM, it will also be necessary to study using GREEN (GREEN (Global action for Reconciling Economic growth and ENvironmental preservation), which is an initiative of the JBIC (Japan Bank for International Cooperation) that requires almost no involvement of the Mexican government.

Because the level of understanding and interest in ISO 14404 and energy management/CO<sub>2</sub> reduction in iron/steel works differs depending on the company, it is necessary to encourage wider adoption of ISO 14404, etc. It may also be noted that Mexican steel makers appear to have a high interest in the energy management standard ISO 50001.

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<sup>66</sup> ICAP, ETS Detailed Information, 2021.8.9

<sup>67</sup> Nikkei ESG, 2021.09.24

(<https://project.nikkeibp.co.jp/ESG/atcl/column/00003/091700022/?P=3>)

### **2.7.3 Consideration and proposal of cooperation programs**

#### **(1) Status of the country supported**

##### **a) Motivations and gaps in Mexican government**

Regarding the perspective of climate change, it was assumed that the contribution of the steel industry to climate change countermeasures through energy conservation was relatively large, however, the expectations and motivation of the Mexican government toward the steel industry were not confirmed. The survey up to the above revealed that the GHG emission ratio of the steel industry to the country as a whole is as high as 7%, compared to the maximum of 3.9% estimated by the survey team, suggesting that the contribution to GHG reduction by energy conservation may be significant. However, the NDC does not specifically mention the steel industry, and the presence of the steel industry in the government's view of climate change measures is unclear. This may be the government's view in light of the high ratio of electric furnaces and low GHG emission intensity per unit of crude steel production, which will be discussed later. On the other hand, Mexico, which has enacted a carbon tax and has been experimenting an emissions trading system, is considered to have a high awareness of climate change measures in general.

In terms of industrial development, the government does not seem to have a special interest in the steel industry, although it was found that the country may have certain strengths in crude steel production. As mentioned above, Brazil is the second largest producer of crude steel in Latin America, so the steel industry seems to have a strong geographical presence. In addition, given that steel production is increasing due to the growing supply to the automobile industry, the future of the industry looks promising. On the other hand, in the Mexican government's National Development Plan PND (Plan Nacional de Desarrollo) 2019-2024, there is no mention of a specific focus on the steel industry, and Ahmsa, a major steel producer, was privatized in 1991, leaving the country without a state-owned company.

Considering the above, this desktop study indicates that the Mexican government's motivation for the steel industry is most likely low, if not unclear to some extent. However, as the effects of the carbon border adjustment by the U.S., a major trading partner, are expected to enter the stage of concrete manifestation in the future, it is assumed that a national response and change will be required. Therefore, it will be important to closely monitor the national response to these developments.

##### **b) Motivation and gaps in Mexican steel producers**

As for Mexican steel producers, the Mexican Association of Steel Producers

(CANACERO) plays an important and leading role, and it was assumed that they are highly motivated for energy efficiency and conservation. In Mexico, where electric furnaces are commonly used, the GHG emission intensity per unit of crude steel production is already low, and there is concern that the scope of reduction through cooperative activities may be small. Although CANACERO is well aware of this situation, they are proposing to reduce CO<sub>2</sub> emissions in the steel industry by 65MtCO<sub>2</sub>/year (14% reduction from 2030 BAU). In order to achieve this goal, they cited the improvement of emission factors, domestic production of materials, and the supply of renewable energy, which are considered to be in line with the direction of this project. CANACERO is an important stakeholder in the promotion of this ambitious goal, and their motivation is presumably very high. Therefore, although there is no connection with the survey team at present, it is expected that CANACERO will be the entry point for future cooperation.

(2) Compatibility with the Japanese cooperation and development policy

In the development cooperation policy, industrial promotion and triangular cooperation are positioned as priority areas in Mexico. Considering this and the position of the iron and steel industry in Mexico, which has a strong presence in Latin America, it is assumed that by establishing a way to support the iron and steel industry through this project, it will be possible to spread the efforts to neighboring countries (such as Brazil). As a starting point, support for the steel industry in Mexico has an important meaning.

On the other hand, the project development plan assumes that support will be provided mainly for the automobile industry as priority area of industrial promotion. Therefore, supporting the steel industry, which forms the foundation of the automobile industry, is expected to have a synergistic effect on these projects. Therefore, this project is expected to be an effective support that is consistent with Japan's cooperative development policy.

(3) Proposal of cooperation programs for the country

The direction of the cooperation program and specific proposals will be described (the chart below). In Mexico, as CANACERO's proposals and initiatives are much more active and visible than government policies, it is important to take a bottom-up approach to the government and a top-down approach to the private sector starting with CANACERO.

Table 2-24 Cooperation programs proposed for Mexico

Cooperation program	Scope	Importance & policy for cooperation
<p>Policy building capacity improvement, policy recommendation</p> <ul style="list-style-type: none"> <li>➤ Implementation of periodic statutory reporting system, etc. for energy conservation</li> <li>➤ Support for formulating energy conservation/decarbonization promotion policies and roadmap development</li> <li>➤ Support for implementation of energy efficiency and conservation incentive system</li> </ul>	Government	<p>It is important but low priority. In contrast to the proactive attitude of the Mexican government about the climate change, the steel industry is led by CANACERO and therefore top-down implementation of cooperation from the government side may discourage CANACERO. A careful approach to the process of establishing cooperation is required, including understanding the government's perception of the steel industry in the first place.</p>
<p>Energy efficiency and conservation assessment at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ BAT feasibility study</li> <li>➤ Survey on potential for utilization of unused energy (exhaust heat, by-product gas, etc.)</li> </ul>	Private business organizations and private business operators	<p>Extremely important and high priority. In order to motivate the Mexican government, it is essential to establish data on the actual situation of the business field and visualize the detailed situation in the country. since CANACERO is also active in energy conservation, so it would be better to understand the actual situation in specific factories.</p>
<p>Support for developing a roadmap for CO<sub>2</sub> reduction in the steel industry</p> <ul style="list-style-type: none"> <li>➤ Hold public-private meetings and seminars for industry</li> </ul>	Government & private business operators (Japanese government/Japanese	<p>Important, but lower priority compared to iron/steel works energy diagnoses. As CANACERO has</p>

Cooperation program	Scope	Importance & policy for cooperation
<p>players</p> <ul style="list-style-type: none"> <li>➤ Top management level capability improvement (ISO 50001, ISO 14001)</li> <li>➤ Support for developing supply chain CO<sub>2</sub> reduction roadmaps</li> </ul>	private business operators)	<p>already identified future energy efficiency and conservation targets and roadmaps, complementary cooperation in a way that is consistent with this is desirable; if CANACERO requests government support, public-private meetings will be important as a forum to coordinate for the support.</p>
<p>Support for planning the implementation of eco-processes and pilot equipment</p> <ul style="list-style-type: none"> <li>➤ Support for detailed planning</li> <li>➤ Support for matching with equipment manufacturers, etc.</li> <li>➤ Support for consideration of financing methods</li> </ul>	Private business operators	<p>Cooperation with individual private contractors should be based on the detailed trends and intentions of CANACERO.</p>
<p>Development of tools to support decarbonization and energy conservation at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ Promotion of ISO 14404</li> <li>➤ TCL formulation and promotion</li> <li>➤ BAT preparation and promotion</li> <li>➤ Energy balance modeling tool</li> <li>➤ Improvement measures identification tool</li> </ul>	Government & private business organizations	<p>Since it was observed that the intentions and motivational directions of the government and CANACERO may not be aligned, it is desirable that the meeting be held in light of the public-private meetings to bring the two sides into agreement.</p>

## 2.8 India

### 2.8.1 Analysis of Current Condition (Equipment Capacity, Technologies and Energy Management Level of Main Companies, Policies and Systems, Etc.)

#### (1) Overview of the steel industry in India

In India, the Joint Plant Committee (JPC) under the Ministry of Steel, Government of India, manages statistical data on the iron and steel industry such as production capacity, production volume, etc. According to the JPC's annual statistics for 2019-2020, India's iron and steel production is increasing year by year, but production of crude steel by the electric arc furnace (EAF) has been largely flat for the past 5 years, while production by the electric induction furnace (EIF) has increased and now accounts for the larger share. India's total crude steel production during fiscal year 2019-20 was 109.137 million tons, and of this amount, the share of production by the EAF process was reported to be 26% (28.37 million tons), while the share of the EIF were 30% and that of the basic oxygen furnace (BOF) was 44%.

Table 2-25 Transition of crude steel production in India (million tons)

	2015-16	2016-17	2017-18	2018-19	2019-20
BF	38.3	41.9	47.4	49.5	48.6
EAF	24.7	29.1	26.5	28.5	28.4
EIF	26.8	27.0	29.2	33.0	32.2
EF Total	51.5	56.0	55.7	61.5	60.6
Total Production	87.8	97.9	103.1	110.9	109.1

Table 2-26 Production status in the Indian steel industry (2017-2018)

Type of Industry	No. of units	Total capacity ('000 tonnes)	No of working units	Production ('000 tonnes)	Capacity utilization (%)
Blast furnace – hot metal	61	80,873	60	68,016	84.4
BOF	18	55,267	18	47,489	85.9
Electric Arc Furnace	56	40,734	50	26,421	65.7
Induction Furnace	1,187	46,407	999	29,221	68.8
Sponge iron	346	51,531	312	30,511	61.5

Source: TERI, "Towards a Low Carbon Steel Sector", (2020)

Energy consumption by all industrial sectors in India was 307 Mtoe (2017-18), and energy consumption by the iron and steel sector accounted for 23%.

While coal-fired thermal power generation is the largest power source in India, many industries including the steel sector have installed private power plants due to problems with the reliability of the power grid. In 2015-16, 91% of the power consumed in the steel industry was reported to be coal-derived.

In a report published by TERI in 2020, the energy intensity of the Indian steel industry was compared with data from other developed countries' steel industries, as shown in the figure below, pointing out that India's energy efficiency is low, but that there is significant room for the steel industry as a whole to save energy by adopting BAT (best available technology).

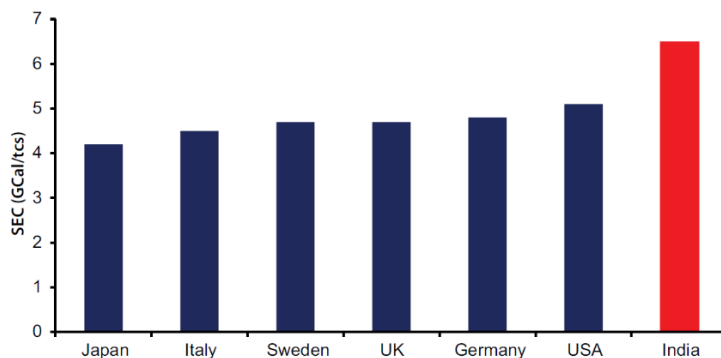


Figure 2-34 Average specific energy consumption of integrated iron/steel works by country (2012 base)

Source: TERI, "Towards a Low Carbon Steel Sector", (2020)

## (2) Overview of main steel companies in India

Following India's independence in 1947, three companies, TISCO (Tata Iron & Steel Ltd., now Tata Steel Ltd.), IISCO (Indian Iron & Steel Company, now IISCO Steel Plant, which is part of SAIL) and Mysore State Iron and Steel Works (now VISL, a subsidiary of SAIL), were the main iron and steel producers in India, and all these companies produced steel by the blast furnace. After 1950, large nationally owned integrated iron/steel works were established by the Indian government. From 1970 onward, the government approved the installation of small-scale steel making plants and processing plants, and in the years up to 1985, many scrap-based EAF plants and rolling mills were constructed in the country. In the mid-1980s, there were at least 180 to 185 EAF plants in India, which accounted for approximately 30 to 35% of domestic crude steel production. However, India had imported large amounts of scrap from other countries because domestic supplies of scrap were limited. Almost all of these plants had a production capacity on the scale of several 1,000 t/y.

After approval of the installation of electric induction furnace (EIF) plants became possible following the deregulation of the steel industry in 1991, switchover from EAF to EIF occurred, and the number of EAF-based mills declined from the above-mentioned 180-185 to around 50. However, between 2000 and 2005, large-scale iron/steel works employing the EAF process began to appear, utilizing reduced iron produced by gas reduction or pig iron from the blast furnace as iron sources.

Today, India's steel industry is extremely fragmented. According to the JPC data book, there are large-scale integrated steel makers (called Large Iron and Steel Producers of Large ISP) with production capacities of several million tons. These include SAIL (Steel Authority of India Ltd.), RINL (Rastriya Ispat Nigam Ltd. 67), Tata Steel Ltd., AM/NS, JSW Steel Ltd. and Jindal Steel & Power Ltd. (JSPL). These large-scale ISPs are sometimes collectively termed "Main Producers" or "Major Producers."

The JPC uses the single classification "Mini/Other" for coal-based DRI-EAF and EIF integrated units, scrap-based stand-alone EAF and EIF, and MBF-EAF. With a few exceptions such as Bhushan Power & Steel Ltd. (BPSL) and Monnet Ispat & Energy Ltd., almost all of these units have a production capacity or actual production volume of less than 1 million t/y. Many of these units are equipped with production facilities for iron sources (molten pig iron/DRI) for internal consumption.

In addition to the Large ISPs and Mini/Other steel producers, India also has a large number of plants that produce semi-finished materials such as pellets and DRI (direct reduced iron). These are either under the control of the large-scale ISPs or Mini/Other steel producers, or independent plants that produce products for sale.

Table 2-27 Classification of the Indian steel industry

Classification	Explanation
Large ISPs Main/Major Producers	<ul style="list-style-type: none"> <li>Large integrated steel producers / companies</li> <li>This includes the categories which was used by JPC before as below <ul style="list-style-type: none"> <li>➤ Main Producers : Traditional steel producers as SAIL, RINL etc.</li> <li>➤ Major Producers : New large steel producers (JSW, Ispat Industries (now as JSW) , JSPL, Essar, etc.)</li> </ul> </li> <li>Includes SAIL, RINL, Tata Steel, AM/NS, JSW, JSPL</li> </ul>
Mini/Other	<ul style="list-style-type: none"> <li>Other small steel producers than above</li> <li>Most of them have production capacities of less than 1 million tonnes per annum, except a few like BPSL and Monnet Ispat &amp; Energy</li> <li>"Others" under the past category by JPC (Though some has capacities over 3 million tonnes now)</li> <li>Many of them have captive ironmaking (hot metal / DRI) facilities</li> </ul>

Table 2-28 Production status in the Indian steel industry (2019-20)

Sector	Number of iron/steel works		Annual production capacity (Mt/y)		Annual production (Mt/y)	
	Total	Others	Total	Others	Total	Others
Iron Ore Pellets	39	33	81.14	42.54	67.99	35.65
Direct Reduced Iron (DRI)	285	278	47.85	33.15	37.1	27.38
Blast Furnace	57	40	79.6	13.68	73.01	7.28

Sector	Number of iron/steel works		Annual production capacity (Mt/y)		Annual production (Mt/y)	
	Total	Others	Total	Others	Total	Others
Basic Oxygen Furnace (BOF)	17	5	57.3	4.08	48.57	1.84
Electric Arc Furnace (EAF)	39	29	40.51	11.8	28.37	6.72
Electric Induction Furnace (EIF)	858	858	44.5	44.5	32.2	32.2
Steel Re-rolling Mills (SRRMs)	1,020	1,004	79.6	56.8	55.6	36.72
Hot Strip Mills	23	9	54.4	7.6	46.2	4.66
Cold Rolling Mills	68	52	26.4	10.8	17.7	6.17
Galvanizing Units	28	15	9.6	4.03	7.57	2.92
Color Coating Units	17	10	2.8	1.23	2.26	1.04
Tin Plate Units	4	1	0.84	0.38	0.37	0.2

Table 2-29 BOF, EAF and EIF based steel makers (2019-20)

Company	Production through BOF (million tons / year)	Production through EAF (million tons / year)	Inputs in EAF
SAIL Group	15.95	0.21	Mainly scrap
RINL	4.75	-	-
Tata Group	16.4	2.13	Captive hot metal +DRI
JSW Group	9.64	6.33	-do-
AM/NS	-	7.12	-do-
JSPL Group	-	5.86*	-do-
BPSL	-	2.9	-do-
Mini BOF Total	1.84	-	Captive hot metal
Mini EAF (28 plants) total	-	3.82	Mostly scrap + purchased DRI
subtotal	48.57	28.37	-
EIF total (858 plants)	32.2		-
Grand total	109.14		-

Virtually almost all EAF-based Large ISPs produce conventional unalloyed steel or carbon steel (flat products, long products) for mass consumption. The majority of the Mini/Other EAF mills produce mainly alloys, special steels and/or stainless steels, and produce long products primarily for engineering and high-end applications.

Almost all EAF-based Large ISPs have production capabilities for iron sources for internal consumption, such as gas-based DRI, coal-based DRI or blast furnace-based molten pig iron. The majority of these plants use either DRI or molten pig iron as the iron source for the EAF process.

In addition, several plants are equipped with CONARC furnaces, DC arc furnaces, new energy oxygen furnaces or similar facilities, and normally use a large amount of hot metal or other molten charging materials in order to minimize steel scrap and power consumption. On the other hand, the majority of the EAF-based Mini/Other mills use steel scrap and pig iron as the main charge mix, while the remainder use purchased coal-based DRI. However, there are large variations in the scrap and DRI use patterns of the mini/other mills, depending on the region and the availability and price of scrap and DRI. The DRI use ratio is high in the eastern part of India, where DRI is readily available in large quantities and at a low price, and use of steel scrap is large in northern and western India, where DRI is difficult to obtain.

Due to the limited availability of domestic steel scrap in India, scrap is consumed internally at the Large ISPs, but mini/other producers depend on imported scrap. At present, India imports approximately 6.5 million tons of steel scrap each year.

Table 2-30 shows an outline of the main steel companies, and Table 2-31 shows their equipment composition. Figure 2-35 shows the locations of the main iron/steel works.

JSW Steel has four blast furnaces and produces hot-rolled and cold-rolled steel sheets, galvanized steel sheets, wire rod material and steel bars as main products. The Japanese company JFE Steel has an equity investment of 15%. In addition to the steel business, the JSW Group also operates multiple other businesses, including mining, electric power, industrial gas, etc.

As efforts related to production technology, in September 2021, it was reported that JSW plans to create a network of digitally connected smart iron/steel works in India by FY 2024 by introducing advanced technologies such as enhanced AI, machine learning, robotics and connected cloud capabilities.

JSW Steel also blew-in blast furnace No. 2 at Dolvi in Maharashtra State in October of 2021, and announced that it will increase the production capacity of Dolvi Works to 10 million t/y. The company's production capacity was 18 million t/y, but increased to 21.5 million t/y with the completion of its acquisition of BSPL. With the expansion at Dolvi, JSW Steel's production capacity is expected to exceed 26 million t/y. Although the start of a further expansion at Dolvi Works to 14 million t/y is also planned, the details have not been announced. In October 2021, JSW Steel announced that it will also construct a new plant to produce prepainted steel sheets in the Kashmir region at an investment cost of US\$ 20 million.

Tata Steel (formerly Tata Iron and Steel: TISCO) is India's largest privately-owned integrated steel maker. In September 2021, the company commissioned a 5 t/d carbon (CO<sub>2</sub>) capture plant at Jamshedpur Works, becoming the first company in the Indian steel industry to adopt a CO<sub>2</sub> separation and recovery technology which extracts CO<sub>2</sub> directly from blast furnace (BF) gas. The project was carried out with technological support from the English company Carbon Clean. CO<sub>2</sub> is planned to be captured using an amine adsorbent, and recycled within the iron/steel works. Beginning in September 2020, Tata has also been involved in the field of carbon capture, utilization and storage (CCUS) in cooperation with the Council of Scientific & Industrial Research (CSIR), an organization under India's Ministry of Science and Technology.

In a move related to steel scrap, in August 2021, Tata started up a steel recycling plant with a production capacity of 500,000 t/y in Rohtak City in Haryana State. On the other hand, in May 2020, the company announced its sudden withdrawal from the Indian Steel Association (ISA), which consists of major iron and steel producers such as SAIL, RINL and JSPL.

SAIL (Steel Authority of India Ltd.), which was established in 1973, is India's national steel producer and has a total of 8 blast furnaces at 5 integrated iron/steel works.

In 2020, the company completed the construction of 3 new blast furnaces (BFs), increasing its production system from 16.16 million t/y with the existing system to 21.40 million t/y. However, due to the downturn in the global economy, an expansion plan for Durgapur Steel Plant (DSP) in West Bengal State was adjusted downward from the original 3.5 million t/y of molten pig iron to 2.5 million t/y.

AM/NS (AcerlorMittal Nippon Steel India) is 60% owned by ArcelorMittal and 40% owned by Japan's Nippon Steel Corporation.

AM/NS plans to double the current 9.6 million ton system at its Hazira BF iron/steel works in some number of stages, and is also studying a new plant in Odisha State. The company is also attempting to obtain environmental clearance to add 4.08 million t/y of crude steel and 6 million t/y of HRC (hot-rolled coil) production capacity at Hazira Works, and is trying to increase its hot metal (molten steel) production capacity to 14 million t/y. Prior to those moves, AM/NS started up a new 6 million t/y iron ore pellet plant in the first half of 2021, in addition to its existing capacity of 14 million t/y.

Table 2-30 Outline of main steel companies in India

No	Company name	Office	Crude steel production capacity (thousand tons/year)	Upper process	Main Products	National/Foreign	Information on saving CO2 and energy	Notes
1	JSW Steel	Vijayanagar, KR Province	13,500	Blast furnace, DR, Corex-converter	Steel rebars, wire rods, hot rolled, cold rolled, CG, electromagnetic	Includes about 10.5% foreign capital (Japan)?		Jindal Group Jindal Gr 35%, JFE 14.92%, listed in Bombay
2	Tata Steel	Jamshedpur, JH Province	10,000	Blast furnace - converter, EOF	Steel rebars, wire rods, hot rolled, cold rolled, CG, welded tubes, seamless	Local	Three CDQ units (introduced in 2011) Ordered to suspend one coke oven due to environmental problems	Tata Group
3	SAIL	Bhilai, CH Province	8,300	Blast furnace - converter	Steel rebars, shaped steel (including railroad tracks), wire rods, thick and medium plates	State-owned company	One CDQ (14 years?) . PCI (150kg/t-pig) will be ordered in 2017	
4	Tata Steel BSL	Meramandali, Dhenkanal District, OR	7,900	Blast furnace, DR-electric furnace	Hot-rolled and cold-rolled	Local		Tata Group
5	JSW Steel (Formerly Ispat Industries)	Dolvi, Raigad Province, MH	5,000	Blast furnace, DR-electric furnace	Hot Rolled *Cold-rolled-CG-Color available in Nagpur, MH	Includes about 10.5% foreign capital (Japan)?	Two CDQ units (20 years)	Merger with JSW Steel in 2013 Jindal Group Jindal Gr 35%, JFE 14.92%, listed in Bombay
6	ArcelorMittal Nippon Steel India (AM/NS India)	Hazira (Plant B), Surat Province, GJ	5,000	Blast furnace, DR, Corex-electric furnace	Thick plate, thin slab type hot rolled	ArcelorMittal 60%, NIPPON STEEL 40%		ArcelorMittal Nippon Steel India (AM/NS India, formerly Essar Group) ArcelorMittal 60%, Nippon Steel 40%
7	ArcelorMittal Nippon Steel India (AM/NS India)	Hazira (Plant A), Surat Province, GJ	4,600	DR-Electric furnace	Hot-rolled, cold-rolled, CG, welded tubes	ArcelorMittal 60%, NIPPON STEEL 40%		ArcelorMittal Nippon Steel India (AM/NS India, formerly Essar Group) ArcelorMittal 60%, Nippon Steel 40%
8	Bhushan Power & Steel (BPSL)	Sambalpur District, OR	4,000	Blast furnace, DR-electric furnace	Steel rebars, thin slab hot-rolled, cold-rolled, CG, color, welded tubes	Includes about 10.5% foreign capital (Japan)? Acquired by JSW Steel?		2020, NCLAT approves the proposed acquisition of BPSL by JSW Steel

Table 2-31 Equipment composition of main steel companies in India

No	Company name	Number of units (start of operation year)						
		Blast Furnace	Converter	Coke Ovens	Sintering Furnace	Electric Furnace	Heating Furnace	DR
1	JSW Steel	4 units (04, 06, 09, 11)	5 base (97, 01, 07, 09, 11)	4 units (06, 06, 08, 10)	4 units (06, 09?, 11, 11)	1 unit (14) ※160tEF	5 units (97?, 10?)	1 units (14)
2	Tata Steel	9units (60 × 5 units, 58, 92, 08, 12)	7 units? (2 × 83, 3 × 94, 2 × 12)	9 units (75, 68, 73, 89, 98, 00, 13, 10, 14)	3 units (59, 88, 07)	—	2 units? (11, 12)	—
3	SAIL	8 units (59, 59, 60, 64, 66, 71, 87, 18)	6 units (59, 59, 60, 64, 66, 71, 87, 18 years)	11 units (59, 59, 60, 64, 65, 66, 72, 79, 88, 96, 14)	10 units (61, 61, 66, 71, 79, 81, 86, 91, 99, 14)	Is there? ※6,020t/day	?	—
4	Tata Steel BSL	2 units (10, 14)	2units (14, 14)	3 units (10, 10, 14)	3 units (08?, 13, 13)	3 units (2006, 2008, 2009)	2 units (09, 09?)	3 units (05, 14?, 14?)
5	JSW Steel(Formerly Ispat Industries)	1unit (00)	2 units (21?)	4 units (14)	1 unit (99)	4 units (97, 98, 05, 06)	More than 2 units? (18?)	1 unit (1994)
6	ArcelorMittal Nippon Steel India (AM/NS India)	1 unit (10)	—	—	—	4 units (10, 10, 11, 11) ※Including two 200-ton EF units	?	1 unit (10)
7	ArcelorMittal Nippon Steel India (AM/NS India)	—	—	—	—	4 units (96 × 3 units, 06) ※150tEF 3 units	2 units (95?)	5 units (90, 90, 92, 04, 06)
8	Bhushan Power & Steel (BPSL)	2 units (2007, 2005)	—	1 unit (07)	1 unit (07)	6 units (08 × 2 units, 10 × 3 units, 17) ※90tEF × 4, 100tEF	?	8 units (05 年 × 2 units, 07年 × 4 units, 10 × 2 units)

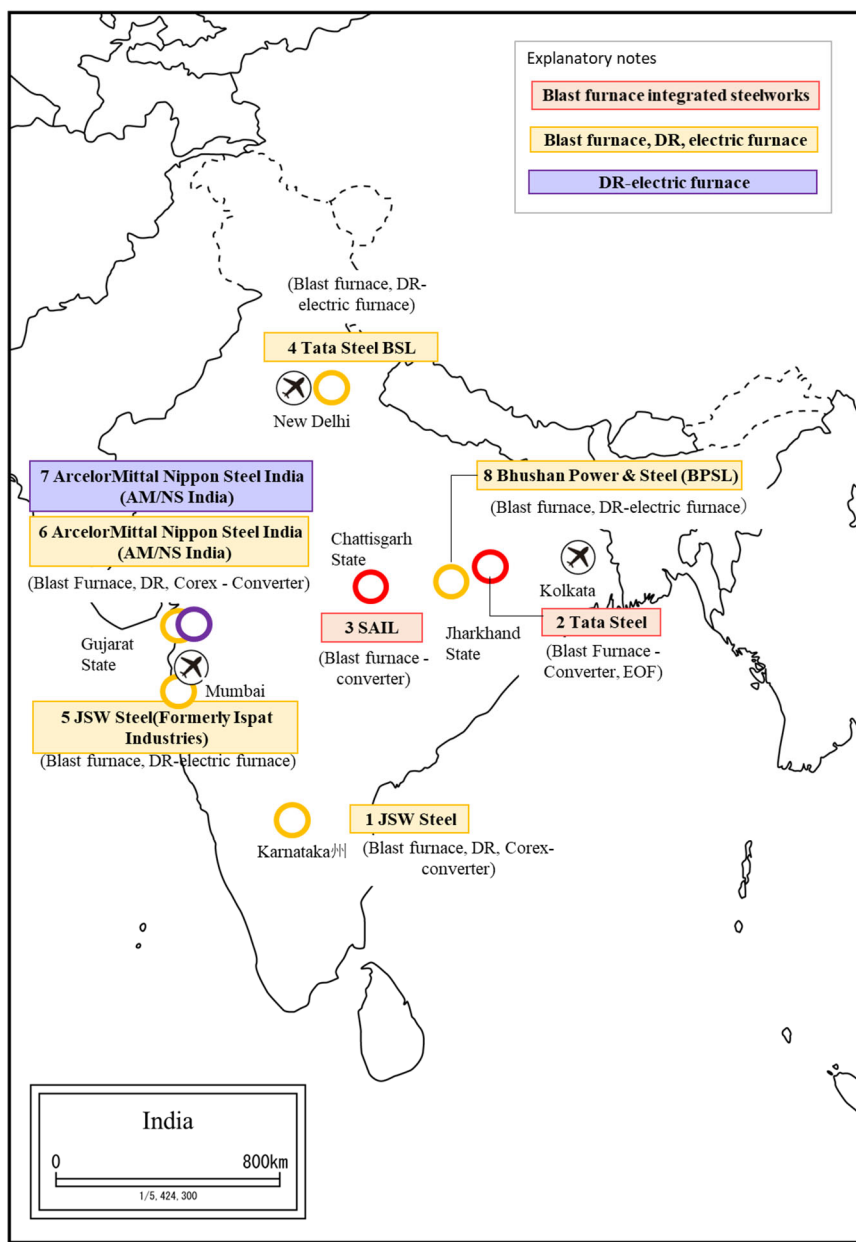


Figure 2-35 Locations of main iron/steel works in India

(3) Energy saving, low carbon and decarbonization-related policies and systems in India

The NDC (Nationally Determined Contribution) announced by India in 2016 targets a reduction of 33% to 35% in GHG emissions per unit of GDP in comparison with 2005, to be achieved by 2030. The steel industry as a whole is targeting improvement of emission intensity (emissions per unit of production) of 1% per year until 2030.

In 2012, India began a mandatory energy conservation target achievement certification system called the PAT (Perform, Achieve and Trade) scheme, which is the first of its kind in a developing country. The PAT scheme is positioned as

a key component element for achieving the National Mission for Enhanced Energy Efficiency (NMEEE), which is one of missions in the India's National Action Plan on Climate Change established in 2008.

Under the Cycle I of the PAT scheme, Designated Consumers (DCs) identified from energy-intensive industries and other establishments specified in the Energy Conservation Act 2001 were required to achieve an average 4.8% improvement in Specific Energy Consumption (SEC) over a 3-year period (PAT Cycle) covering fiscal years 2012-2015 against the baseline of fiscal years 2007-2009. Companies which are not able to achieve their targets are required to purchase credits called ES-CERT (Energy Saving Certification) in the market, or to pay a financial penalty. (The credits are energy saving credits earned by other companies which over-achieved their targets.) The implementation period of PAT Cycle I was set for 13 industrial sectors, including the steel industry, for 2012 through 2014. Accompanying the ratification of the Paris Agreement at COP21, from 2015-16 the scheme proceeded to the Cycle II targets, which were linked to India's Intended Nationally Determined Contribution (INDC) under the Paris Agreement. The PAT program is currently in Cycle IV, covering 2018-21.

In the case of the steel industry, energy unit targets (efficiency target per ton of crude steel) were assigned to establishments with energy consumption exceeding 30,000 toe (158 factories in Cycle I). Energy consumption was reduced by 8.6 million toe in India as a whole, including 2.1 million toe in the steel sector in PAT Cycle I. Thus, the PAT scheme is considered a key element for achieving the National Mission of improving energy efficiency in India.

In the steel industry, the following efforts have been carried out to date by Japan's New Energy and Industrial Technology Development Organization (NEDO), private-sector companies and others.

- High performance industrial furnace (NEDO demonstration project, to 2018)
- Energy center optimum control technology for iron/steel works (NEDO demonstration project, to 2019)
- Sintering cooler waste heat recovery equipment (NEDO demonstration project, to 2014)
- Coke dry quenching (CDQ) equipment (NEDO demonstration project, to 2011)
- Equipment for effective utilization of the sensible heat of blast furnace hot stove flue gas (NEDO demonstration project, to 2004)

India's Ministry of Steel (MoS) has also announced production targets and energy efficiency improvement targets by production process for "BF-BOF

method” and “EAF & DRI” under the name of “Steel Sector NDC.” These targets are voluntary in nature. However, the target for the steel industry as a whole is to reduce energy intensity (unit consumption) of 3.1 t-CO<sub>2</sub>/t-crude steel in 2005 to 2.4 t-CO<sub>2</sub>/t-crude steel by 2030. A unit improvement of 1% per year during the period until 2030 is targeted, and the investment necessary to achieve this is calculated as 520 billion rupees.

Table 2-32 Efficiency improvement targets for steel sector in India (2017)

		BF-BOF	DRI-EAF	Total
2005	Production (Mil t)	24.4	22.07	46.5
	Emissions (Mil t-CO <sub>2</sub> )	73	71	144
	Intensity (t-CO <sub>2</sub> /t-cs)	3.0	3.2	3.1
2020- 2021	Production (Mil t)	90	60	150
	Emissions (Mil t-CO <sub>2</sub> )	225	171	396
	Intensity (t-CO <sub>2</sub> /t-cs)	2.5	2.9	2.6
2030- 2031	Production (Mil t)	210	90	300
	Emissions (Mil t-CO <sub>2</sub> )	483	239	722
	Intensity (t-CO <sub>2</sub> /t-cs)	2.3	2.7	2.4

The Indian government established the Steel Research & Technology Mission of India (SRTMI) to promote the development of iron and steel technology for achieving India’s National Steel Policy (NSP) 2017, which is targeting a steel production capacity of 300 million tons by 2030. The SRTMI promotes cooperation with domestic scientific and research organizations and international organizations with the aim of improving the international competitiveness of India’s iron and steel industry.

“Towards a Low Carbon Steel Sector” was published by The Energy and Resource Research Institute (TERI) in 2020 as a “roadmap” to 2050 for the steel industry in India, and proposes the following “three key pillars” as a transition strategy for achieving low carbon in the steel industry.

① Pillar 1: Improve Energy Efficiency, Resource Efficiency and Material Recycle

According to the TERI report, the average plant could lower energy consumption by unit output by 24% to 38% by implementing energy efficiency improvement measures, and overall emissions could be reduced by up to 15% by 2050 versus the Baseline scenario.

If policies to actively promote resource efficiency are also considered, a 25% improvement by 2050 in comparison with the Baseline scenario could also be expected. For improvement of material circularity, the report proposes increased collection and use of domestic scrap, and states that a

scenario combining resource efficiency and increased circularity could achieve a further 20% reduction of emissions by 20% by 2050.

② Pillar 2: Implement Transition Strategies by the 2030s and Deep Decarbonization Options by the 2040s

As a promising transition option, the HIsarna process is proposed. The HIsarna process has already been used in Europe on a trial basis by Tata Steel, and can reduce emissions by 20% compared to the traditional blast furnace-basic oxygen furnace (BF-BOF) route. Emissions can be reduced by up to 80% by using this process in combination with CCUS.

The TERI report also foresees commercial availability of technologies which are currently in the demonstration stage by 2040, including the use of hydrogen as a reducing agent in the ironmaking process. Preconditioned on reduction of the cost of electrolytic hydrogen production and renewable electric power, a 94% reduction in total iron and steel emissions by the hydrogen route is considered possible.

The same report also summarizes the cumulative impacts of the proposed measures, as shown in Figure 2-36.

③ Pillar 3: Promote International Collaboration, Innovation and Technology Diffusion and Develop a Domestic Low Carbon Steel Strategy

The TERI report notes that steel demand will still be growing in India by 2050, and stresses the necessity of a long-term low emissions development strategy that includes active international promotion of innovative technologies such as renewable energy and hydrogen reduction, proactively pushing for international collaborative research, development and demonstration (RD&D) programs, engagement in international consortiums, and seeking funding and technology from international donors. In addition, in order to stimulate demand for low carbon-intensity steel, the report also proposes a mechanism whereby users would agree to buy low carbon-intensity steel at a premium (so as to market products as environment-friendly alternatives).

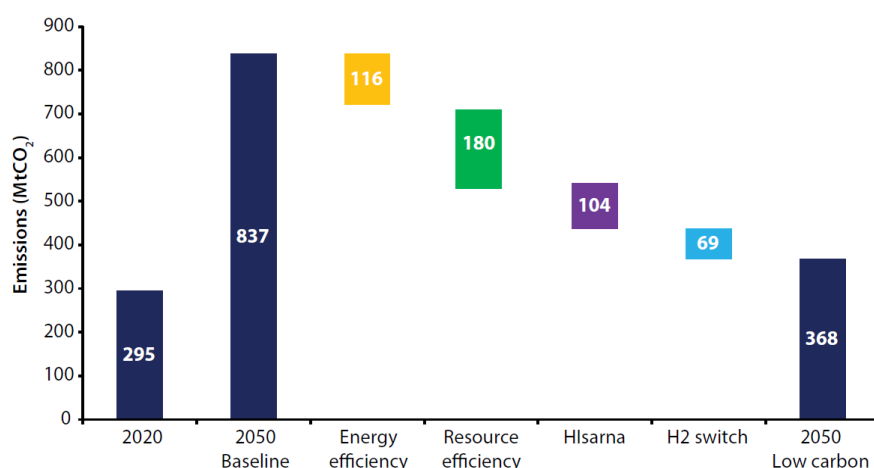


Figure 2-36 Cumulative impact of measures proposed by TERI

## 2.8.2 Identification of Issues Related to Low Carbon and Decarbonization (Technical, Financial and Policy Aspects)

India now ranks No. 2 in the world in crude steel production, having overtaken Japan, and further increases are expected in the future accompanying the growth of the Indian economy. With increases in steel demand also foreseen in the future, India is expected to have a high CO<sub>2</sub> reduction potential, since its unit energy consumption (energy intensity) and unit GHG emissions are high in comparison with those of other countries.

Because the absolute supply of scrap is increasing at a slower pace than India's iron and steel production, the International Energy Agency (IEA) has pointed out that there is a high possibility that the increased steel demand in India will be covered by primary production using iron ore as the raw material<sup>68</sup>.

In India, improving the operating efficiency of existing equipment and minimizing emissions by introducing BAT (best available technology) will be important in the short term. For example, only about 40% of India's existing blast furnaces are equipped with top pressure recovery turbines (TRT), and 30% or more of coke ovens are equipped with coke dry quenching (CDQ) facilities. Ensuring that these mature technologies are also introduced at newly-constructed facilities will be a key strategy.

In the long term, introduction of innovative zero emission technologies such as hydrogen-based DRI and steel production with CCUS is expected. Further support by the government and private sector and cooperation with other countries will be important for the development of these technologies. The Indian government is supporting many research and development projects through the Ministry of Steel based on the scheme of "Promotion of R&D in Iron and Steel

<sup>68</sup> IEA(2020), Iron and Steel Technology Roadmap

Sector,” and had a cumulative budget of more than US\$ 17 million over the past 5 years <sup>69</sup>.

To assess the actual condition of energy conservation in electric arc furnaces in India, in 2020, the Japan Iron and Steel Federation (JISF) conducted a survey of the status of the application of energy-saving technologies which are already widely used in Japan and other countries, focusing on Indian EAF iron/steel works that mainly use scrap as an iron source.

Among the eight EAF iron/steel works that replied, the application rate of technologies such as scrap preheating and slag foaming in EAFs was low. In the case of heating furnaces, excluding situations where use was impossible due to the equipment configuration of the plant, (i.e., direct rolling), application of regenerative burners and fiber block refractories (wall insulation material) was also judged to be inadequate.

Based on these results, it was found that mini-EAF mills in India do not have a high level of application of energy-saving technologies that are already widely used in other countries. The above-mentioned technologies include items that can be installed at a comparatively small capital investment cost and will also have a high return on investment. Thus, it would seem to be possible to recoup the initial investment within a short period. However, it is also possible that these technologies have not been introduced due to the inadequate financial resources of these small iron/steel works.

In the governmental policy and financial aspects, it appears that adaptation of the steel industry to the PAT scheme and further progress in realizing low carbon are issues. Since there are many small steel makers in India, especially in the EAF sector, it is possible that these companies do not have sufficient financial resources to apply the above-mentioned energy-saving technologies. This suggests that enhancement of government policies so as to support countermeasures by these small steel makers is an issue which should be addressed.

Moreover, India has a high proportion of coal-fired thermal power plants. Therefore, in addition to efforts to realize low carbon in the steel sector, and particularly EAF mills, efforts to achieve low-carbon or decarbonization in the electric power sector are also considered to be an important issue. The electric power sector is also an object of the PAT scheme.

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<sup>69</sup> Ministry of Steel

[https://steel.gov.in/sites/default/files/R%26D%20Chapter%20for%20MoS%20Website%20July%202019%20updated\\_0.pdf](https://steel.gov.in/sites/default/files/R%26D%20Chapter%20for%20MoS%20Website%20July%202019%20updated_0.pdf)

With the ongoing implementation of the PAT system, the steel sector is also making efforts to deploy technologies from Japan like those described above. However, as in the past, there are also comments from the Indian side that, although the quality of Japanese-made technologies is high, the cost is a barrier.

In India-Japan cooperation in the iron and steel sector, the India-Japan Public and Private Collaborative Meeting on the Iron and Steel Industry has continued to be an effective tool for more than 10 years. As part of this initiative, the Japan Iron and Steel Federation (JISF) prepares a “Technologies Customized List (TCL)” of technologies for which needs exist in the India steel industry and which can be supplied by Japanese equipment manufacturers. A number of energy-saving technologies have also been introduced in the iron and steel industry through NEDO demonstration projects. However, when the listed technologies are procured, Chinese equipment, which is cheaper than Japanese ones, is often introduced..

The Japanese government’s liaison with the above-mentioned India-Japan collaborative meeting is the Iron and Steel Division of the Manufacturing Industries Bureau, Ministry of Economy, Trade and Industry (METI), and its counterpart on the Indian side is the Ministry of Steel. However, for matters related to the PAT scheme, coordination with the Agency for Natural Resources and Energy of METI is necessary, as this is the counterpart of India’s Ministry of Power (MoP), which supervises the PAT scheme. Multiple energy diagnosis projects have been carried out at iron/steel works in India as part of JISF and Indo-Japanese cooperation, but those efforts have been hampered by various issues, including the complexities of the bureaucratic organization in Indian government agencies, the large number of regulations in India, and unilateral postponement of Public and Private Collaborate Meetings between Japan and India by the Indian side immediately before meetings were to be held, etc. Thus, the difficulty of advancing cooperative projects has also been pointed out.

### **2.8.3 Consideration and proposal of cooperation programs**

#### **(1) Status of the country supported**

##### **a) Motivations and gaps in Indian government**

In terms of climate change, it was confirmed that the Indian government has provided sufficient policies to the steel industry and has a concrete mindset to decarbonize the steel industry. For example, India's NDCs specifically address the steel industry, and the target is to improve emissions intensity by 1% per year by 2030. In addition, the country has established a mandatory PAT system and a long-term roadmap for 2050, which includes energy conservation and decarbonization. From these policies, it can be read that energy efficiency and

conservation in the steel industry also occupies an important position in achieving the NDC. Therefore, the study team's estimate of the steel industry's share of CO<sub>2</sub> emissions is 4.7-5.7%, which can dispel the suspicion that the government may have underestimated its contribution to combating climate change.

In terms of industrial promotion, the government's motivation for the steel industry is expected to expand further in the future. First of all, India is the second largest steel producer in the world and the production is increasing every year, so the industry itself is considered to have a strong presence in the country. India also has a state-owned company, Tata Steel, which is active on a global scale, so support for the industry is essential as it directly affects its international reputation.

On the other hand, energy efficiency is low due to the system's dependence on coal for fuel, and improvements will focus on the entire supply chain, including the government's efforts to ensure reliability of electricity. Therefore, there are sufficient measures that should be taken by the government, and it is highly likely that support for the study and implementation of measures to close the gap with the future vision will be accepted.

#### b) Motivation and gaps in Indian steel producers

As for Indian steelmakers, it can be presumed that they are in a situation of heightened motivation because they have a sufficiently favorable environment in which the importance of energy efficiency and conservation is emphasized by the various government measures mentioned earlier. In fact, given the fact that a number of NEDO demonstration projects have already been implemented and the India-India Steel Public-Private Cooperation Meeting has continued as an effective tool for more than 10 years, cooperation under this project is expected to complement existing cooperative projects and create synergy effects. On the other hand, while it is important to continue cooperation among major steel companies in India, small-scale iron/steel works (mini-EAF plants) do not have a high level of energy efficiency and conservation readiness and are not making capital investments in terms of funding and scale of operations. This support is also an important factor in closing the gap against the 2050 target. On the other hand, the Indian Iron and Steel Institute (ISA) is assumed to be relatively inadequate in organizing steelmakers due to the withdrawal of Tata Steel, so it will be necessary to carefully examine the scope of support.

#### (2) Compatibility with the Japanese cooperation and development policy

The development cooperation policy for India has mentioned strengthening

connectivity and industrial competitiveness. Strengthening industrial competitiveness is very much in line with this project, especially since it is intended to strengthen the manufacturing sector. On the other hand, for the enhancement of connectivity, the development of railroad infrastructure and electric power infrastructure is mentioned, and electric power infrastructure is a factor that enables energy conservation in this project, as well as railroad infrastructure is positioned for the use of manufactured goods. Therefore, the significance of this project is very high in that it not only matches the existing direction of the country, but can also enhance and facilitate the direction. In light of the project development plan, the majority of the cooperation is related to large infrastructure, and therefore continuous cooperation is expected in the future.

### (3) Proposal of cooperation programs for the country

The direction of the cooperation program and specific proposals will be described (the chart below). In India, programs that takes into account existing cooperation activities and complements them are required. Therefore, it is considered that the first step should be to examine the status of existing cooperation programs and identify the scope of cooperation that is lacking or needs to be supplemented. For this purpose, it is important to have a detailed understanding of the contents of previous cooperation activities from Japan (such as NEDO projects).

Table 2-33 Cooperation programs proposed for India

Cooperation program	Scope	Importance & policy for cooperation
Policy building capacity improvement, policy recommendation ➤ Implementation of periodic statutory reporting system, etc. for energy conservation ➤ Support for formulating energy conservation/decarbonization promotion policies and roadmap development ➤ Support for implementation of energy efficiency and conservation incentive system	Government	They are already in place and are low priority. Measures to reinforce these policies in a concrete way should be proposed/supported.
Energy efficiency and	Private business	Although not a high

Cooperation program	Scope	Importance & policy for cooperation
<p>conservation assessment at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ BAT feasibility study</li> <li>➤ Survey on potential for utilization of unused energy (exhaust heat, by-product gas, etc.)</li> </ul>	organizations and private business operators	priority for the major steel companies, there is room for implementation for the smaller steel companies.
<p>Support for developing a roadmap for CO<sub>2</sub> reduction in the steel industry</p> <ul style="list-style-type: none"> <li>➤ Hold public-private meetings and seminars for industry players</li> <li>➤ Top management level capability improvement (ISO 50001, ISO 14001)</li> <li>➤ Support for developing supply chain CO<sub>2</sub> reduction roadmaps</li> </ul>	Government & private business operators (Japanese government/Japanese private business operators)	Although it is a low priority since most of it has already been implemented, the supply chain CO <sub>2</sub> reduction roadmap should be harmonized and complementary to the existing power grid development plan described in the business development plan.
<p>Support for planning the implementation of eco-processes and pilot equipment</p> <ul style="list-style-type: none"> <li>➤ Support for detailed planning</li> <li>➤ Support for matching with equipment manufacturers, etc.</li> <li>➤ Support for consideration of financing methods</li> </ul>	Private business operators	Implementation through channels such as the Japan-India Public-Private Dialogue should be explored.
<p>Development of tools to support decarbonization and energy conservation at iron/steel works</p> <ul style="list-style-type: none"> <li>➤ Promotion of ISO 14404</li> <li>➤ TCL formulation and promotion</li> <li>➤ BAT preparation and promotion</li> <li>➤ Energy balance modeling tool</li> <li>➤ Improvement measures identification tool</li> </ul>	Government & private business organizations	Since some of these tools have already been introduced, a cooperative program that focuses on rollout rather than the introduction of various tools should be considered.

### 3. Proposal of cooperation projects to priority country

Select one priority target country from the candidate countries for cooperation, and consider and propose specific cooperation projects through information gathering based on online meetings with stakeholders.

#### 3.1 Anticipated challenges for priority countries

According to the desktop study, Turkey is considered to be highly potential due to its high energy consumption intensity and room for reduction potential, and also because both the government and private sectors are highly motivated to conserve energy, which is beneficial for the formation of cooperative programs and the size of their effects. In particular, the EU's Carbon Border Adjustment Measure (CBAM), which is a major challenge for Turkey in the current climate, is expected to be an important motivation to accept the cooperation. On the other hand, since climate change and economic enhancement are seen as two opposing factors by the government, it was difficult to confirm whether energy efficiency and conservation is judged to be an excellent solution that satisfies both. In this section, in order to examine the future course of the cooperation program in Turkey, which is a priority target country, we will confirm the government's intentions, details of the situation, and the willingness of the private sector to accept the cooperation, through interviews and research.

#### 3.2 Discussion with the stakeholders

##### 3.2.1 Online discussion with Counterpart Organizations

Online discussion was held with the Ministry of Energy and Natural Resources and the Turkish Confederation of Steel Producers (TCUD), which are potential Turkish C/P in this cooperation program. The summary is as follows.

Table 3-1 Information of online discussion with candidate C/P institutions

Meeting name	Online Conference with the Ministry of Energy and Natural Resources and TCUD
Date and time	Thursday, January 27, 2022, 16:30-18:15 JST
Location	Online via ZOOM
Participants	(In no particular order, titles omitted) 【Turkey】 ◆ the Ministry of Energy and Natural Resources T.C. Enerji ve Tabii Kaynaklar Bakanlığı EVÇED Başkanı (Absence on the day) T.C. Enerji ve Tabii Kaynaklar Bakanlığı EVÇED Planlama ve Denetim Daire Başkanı T.C. Enerji ve Tabii Kaynaklar Bakanlığı EVÇED Planlama ve Denetim Daire Başkanlığı Planlama ve Denetim Koordinatörü T.C. Enerji ve Tabii Kaynaklar Bakanlığı EVÇED Planlama ve Denetim Daire Başkanlığı Ölçme ve Değerlendirme Koordinatörü

	<p>T.C. Enerji ve Tabii Kaynaklar Bakanlığı Dış İlişkiler Genel Müdürlüğü / Uzman</p> <p>◆ TCUD</p> <p>Türkiye Çelik Üreticileri Derneği Genel Sekreter (JICA fellow)</p> <p>Türkiye Çelik Üreticileri Derneği Teknik İşler Direktörü</p> <p>◆ Companies in the steel industry</p> <p>Çolakoğlu/ CEO (JICA fellow)</p> <p>Kardemir/ President (JICA fellow)</p> <p>TOSYALI Group, Tosçelik / Plant Manager, Flat Plate and Structural Steel Manufacturing Plant</p> <p>Erdemir Oyak Maden ve Metalürji group / person in charge</p> <p>Erdemir/ Strategic Planning and Sustainability Supervisor</p> <p>İsdemir / Head of Energy Management</p> <p><b>【Japan】</b></p> <p>◆ JICA Headquarters</p> <p>◆ JICA Turkey Office: 3 people</p> <p>◆ ECCJ: 3 people</p> <p>◆ NSRI: 4 people</p> <p>◆ JFE-TEC: 3 people</p> <p>◆ International Environmental Strategy Committee, the Japan Iron and Steel Federation: 5 people</p> <p>◆ PCKK: 3 people</p> <p>◆ Japanese-Turkish interpreter and coordinator</p>
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In the discussions, the consortium presented an outline of the cooperation program envisioned by the Japanese side, confirmed the motivation of each entity, and tried to collect data that could not be supplemented by the desktop survey. A summary of the questions and answers is as follows.

Table 3-2 Overview of online discussion with candidate C/P institutions

No.	Outline of Questions and Answers
Q1	Is there any data available on (1) annual crude steel production (t-crude steel/year), (2) annual energy use (GJ/year), (3) annual greenhouse gas emissions (tCO <sub>2</sub> /year), and (4) energy use per unit of production (GJ/t-steel) for the Turkish steel industry as a whole?
A1	<ul style="list-style-type: none"> <li>● As TCUD, crude steel volume data is collected from each steel mill and reported to the World Steel Association (worldsteel). In addition, since 2015, in accordance with the law providing the framework of the Greenhouse Gas Emissions Monitoring, Reporting and Verification System, steel producers have been reporting their verified emissions (Framework 1) to the Ministry of Environment, Urban Development and Climate Change. (TCUD)</li> <li>● As for (4), each steel mill inputs information regarding raw materials, production volume and energy consumption into the ENVER portal of the Ministry of Energy and Natural Resources in accordance with regulations. (TCUD)</li> </ul>
Q2	Does the Turkish government impose a system of regular reporting of annual energy use or other obligations on steel mills?
A2	<ul style="list-style-type: none"> <li>● There is no such obligation in Turkey, but there is a voluntary 10%</li> </ul>

No.	Outline of Questions and Answers
	reduction in energy intensity, but this has not been implemented in steel mills. (TCUD)
Q3	Do the Ministry of Energy and Natural Resources, the National Energy Conservation Center, the Turkish Steel Producers Association, etc. provide information and other support to each steel mill regarding energy efficiency and conservation measures?
A3	<ul style="list-style-type: none"> <li>● Efforts are underway with support from the Ministry of Energy and the National Energy Conservation Center. (TCUD)</li> </ul>
Q4	In the nationally determined contributions (NDCs) submitted to the United Nations by the countries participating in the Paris Agreement, Turkey has announced that it will achieve net zero emissions by 2053. Is there any political movement or growing public opinion in Turkey to achieve the NDCs? Also, are there any movements in the Turkish steel industry to contribute to or collaborate with such efforts?
A4	<ul style="list-style-type: none"> <li>● The Paris Agreement established a zero emission target by 2053, and a climate change project is underway in cooperation with UNDP. The reduction target will be updated annually. (TCUD)</li> </ul>
Q5	<p>The position of the Turkish steel industry in the systems and frameworks related to low-carbon and decarbonization, and the needs of each steel mill for energy efficiency and conservation measures.</p> <p>(1) Under the energy efficiency and conservation policy in Turkey, is each steel mill required to achieve the mandatory energy usage reduction target?</p> <p>(2) Have you ever received requests from customers, banks, etc. (especially in overseas markets) to disclose information on energy efficiency and conservation and decarbonization measures (e.g., in response to the carbon border adjustment measures (CBAM) by the EU)?</p> <p>(3) If there is a request for (1) or (2) above, what kind of plans or measures is each steel mill considering to achieve it?</p>
A5	<ul style="list-style-type: none"> <li>● Regarding (1), 81 action plans have been defined for the European Green Agreements for low-carbon and decarbonization initiatives. A strategy document will be developed and concrete actions will be taken. (TCUD)</li> <li>● As for (2), the Ministry of Economy, Trade and Industry (METI) of Turkey is leading various efforts in this area, as it has a great impact. (TCUD)</li> <li>● As for (3), I will skip this point as it was mentioned earlier by each steel mill. (TCUD)</li> </ul>
Q6	<p>Support for promoting energy efficiency and conservation in the steelmaking sector by public organizations and international donors.</p> <p>(1) Have you ever received third-party, objective audits or consulting regarding the identification of energy efficiency and conservation measures?</p> <p>(2) Are there any public support systems (e.g., efficiency improvement projects (VAP) based on the Energy Efficiency Law) or organizations that provide advisory services in Turkey?</p> <p>(3) Have you received any such support from international donors in Europe or elsewhere?</p>
A6	<ul style="list-style-type: none"> <li>● Regarding (1), there are various initiatives under the Ministry of Energy, mainly related to energy audit (TCUD).</li> <li>● As for (2), support is sometimes received from energy efficiency improvement projects, but further improvements are still required in terms of budget and effectiveness. (TCUD)</li> <li>● Regarding (3), a low-carbon steel production project will be launched with the support of the European Bank for Reconstruction and Development (EBRD). (TCUD)</li> </ul>

No.	Outline of Questions and Answers
Q7	<p>Equipment capacity, applicable technologies, energy management level, and room for energy conservation at each steel mill</p> <p>(1) Please tell us the energy consumption intensity (GJ/t-steel) of the entire steel mill, the electricity consumption intensity (MWh/t-steel) of the electric furnace for steelmaking, the energy consumption intensity (kJ/t-steel) of the heating furnace for rolling, and the dimensions of steel products.</p> <p>(2) What are the main iron sources (iron ore, scrap, DRI, etc.)?</p> <p>(3) What are the main steel grades (ordinary steel, special steel (stainless steel, etc.)) and main products (hot-rolled steel sheets, steel bars, etc.)?</p> <p>(4) Please tell us whether you have already introduced the major energy efficiency and conservation technologies.</p> <p>(5) If there are any steel energy efficiency and conservation technologies that you are interested in, please let us know. Also, if there is an opportunity to receive information on that technology through workshops, advice from Japanese experts, or introduction of equipment suppliers, would you like to use it?</p>
A7	<ul style="list-style-type: none"> <li>● As for (1), each steel mill reports to the Turkish government, so I don't know the details, but I can give an average value. The average for a single blast furnace is 22.5 GJ/t-steel. For electric furnaces, the average is 3.78 GJ/t-steel. However, this is said to be at least 2.74 GJ/t-steel, so there is a wide gap between each source. (1) For the value of integrated blast furnaces and electric furnaces, hot rolling is included.</li> <li>● As for (2), iron ore for blast furnaces and scrap for electric furnaces. There is no domestic production of DRI.</li> <li>● As for (3), there are various products such as construction steel bars, wire rods, high quality steel, HRC hot rolled rolls, steel sheets, CRC cold rolled rolls, medium and high alloy steel, and stainless steel.</li> <li>● Regarding (4) and (5), coke dry fire extinguishing system and TRT, which are effective in reducing emissions, have been introduced for integrated blast furnaces. However, there are some places where they have not been introduced, so I think there are energy saving technologies that can be used. As for electric furnaces, the use of exhaust heat is important. Since the exhaust gas from the smokestacks of electric furnace plants is not fully utilized, there is a need for a power generation project using exhaust heat.</li> </ul>

In addition to this questions and answers, we received comments from the Ministry of Energy and Natural Resources, TCUD, and steelmakers who actively supported the cooperation. In particular, steelmakers insisted that they have already accelerated various energy-saving measures and are actively promoting the introduction of renewable energy. On the other hand, the discussion also confirmed that there is a sense of challenge in introducing further technology and raising funds for it, therefore, more detailed information on the issues arising in each of these entities is required in the future.

### 3.2.2 Survey on energy efficiency and conservation at iron/steel works

During this survey period, it became difficult to diagnose individual steel mills by on-site inspection due to the influence of the spread of COVID infection in both Japan and Turkey. Therefore, it was decided to contact each steel mill and conduct online interviews in order to obtain the situation of steel mills and the contents that were lacking in the desktop survey as much as possible. Two companies, Tosyalı Toyo Steel CO. INC. and Icdas Celik, were able to conduct interviews during the period. Icdas Celik, which has an electric furnace, was particularly knowledgeable about the situation in Turkey and the domestic workings of the Turkish steel industry. Thus, the contents of the interviews with Icdas Celik are summarized below.

Table 3-3 Information of online discussion with a steelmaker

Meeting name	Online discussion with Icdas Celik
Date and time	Monday, January 17, 2022, 16:00 - 19:15 JST
Location	Online via ZOOM
Participants	<p>※In no particular order</p> <p>Icdas Celik:</p> <ul style="list-style-type: none"> <li>General Manager, Investment &amp; Business Promotion Dept.</li> <li>General Manager, Environment Department, Steel Works(ICDAS CELIK ENERJI TERSANE ve ULASIM SAN. A.S.)</li> </ul> <p>ECCJ: 3 people  NSRI: 4 people  JFE-TEC: 3 people  PCKK: 3 people  Japan Iron and Steel Federation International  Environmental Strategy Committee: 5 people  Japanese-Turkish interpreter and coordinator</p>

In the discussions, the consortium presented an outline of the cooperation program envisioned by the Japanese side, and tried to collect data that could not be supplemented by the desktop survey.

The summary of the questions and answers are as follows.

Table 3-4 Overview of online discussion with a steelmaker

No.	Outline of Questions and Answers
Q8	Is there any data available on (1) annual crude steel production (t-crude steel/year), (2) annual greenhouse gas emissions (tCO <sub>2</sub> /year), and (3) energy use per unit of production (GJ/t-steel) for the Turkish steel industry as a whole?
A8	● The amount of crude steel production was 33 million tonnes in 2019,

No.	Outline of Questions and Answers
	<p>22 million tonnes is from electric furnaces, and 11 million tonnes is from blast furnaces. For greenhouse gas emissions, data for the entire metals sector is published, but figures specific to steel are not available.</p> <ul style="list-style-type: none"> <li>● As for energy consumption intensity, Turkey does not have a system that requires periodic reporting like the Energy Conservation Law, so there are no statistical figures like those in Japan. However, since Icdas has its own information, it could be shared if the appropriate procedures are taken.</li> </ul>
Q9	Does the Turkish government impose a system of regular reporting of annual energy consumption or any other obligation on steel mills? In Japan, in addition to reporting, annual reduction targets are imposed, but does Turkey have such a system?
A9	<ul style="list-style-type: none"> <li>● In Turkey, there is an obligation to report annual energy consumption and how much electricity or coal is used to the Ministry of Energy and Natural Resources. There are no reduction obligations.</li> </ul>
Q10	Do the Ministry of Energy and Natural Resources, the National Energy Conservation Center, the Turkish Steel Producers Association, etc. provide information and other support to steel mills regarding energy efficiency and conservation measures?
A10	<ul style="list-style-type: none"> <li>● No information is provided by government agencies, but information is shared by the Turkish Steel Producers Association, for example, that Company A has such energy efficiency and conservation technology.</li> <li>● For a limited period of time, the executive body of regional development sometimes can provide loans and grants with good conditions for projects that introduce energy efficiency and conservation technologies. Government-affiliated associations or universities may organize energy improvement projects. Funding may be provided free of charge or on a conditional loan basis. The executive body for regional development belongs to the Ministry of Science, Industry and Technology.</li> </ul>
Q11	Policies related to climate change countermeasures in the Turkish steel industry as a whole (e.g., Turkey's commitment to achieve net zero emissions by 2053 in the national reduction targets (NDCs) submitted to the United Nations by countries participating in the Paris Agreement), and trends in technological development toward achieving these targets. Are there any political movements or growing public opinion in Turkey toward the achievement of NDCs, and are there any movements in the Turkish steel industry to contribute to or collaborate with such efforts?
A11	<ul style="list-style-type: none"> <li>● This is also happening in Turkey, and I think public opinion is growing, accelerated by the Border Carbon Adjustment Mechanism (CBAM) announced by the EU. At the end of this month, the Ministry of Environment and Urban Planning is going to enact a climate-related law, and I think the demands will become even more stringent.</li> <li>● The Ministry of Energy and Natural Resources and the Ministry of Environment, Urban Development and Climate Change also have a role to play, but the Ministry of Trade is putting it together. In addition, an action plan on climate change has been released and 11 ministries are working together on it. The EU's carbon adjustment mechanism seems to be deeply involved in this.</li> <li>● In the future, based on the action plan of the Ministry of Trade, the operators will work with TCUD to develop a roadmap for the industry. There is no action plan published by TCUD for the steel industry only.</li> </ul>
Q12	The position of the Turkish steel industry in the systems and frameworks

No.	Outline of Questions and Answers
	<p>related to low-carbon and decarbonization, and the needs of each steel mill for energy efficiency and conservation measures.</p> <p>(1) Under the energy efficiency and conservation policy in Turkey, is each steel mill required to achieve the mandatory energy usage reduction target?</p> <p>(2) Have you ever received requests from customers, banks, etc. (especially in overseas markets) to disclose information on energy efficiency and conservation and decarbonization measures (e.g., in response to the carbon border adjustment measures (CBAM) by the EU)?</p> <p>(3) If there is a request for (1) or (2) above, what kind of plans or measures is each steel mill considering to achieve it?</p>
A12	<ul style="list-style-type: none"> <li>● Regarding (1), there is no obligation to create and report energy reduction targets at this time.</li> <li>● Regarding (2), in the past six or seven years, once or twice a year, construction steel customers in special projects have asked for greenhouse gas emissions and carbon footprints per material, not from EU countries, but from Turkish companies.</li> <li>● The "special project" was to obtain a green building certification, which is becoming more and more common in Turkey.</li> <li>● Regarding (3), it seems to be important to comply with ISO 50001. However, since investment in energy efficiency and conservation requires a large amount of capital, it is essential to follow up with the government. Projects for factory renovation and technological improvement are being planned. We are also working on our own technology to recover residual heat from the water cold duct for cooling the exhaust gas from the electric furnace. This is different from the gas outlet from the blast furnace, but we are thinking of some way to recover the heat from the chimney for the electric furnace.</li> <li>● There are some projects that have won awards in the past few years. One of them is power generation using water. A power plant has been set up on the plant site, and process cooling water is run up to a high point (52 meters), and when it comes back down, it turns a turbine. This is being done inside a steel plant. It was also presented at the UN COP as a technology for reusing water resources from Turkey, and even won an award in Brazil.</li> <li>● In addition to improving the steel making process in the plant, we are also looking into the use of renewable energy. Solar and wind power generation are also being promoted, and we currently have a 60MW wind power plant. This is a movement to reduce dependence on fuel, rather than relying on energy from outside sources.</li> </ul>
Q13	<p>Support for promoting energy efficiency and conservation in the steelmaking sector by public organizations and international donors.</p> <p>(1) Have you ever received third-party, objective audits or consulting regarding the identification of energy efficiency and conservation measures?</p> <p>(2) Are there any public support systems (e.g., efficiency improvement projects (VAP) based on the Energy Efficiency Law) or organizations that provide advisory services in Turkey?</p> <p>(3) Have you received any such support from international donors in Europe or elsewhere?</p> <p>(4) If there is such support (energy efficiency and conservation audit, etc.) through the JICA technical cooperation program, would you like to use it?</p> <p>(5) If there is any steel energy efficiency and conservation technology you are interested in, please let us know. If there is an opportunity to</p>

No.	Outline of Questions and Answers
	receive information about the technology through workshops, advice from Japanese experts, or introduction to equipment suppliers, would you like to use it?
A13	<ul style="list-style-type: none"> <li>● As for (1), we have received services from a private company, but not from a public company.</li> <li>● As for (2), there is no public organization that provides the service (as far as we know).</li> <li>● Regarding (3), as far as we know, we have never received support from the government. We rarely receive support from the government, but we may receive support for energy efficiency and conservation projects.</li> <li>● As for (4), we would like to use it. Of course, we need to get approval from managers, but we are basically open-minded and are willing to have an auditor come and examine us during a specific period of time.</li> <li>● Regarding (5), waste recovery technology to improve energy efficiency. In particular, the recycle of steel. The second is technology to reuse waste heat. If CO can be burned effectively, CO emissions from chimneys can be reduced. Thirdly, I am interested in whether hydrogen can be used as a heat source. We are dealing with suppliers such as SMS, Danieli (European), and Pirmetas (Japanese) (Probably, this means Primetals Technologies Japan (PTJ)). However, Japanese companies are not well known in Turkey, so we would like an introduction. In the past, we have received services from Japanese companies for rolling mills and waste heat reuse. Also, if there are any companies in Japan that provide AI-based control systems, please let us know. There are such suppliers in Europe, and we are very interested in them. For example, a system that optimizes the temperature of an electric furnace (e.g., 1680°C to 1660°C).</li> </ul>
Q14	<p>Equipment capacity, applicable technologies, energy management level, and room for energy conservation at each steel mill</p> <p>(1) Please tell us the energy consumption intensity (GJ/ton-steel) of the entire steel mill, the electricity consumption intensity (MWh/ton-steel) of the electric furnace for steelmaking, the energy consumption intensity (kJ/ton-steel) of the heating furnace for rolling, and the dimensions of steel.</p> <p>(2) What are the main iron sources (iron ore, scrap, DRI, etc.)?</p> <p>(3) What are the main steel product grades (ordinary steel, special steel (stainless steel, etc.)) and main products (hot-rolled steel sheets, steel bars, etc.)?</p> <p>(4) Please tell us whether you have already introduced various energy-saving technologies.</p>
A14	<ul style="list-style-type: none"> <li>● The electricity consumption per ton of steel is roughly 350-400 megacalories per ton of steel for molten steel and 250-300 megacalories per ton of steel for steelmaking, although we would like to provide exact figures under a confidentiality agreement. For rolling furnaces, it is 30-35 m<sup>3</sup> natural gas/ton steel. On a calorie basis, it is 250,000-300,000 calories/ton steel.</li> <li>● Regarding (2), DRI is not used because it is difficult to transport, but HBI (Hot Briquetting Iron) is used (about 3% of the total). Scrap accounts for 97%, about half of which is procured from domestic sources and half imported from Europe.</li> <li>● As for (3), the company does not manufacture special steel, but uses ordinary steel. The company manufactures semi-finished products, rebar bars, and coils. We also manufacture carbon steel and manganese chromium steel, which we distribute to the electronics industry. We would like to expand our business to the automotive</li> </ul>

No.	Outline of Questions and Answers
	<p>industry.</p> <ul style="list-style-type: none"> <li>● If you send me the TCL download link, I will take a look at it in detail and reply. I think that many of the technologies mentioned here have been introduced. They are mostly being provided by European engineering companies. I think the steel mills in Turkey have introduced them in much the same way.</li> </ul>
Q15	<p>The challenges in implementing energy efficiency and conservation measures at your steel mill</p> <p>(1) Are there any issues (funds, technical information, human resources, policy support (subsidies), etc.) in implementing energy efficiency and conservation measures in steel mills?</p> <p>(2) Are there any technical cooperation menus in the menu list of JICA technical cooperation projects that should be implemented in the Turkish steel industry?</p>
A15	<ul style="list-style-type: none"> <li>● As for (1), the premise is that the Turkish steel industry does not receive financial support from the government. This is a limitation of the ECSC between Turkey and the EU. However, energy conservation and low-carbon projects are exceptions, and in such cases it is sometimes possible to receive assistance. However, we believe that electric furnaces have fewer opportunities than blast furnaces to be exposed to promising technologies for decarbonization, and it is important to create such opportunities.</li> <li>● Regarding (2), almost all of the support menu you presented is necessary or possible in Turkey, and should be implemented.</li> </ul>

Through the interviews, it seems that the motivation of the steel companies to cooperate and the room to introduce energy efficiency and conservation can be confirmed, as shown in the responses above. On the other hand, it was assumed that it would be impossible to obtain information on individual equipment currently installed that would contribute to the introduction of energy efficiency and conservation technologies without a confidential agreement. Therefore, it is desirable to make individual arrangements with representative steel manufacturers for future cooperation programs.

### 3.3 Analysis of Specific Issues Reflecting the Current Situation of the Target Country

This section analyzes the issues that require further confirmation and verification from the aspects of institutions, technologies, and funds, based on the online meetings with the stakeholders mentioned earlier, in order to extract cooperation proposals. In the following, the number of the answer that can be the evidence from the above questionnaire are added (e.g., A1, A13).

#### 3.3.1 Technology

As a summary of the literature survey and discussions with related organizations, it is a future issue for the consortium that the technologies

introduced in individual steel mills have not been completely confirmed. In particular, considering the fact that electric furnaces are the mainstream of worldwide recycling plants in Turkey, it is most important to confirm the technological level of individual steel mills in electric furnaces.

Both TCUD and steelmakers were asked about the status of introduction of the technologies extracted from the TCLs, and it was confirmed that the introduction of these technologies has just started at individual factory, so there is room for further introduction of technologies (A7, A15). On the other hand, it should be noted that the investment in the improvement of the steel making process in the plant is concentrated on the hard solution (A12), while the soft solutions and organizational structure are not taken up to any great extent. The interest in the introduction of hard solutions can be seen in the willingness to introduce state-of-the-art equipment (A13), and there may be a lack of focus on improving the efficiency of overall operations. Therefore, it may be necessary to cooperate with them to accumulate small steps by using soft solutions. This is done by checking the maturity of the overall operation while conducting the diagnosis of each factory. As shown in the desktop study, there are some businesses that conduct implementation and supervision in accordance with ISO 50001, so there is a high possibility that cooperation by using soft solutions will not be avoided.

In addition, the trend toward product diversification as a strategy on the part of businesses should not be overlooked. The response from a steel manufacturer that they would like to expand their product lineup to include not only the electronics industry but also the automobile industry is heard (A14), so our cooperation proposal may need to be creative by introducing technologies that take into consideration the quality of products required by each industry.

### **3.3.2 Policies and institutions**

National policies and systems have been followed by the Energy Conservation Strategy 2012-2023, the National Energy Conservation Action Plan, and the Energy Efficiency Law. However, in view of the forthcoming enactment of climate-related laws (A11), it is considered essential to develop comprehensive laws and roadmaps among multiple ministries and agencies, and to coordinate with them.

As for the reporting system of emission data, it is considered to be an issue of appropriate implementation and enforcement. According to the desktop study, an energy manager system exists and emission performance data of steel mills are reportedly collected, and this was also found to be the case in the discussions with relevant organizations mentioned above, where the reporting system is functioning to a certain extent (A1, A9). On the other hand, it was mentioned in the stakeholder discussions that there may be a difference

between the reported figures and the actual figures (A7). Thus, there may be room for improvement in the way the statistics are organized. Furthermore, TCUD shared that energy consumption intensity is reported by each steel mill (A1), but individual steel mill is not obligated to report it and the issue that it is not statistically organized was pointed out (A8). Therefore, it can be said that it is necessary to pay attention to the issue that solid figures cannot be calculated and published in terms of the lack of steady implementation of mandatory systems.

With regard to emission reduction policies and systems, it was assumed that energy efficiency and conservation measures based on energy intensity are just voluntary systems and are not actually implemented in individual steel mill (A2, A9). However, there is a gap between the efforts of the government and the private sector, as steel mills have been taking measures individually (A12), although the government is still in the preparatory stage in terms of policy to respond to CBAM (A5).

It is possible that TCUD is making efforts to disseminate and raise awareness of the system and policies (A10), but it is assumed that further expansion of sharing information is important. In particular, increasing the accessibility of energy efficiency and conservation technologies to electric furnaces is a challenge (A15).

### **3.3.3 Finance**

According to the desktop study, financial support is provided by VAP, TEYDEB project, TTGV, etc., which seems to be sufficient in the text itself. However, the actual financing available to businesses may be limited in terms of timing and budget (A10), and this may be a barrier to capital investment.

It was suggested that financial support from the VAP is currently available, but questions have been raised by the private sector about the budgetary and effective perspective of the scheme, which may be hindering the further spread of its use (A6). In fact, they are willing to accept EBRD support (A6) and JICA support (A13), which may indicate that their domestic financial support is not sufficient. In particular, since the ECSC is expected to make it difficult for the government to provide large-scale financial support (A15), it is necessary to establish an appropriate financial assistance scheme, taking into account the contents of Turkey's multilateral agreements. Moreover, JBIC's recently issued additional loan to TSKB is likely to be an important source of funding, and it is important to keep a close eye on this in future cooperation projects. However, since the financial support from JICA is limited by the scale of the project and the scheme, it is also important to consider additional financial support schemes.

### 3.4 Proposals for Cooperation Programs

This section organizes and proposes a tentative flow of cooperation programs in the short, medium and long term based on the challenges mentioned in the previous section. This is also based on the information obtained through the desktop survey and discussions with relevant organizations in Turkey.

#### 3.4.1 Short-term cooperation programs

The flow of a short-term cooperation program is shown in the figure below. The first step is to focus on initiating the cooperation program and generating the impetus for full-scale collaboration in the public and private sectors. In other words, the short-term cooperation starts with a request for cooperation from the C/P and ends with holding a public-private meeting. Since it is important to share the actual situation between the government and the steel companies as much as possible, towards a public-private meeting, it is necessary to review the policy of the cooperation program in the medium term by re-organizing the actual situation of steel plants and the policies, systems, and motivations of the C/P organizations that were not supplemented in this study. The first public-private meeting should be held as early as possible because it will affect the mid-term technical cooperation program in terms of fostering the awareness of cooperation among the steel manufacturers. Therefore, the schedule is shortened here by conducting simple energy efficiency and conservation audits for various types of steel mills: blast furnaces, electric furnaces, and hot-rolled mills.

It is assumed that the information collection and confirmation survey will be applied up to get the cooperation request form, and the technical cooperation project scheme will be applied thereafter.

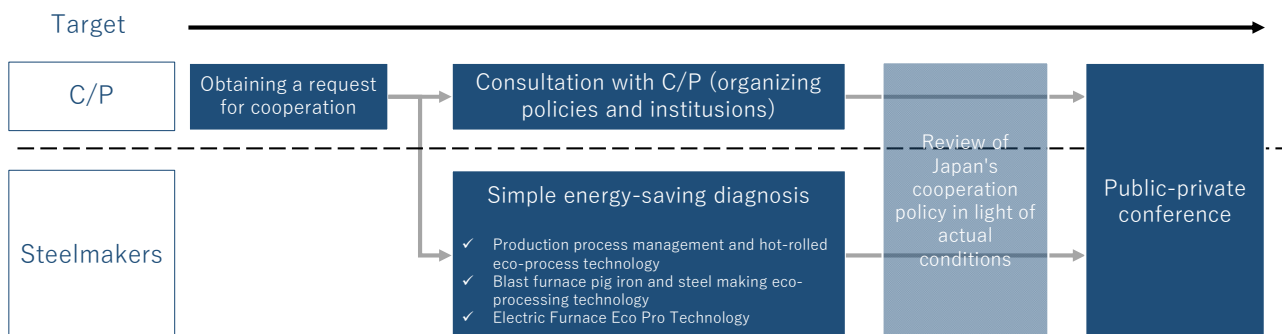


Figure 3-1 Short-term cooperation program flow

### **3.4.2 Mid-term cooperation programs**

The flow of the mid-term cooperation program is shown in the figure below. In light of the fact that long-term policies and roadmaps are still being formulated in Turkey, cooperation in formulating policies to promote energy conservation and decarbonization will first be provided to C/P. However, since it is important to take into account the situation of Turkish steel companies when providing advice to C/P, a detailed energy efficiency and conservation audit of the steel plants at the same time will be conducted so that the information can be shared to C/P. After that, cooperation will shift to support the formulation of various energy efficiency and conservation and decarbonization systems in Turkey, and improve the capacity to implement these systems. The significance and effectiveness of the systems will be clarified by taking into account TCL and BAT, which will be examined based on the steel mill energy efficiency and conservation audits. In the meantime, the supports on investigate the potential of utilizing unused energy and improve the top management level in individual steelmakers will be continued. For this purpose, in the energy efficiency and conservation survey of steel mills, it is assumed that the management system in steel mills will also be surveyed and organized. By educating the top management level, the ability to implement the soft solutions of maximizing energy efficiency and conservation in existing facilities can be cultivated. When the foundation of information collection and efficient operation of existing facilities has been established, cooperation will move on to the next step that supports the formulation of more practical energy conservation and decarbonization business plans for steel mills. Since this is expected to lead to the introduction of eco-process pilot facilities, it is desirable for the government to start considering the financial scheme necessary for the introduction of the facilities earlier than this step. In addition, it is envisaged that seminars will be held from time to time for public and private sector meetings and industry representatives to motivate them to introduce equipment and decide on equipment suppliers, and to promote the formation of connections with Japanese steelmakers and equipment suppliers. Finally, for C/P, support will be provided for the formulation of a supply chain CO<sub>2</sub> reduction roadmap, which will be an initiative related to the new business derivation phase of the long-term cooperation program described below. The long-term cooperation program also envisages the introduction of equipment in steel mills and post-installation support, and after supporting the formulation of the pilot equipment installation plan, cooperation will shift to the equipment installation and operation phase.

In addition, it is assumed that all the activities during this period will be carried out under the technical cooperation project scheme.

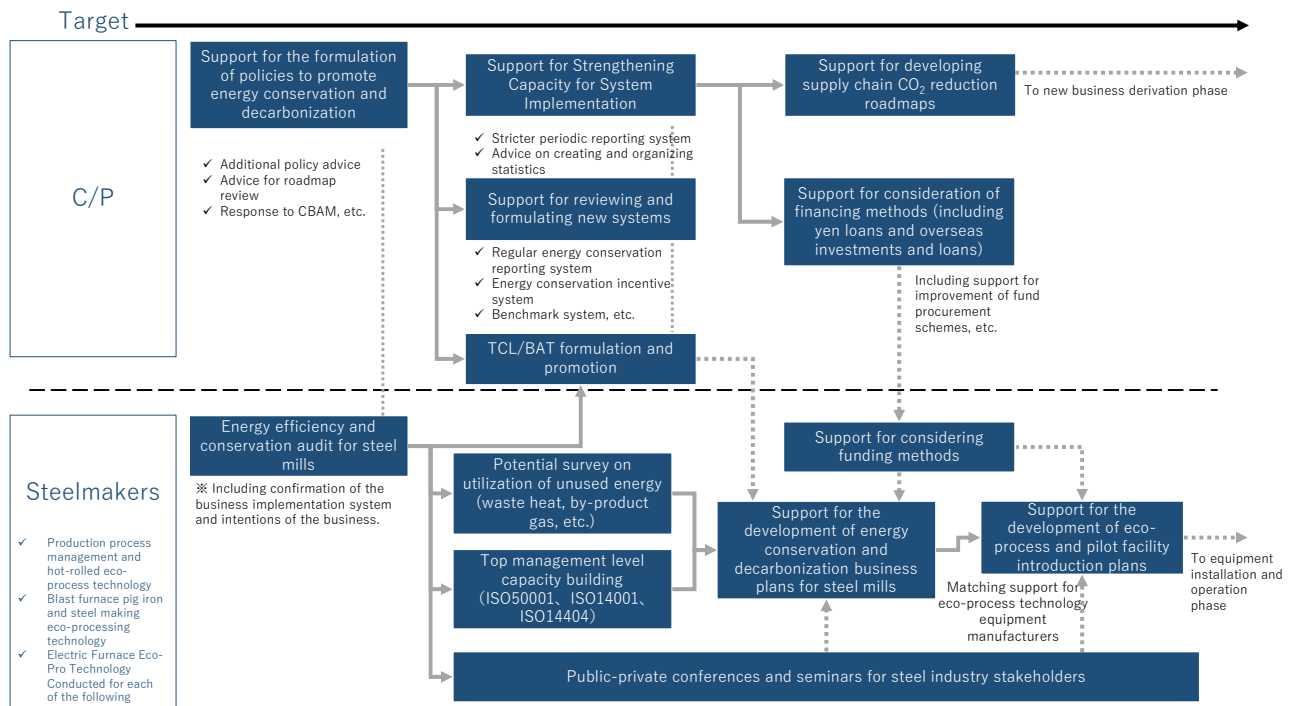


Figure 3-2 Mid-term cooperation program flow

### 3.4.3 Long-term cooperation programs

The flow of the long-term cooperation program is shown in the figure below. The long-term direction of the program is divided into two major phases: one is the introduction and operation phase, which supports the installation of equipment in steel mills and the facilitation of operation after installation. The other is the new field derivation phase, which expands the scope of support to include related industries and regions surrounding steel mills. Since the timing of each phase depends on the progress of the Mid-term Cooperation Program, it should be noted that the current flow is not a simple transition from left to right in the figure below.

In the equipment installation and operation phase, the support aims mainly strengthen the implementation capacity of the C/P in terms of the system assuming that the equipment has been installed. On the business side, the support starts with the demonstration project of the steel eco-process, and it follows that the the maximization of energy conservation and decarbonization through the smooth and efficient operation of the installed facilities. The actual energy-saving and decarbonization effects obtained through this process are expected to be utilized in the C/P's technology dissemination strategy and dissemination activities.

In the new field derivation phase, a comprehensive study on regional energy and resource sharing will be conducted together with the C/P. Efforts related

to energy sharing and resource recycling will be supported, taking into account the region where the steel mill is located, and efforts to contribute to the further actions towards SDGs will be promoted. In addition, assuming that a considerable amount of time has passed since the formulation of this report at that moment, the project will support the demonstration of the utilization of hydrogen, which is expected to be more available at that time.

In the new field derivation phase, it is assumed that the project will be implemented under the technical cooperation project scheme, while in the equipment installation and operation phase, it is assumed that the financing scheme discussed in the Mid-term Cooperative Program will be used for the equipment installation of the steel eco-process technology, and that the technical cooperation project will supplement the efforts.

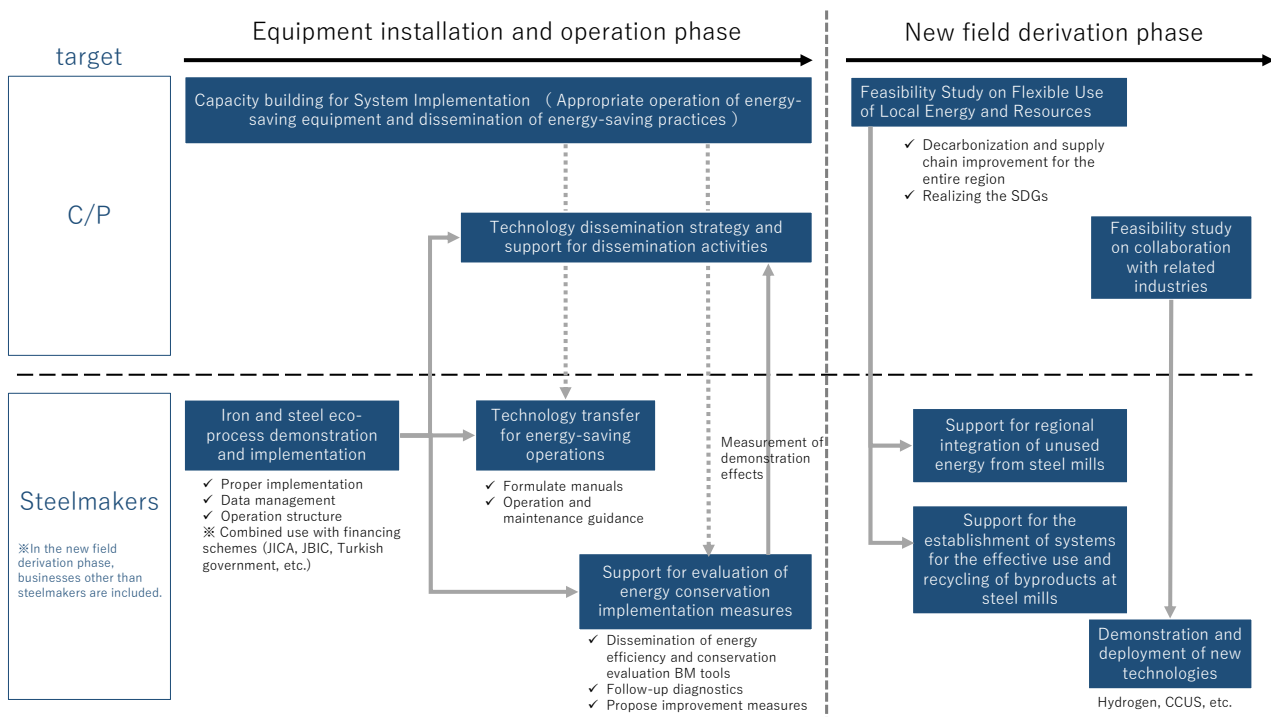


Figure 3-3 Long-term cooperation program flow

### 3.4.4 Challenges and approaches to low carbon of steel production lines

In the following, the introduced technology elements and problem-solving methods assumed in the cooperation program for Turkey up to the above, along with the challenges will be described in detail and supplemented. As mentioned earlier, it should be noted that these cooperation methods are based on current assumptions, as this study was not able to access specific installed technology groups in existing steel mills.

(1) Challenges to low carbon

a) Understanding energy flow

Even if the amount of energy in each facility is understood, it is often difficult to understand how much of the energy converted in the utility facility is supplied to and consumed by the facility, how much is lost in the supply process, and whether the amount is optimal for the facility at the energy demand destination or not too excessive. In many cases, individual optimization does not necessarily lead to overall optimization, and it is important to visualize the energy flow from the primary energy of coal to the final manufacturing process and minimize energy loss in order to achieve a low-carbon society.

b) Identification of equipment to be improved

It is important to see the overall CO<sub>2</sub> balance in line with ISO14404. For this purpose, it is necessary to formulate the energy flow model described in 1) and to visualize the energy loss in each process. Improvement steps can be promoted by visualizing the impact of updated and improved equipment on the entire steel process, CO<sub>2</sub> reduction amount, and energy intensity.

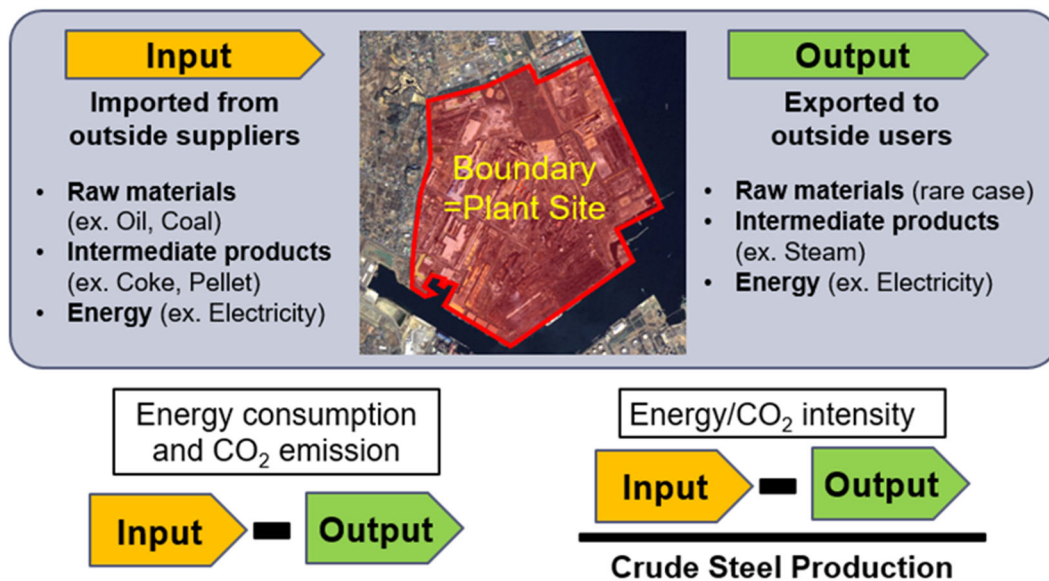


Figure 3-4 Boundary by ISO14404

c) How to proceed with formulation of the energy saving plan

As a step in the formulation of a low-carbon plan in accordance with ISO 50001, we encourage companies to improve their low-carbon operations by conducting an energy review as shown in Figure 3-5.

The energy review begins with the collection of energy data, followed by loss analysis, identification of equipment with large losses, and the formulation of improvement plans.

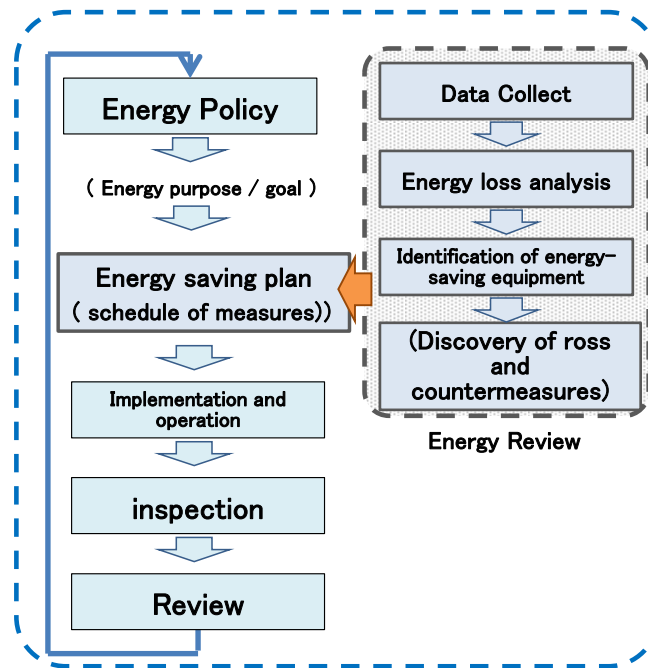


Figure 3-5 Energy review by ISO50001

## (2) Step to Low carbon

### a) Energy data collection

The first step in energy saving is to know the energy consumption of the equipment, process and factory as a whole. As for the energy consumption targeted in the energy saving survey, it is sufficient to integrate the energy consumption for each hour or one day, and it is not necessary to grasp it in real time.

If you try to formulate an energy flow based on the collected energy data, you can see which process consumes a lot of energy and which equipment has a lot of loss.

As factory equipment, it can be roughly divided into utility equipment that converts primary energy into secondary energy and supplies it to the production line, and manufacturing equipment that consumes secondary energy to manufacture products. Since these two facilities have different approaches for energy collection and low carbon, it is necessary to proceed with the approaches individually.

#### ① Understanding energy data of utility equipment

Utility equipment is equipment that converts primary energy into secondary energy. Therefore, it is necessary to measure the amount of input energy and the amount of output energy to the equipment. The difference between the amount

of input energy and the amount of output energy is the conversion loss. For example, in the case of a steam boiler, the amount of heavy oil used as the primary energy amount becomes the input, and the amount of steam generated becomes the secondary energy amount. In addition, the difference between the amount of secondary energy from the boiler and the amount of steam consumed at the demand destination is the delivery loss. By formulating the energy flow in this way, various losses can be seen. In actual operation, the operating rate is unlikely to be 100% and the load factor is not 100%, and standby loss is included, so the conversion loss is worse than the manufacturer's specifications.

## ②Collection of energy data for manufacturing equipment

Since the manufacturing equipment is the final energy consumption equipment, it is sufficient to measure the amount of input energy, but this alone does not show any loss. Based on the concept of material flow cost accounting, only the energy given to the product is considered as necessary energy and other input energy amounts are considered as losses. For example, when heating a steel block in a conventional furnace, the amount of energy to heat the entire furnace, the amount of energy to dissipate heat from the furnace, and other energy to heat something other than the steel block would be generated, but these are considered losses. If the heating method is changed to IH and only the iron ingot is heated, the loss will be significantly reduced, so it is necessary to consider what the required amount of energy is.

## b) Loss analysis

### ①Loss analysis of utility equipment

Figure 3-6 shows an example of the energy flow of utility equipment. A boiler is equipment that converts city gas, which is the primary energy, into steam, which is the secondary energy. Conversion loss occurs during the conversion, and energy is lost as heat is dissipated to the atmosphere.

For utility facilities, it is important to minimize conversion loss and deliver the necessary amount of energy when it is needed with little supply loss.

There are three major losses in utility equipment.

- 1) Conversion loss
- 2) Conversion loss to excessive energy
- 3) Energy delivery loss

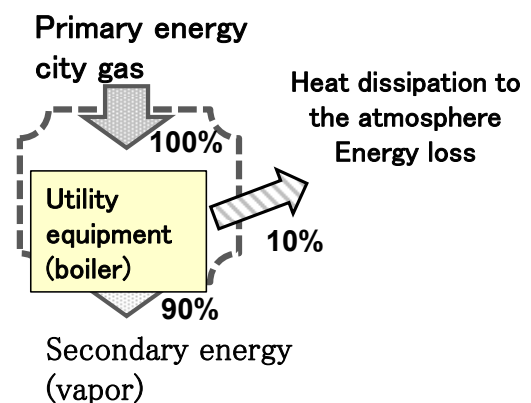


Figure 3-6 Thermal flow of utility equipment

### 1) Conversion loss

As utility equipment, it is important to select and renew equipment with high conversion efficiency from the viewpoint of reducing energy loss. For example, in the case of a transformer, it is possible to minimize energy loss in terms of both copper loss and iron loss during standby by using an amorphous transformer. In the case of an air compressor, the screw type compressor has a small loss during conversion, but the loss during standby is close to 70% of that during actual operation, and if the equipment is excessive, the standby loss will be large. It is necessary to consider the conditions of use. Since air compressors and steam boilers have large standby losses, introduction of tools such as inverters are also effective to convert only the required amount.

In the case of boilers, the once-through boiler has higher conversion efficiency than the furnace cylinder smoke tube boiler that stores hot water in the furnace cylinder, and there are few operational issues if only heating is performed, but the once-through boiler is vulnerable to fluctuations in demand. The degree of steam thirst may worsen, so care must be taken when selecting it only for conversion efficiency. In the steel process, many establishments have private power generation facilities, and it is important to improve the conversion efficiency as much as possible by selecting a power generation system according to the scale, using waste heat, and adopting bleed air.

### 2) Conversion loss to excessive energy

Regarding air compressors, there are many cases where the production line, which is the demand destination, requires only 0.5MPa of air pressure, but supply is at 0.7MPa. Even if the energy is supplied with an excessive amount of energy more than necessary, the pressure is reduced to 0.5 MPa at the demand destination using a pressure reducing valve, so the decompressed amount causes a loss.

### 3) Energy delivery loss

Utility equipment is often oversized so that any request from the production line can be satisfied. It is necessary to investigate and analyze temporal fluctuations, monthly fluctuations, and fluctuations with respect to the production volume of the required energy from the production line in the actual steel production line, and to synchronize the supply and demand of the production line and infrastructure equipment. A system that can supply the amount of energy when and as much as needed is important for loss reduction. For this reason, it is important to investigate and analyze data on energy consumption and trends in actual manufacturing lines, synchronize with utility equipment, and build an energy management system that can reduce losses.

## ① Loss analysis of manufacturing equipment

As mentioned above, the basic idea of energy loss in manufacturing equipment is to consider only the amount of energy given to the product as the net energy and the remaining amount of energy as the loss.

Figure 3-7 shows the energy flow in the manufacturing equipment.

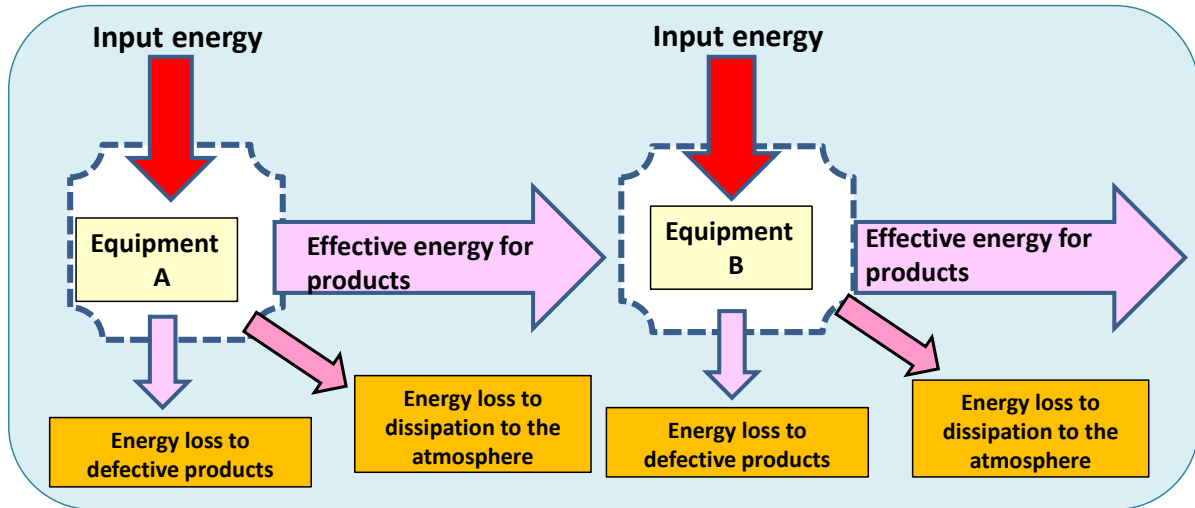


Figure 3-7 Energy flow of manufacturing equipment

As for the input energy, the energy for manufacturing the product becomes the effective energy, and the energy for dissipating to the atmosphere and manufacturing the defective product becomes a loss. Since the effective energy of the product is added each time the process is performed, the energy loss due to the defective product in the subsequent process also increases.

#### 1) Loss in manufacturing defective or non-conforming products

In the process of manufacturing the product, defective products and scraps are cut off. It does not become a product and is discarded or returned to the initial process, but energy is also required when making defective products, and this loss increases as the final process is reached. In addition, nonconforming products that do not meet the design specifications are often commercialized by reworking, but the amount of energy for reworking, or the stopping of the line due to reworking, causes standby loss.

One of the loss improvement measures is to visualize these quality conditions by the defect rate and the pass-through rate, and to give an incentive for quality improvement in terms of cost.

#### 2) Standby loss

Each facility on the production line does not operate with the same tact time, but there is a neck process with the longest tact time. For this reason, standby energy is generated in other equipment, and energy loss occurs. By shortening the tact time of the entire production line, it is possible to reduce the fixed energy amount of the entire factory, for example, the fixed energy of lighting, air compressor, etc., and it is possible to greatly reduce the loss.

### c) Energy flow

Figure 3-8 shows an example of energy flow formulation in the manufacturing process by collecting energy in the manufacturing process. This makes it possible to visualize in which process and equipment the energy input to each process is consumed, and how much energy loss is generated due to defects.

From this, it is possible to link quality improvement with low carbon, and low carbon activities can be carried out together with the quality department. From ISO50001, it is recommended to specify the equipment that should be improved from (1) equipment with large energy consumption and (2) equipment with large loss, which is a map for low carbon measures.

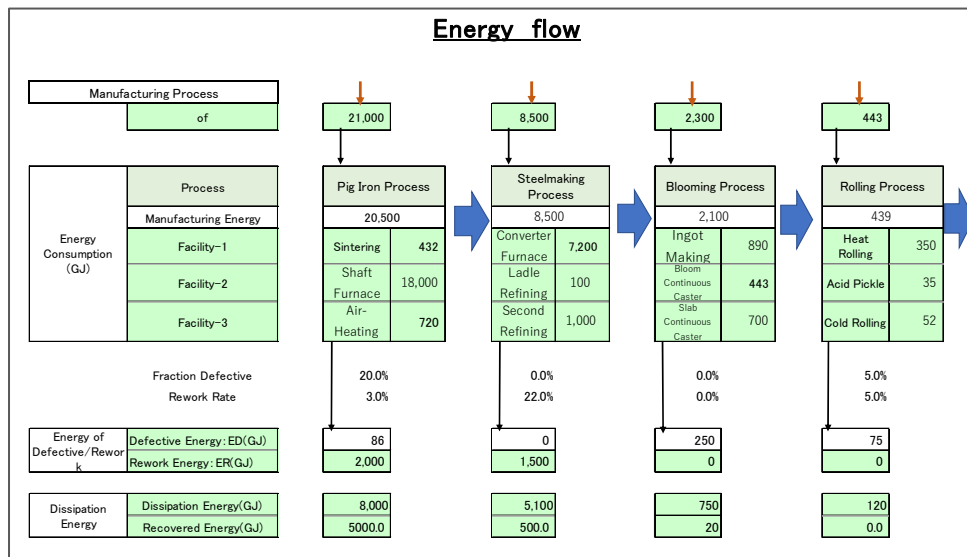


Figure 3-8 Example of Energy flow

### d) Measure for low carbon

When considering measures to reduce CO<sub>2</sub> emissions, it is important to sort out what methods can be used to reduce CO<sub>2</sub> emissions.

The blue and red boxes on the left show the CO<sub>2</sub> emissions from the consumption of electrical and thermal energy, respectively. The horizontal axis is the energy consumption and the vertical axis is the CO<sub>2</sub> emission intensity. Multiplying the energy consumption by the CO<sub>2</sub> emission intensity gives the amount of CO<sub>2</sub> emissions.

As Figure 3.5 shows, in order to reduce CO<sub>2</sub> emissions, it is necessary to consider two axes: how to reduce energy consumption and how to lower the CO<sub>2</sub> emission intensity. Then, specific approaches to reducing CO<sub>2</sub> emissions can be divided into three categories.

The first approach is to reduce energy consumption, which is to promote energy conservation. The second approach is to reduce the CO<sub>2</sub> emission intensity, which includes various types of renewable energy, CCUS, hydrogen, ammonia and other low-carbon or carbon-recycling technologies, as well as nuclear power generation. Some of these technologies are yet completed but the process itself

is very conventional and expected to be applicable in near future. The third is the conversion of thermal energy to electrical energy. In general, electric energy has a lower CO<sub>2</sub> emission intensity than thermal energy, so there are cases where CO<sub>2</sub> emissions can be reduced by switching from using thermal energy to electric energy. This can be done by applying electrical heating technologies such as heat pumps instead of fossil fuel firing, and in case of machinery changing steam drive to electric motor.

① Reduction of energy consumption ② Low-carbon energy ③ Conversion of energy use

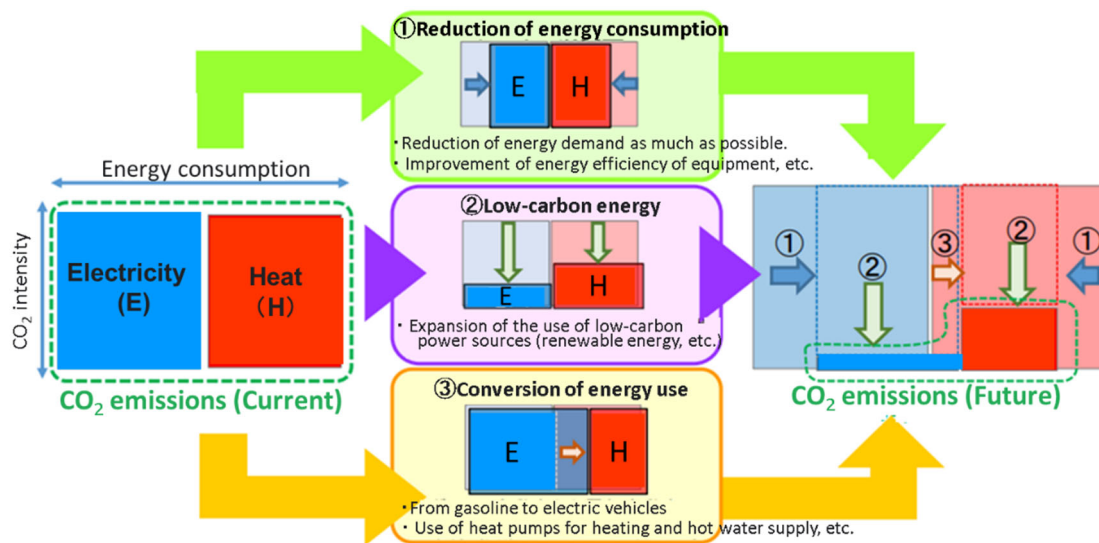


Figure 3-9 Concept of low carbon by improving the process

e) Measures for low carbon in steel production lines

① Use of management standards

Currently, in Japan, the Energy Conservation Act requires the establishment of management standards, and equipment maintenance and management are carried out in accordance with these management standards. However, in the operation at the time of implementation, there are many cases where the operation deviates from the standard value of the management standards, and this deviation amount has room for improvement of loss. In addition, if the margin of the standard value set in the management standard is too large, reviewing the margin will be a countermeasure for low carbon.

In particular, utility equipment is mass-produced equipment, and judgment criteria are set by the Energy Conservation Act, making it easy to reduce losses using management standards. This case also applies to processes for which control standards have been established for this steel process. (See Figure 3-10)

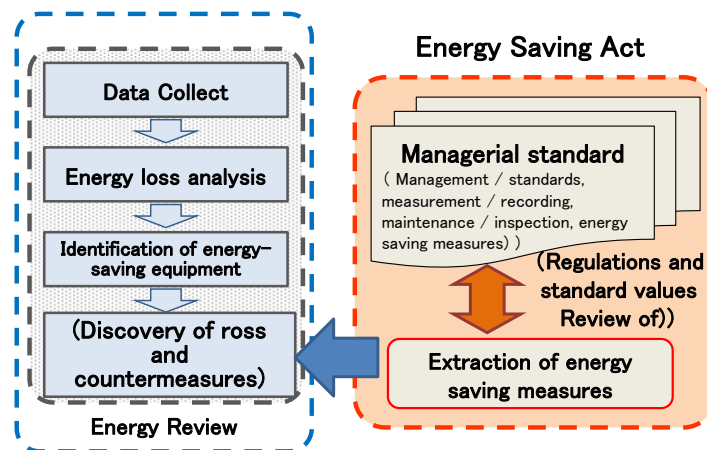


Figure 3-10 Loss reduction by management standard

## ②Energy intensity management

Even when manufacturing the same product, the processes and equipment are often different, it is difficult to set common management standards, and it is difficult to improve losses if the management standards are unique to the equipment. In the case of the manufacturing process, based on the energy intensity for producing 1 ton of iron for each process using the steelmaking process in Japan as an ideal model, room for energy saving is extracted by comparing with the intensity of the local steel process. Loss can be reduced by considering measures for low carbon. Therefore, it is necessary to investigate and analyze the energy intensity of the Japanese steelmaking process.

## ③Heat interchange between processes

In the steel production line, each process is carried out by repeating heating and cooling. By utilizing this waste heat during cooling in other processes or utility equipment, it is possible to reduce energy during heating. (See Figure 3-11) For this purpose, it is important to measure the temperature of each process in the field, formulate the heat history of the entire process, grasp and study the amount of waste heat.

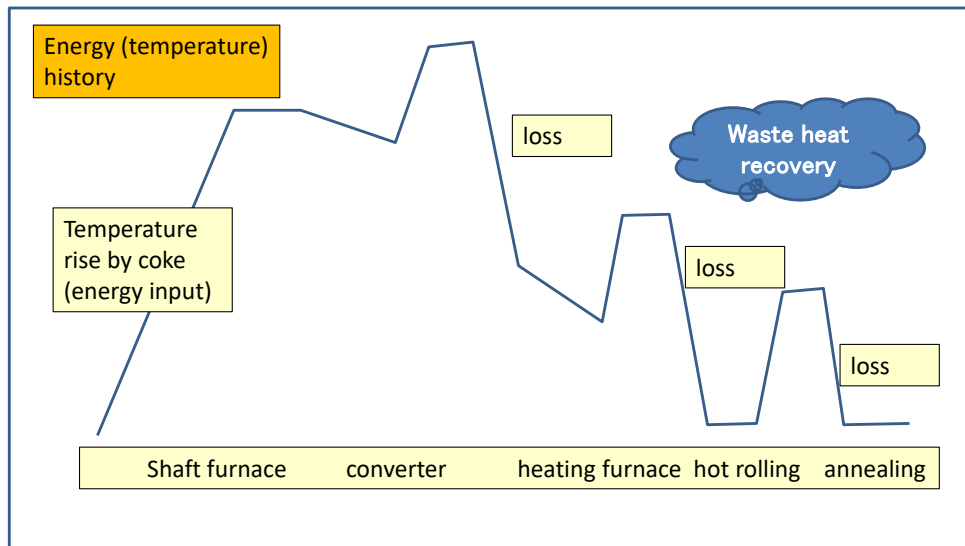


Figure 3-11 Example of thermal history of steel manufacturing process

#### f) Formulation of low carbon realization plan

In this section, we will show an example of an analysis method for a series of low-carbon realization plan, such as energy reduction plans or CO<sub>2</sub> reduction plans and associated investment plans.

As mentioned in 3.4.4(2)c), in order to reduce CO<sub>2</sub> emissions, it is necessary to find the optimal solution in terms of cost effectiveness and feasibility for each of the following methods: (1) reduction of energy consumption, (2) low-carbon energy use, and (3) conversion of energy use.

The reduction of energy consumption is often achieved by investing in new energy-saving equipment. The amount of CO<sub>2</sub> reduction due to the installation of new energy-saving equipment is calculated by multiplying the amount of energy to be reduced by the relevant CO<sub>2</sub> emission factor.

Although energy expenditure will be reduced by reducing energy consumption, it will be necessary to invest in energy-saving equipment, so it is important for planning to understand the cost-effectiveness in cash flow. At the same time, considering switching to a low-carbon grid power source, using renewable energy, and converting fuel will be an approach to achieve more effective low-carbon.

■ List of proposed measures (CO2 reduction amount)													
Noumber	Measure	Planning Year CO2 Reduction											
		2021	2022	2023	2024	2025	2026	2027	Goal	2028	2029	2030	2050
Sum		0.0	80.0	305.3	385.3	483.1	564.2	643.8	761.2	839.9	1017.7	1169.8	
Power													
Power1	4	Update to high efficiency air conditioning	0.0	1.5	3.0	4.5	6.0	7.5	9.0	45.6	46.2	46.8	48.0
	5	Installation of Solar Panel Generation	0.0	5.6	11.2	16.8	39.6	44.8	50.0	55.2	60.4	65.6	76.0
Power2	7	Inverter Compressor Update	0.0	6.7	13.3	20.0	26.7	33.4	40.0	46.7	53.4	159.2	167.2
Fuel													
	1	Boiler gas-fired high-efficiency machine update	0.0	0.0	145.3	145.3	145.3	145.3	145.3	145.3	145.3	145.3	145.3
	2	Insulation to unheated areas of steam piping	0.0	0.0	0.0	0.0	0.0	1.5	1.5	1.5	1.5	1.5	1.5
	3	Replacing the failed steam trap	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	2.7	2.7	2.7
Fuel→Power													
	8	Updated to high efficiency air conditioning and abolished stove	0.0	3.0	6.0	9.0	12.6	15.6	18.6	21.6	24.6	27.6	33.6
低炭素系統電力への変更（電力、燃料、燃料→電力の対策費を除外）													
Power1	23	Change to low-carbon grid power1	0.0	19.9	39.8	59.7	79.6	99.5	119.4	139.3	159.2	179.1	218.9
Power2	24	Change to low-carbon grid power2	0.0	43.3	86.7	130.0	173.3	216.7	260.0	303.3	346.6	390.0	476.6

Figure 3-12 Low carbon realization plan (eg)

Regarding energy saving measures such as equipment introduction and equipment renewal and their cost effectiveness, we will compare the case where no measures are taken (BAU) and the case where certain measures are taken. For the list of equipment installation and equipment update, use the information surveyed in advance. By setting goals for reduction lines and their timing and visualizing them, it becomes information for making decisions to decide measures.

In a low-carbon plan, it is necessary to consider various measures for low-carbon in chronological order, and for its cost-effectiveness, the simulation function for estimating it and the function for visualizing the results are important.

#### g) Energy Conservation Assist Tool

In this low carbon project, the energy saving support tool developed by ECCJ will be applied to reduce energy loss and improve the process, which are measures to achieve low carbon. The outline and examples are described below.

##### ① Outline of energy saving support tool

As shown in Figure 3-13, the internal configuration of the energy-saving support tool has a three-layer configuration centered on the energy loss visualization screen, the equipment management standards, and the energy-saving amount calculation sheet. The usability is improved by associating the related files in each layer, and the energy reduction effect and loss reduction status of energy saving measures are reflected on the visualization screen through a common database. In addition, the degree of impact of the amount of energy saved by individual equipment on the improvement of the overall intensity can be calculated, which is useful for formulating medium- to long-term plans for the Energy Conservation Act.

With such an internal configuration, it is possible to functionally evolve from loss analysis of ISO50001 energy review to identification of improvement opportunities.

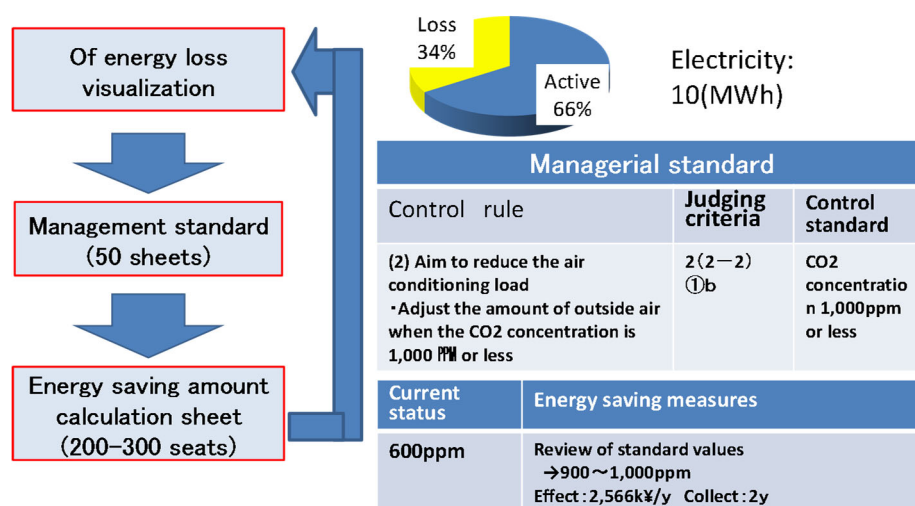


Figure 3-13 Internal configuration of energy saving

## ②Functions of energy saving support tools

In order to identify the equipment that should save energy, the amount of loss is displayed in a pie chart to provide visualization of energy loss. (Reference: Figure 3-14)

In order to identify equipment with a large amount of loss and study energy conservation measures, we provide a mechanism to extract new energy conservation measures by reviewing the management standards and standards of the Energy Conservation Act. Specifically, by clicking the equipment name in the screen diagram (Figure 3-14) of the visualization of energy loss, the target management standard is called, and energy saving measures are presented for each regulation of the management standard. Applicable measures are selected and the energy saving amount is calculated using the energy saving amount calculation sheet. The energy saving amount calculation sheet consists of more than 200 types.

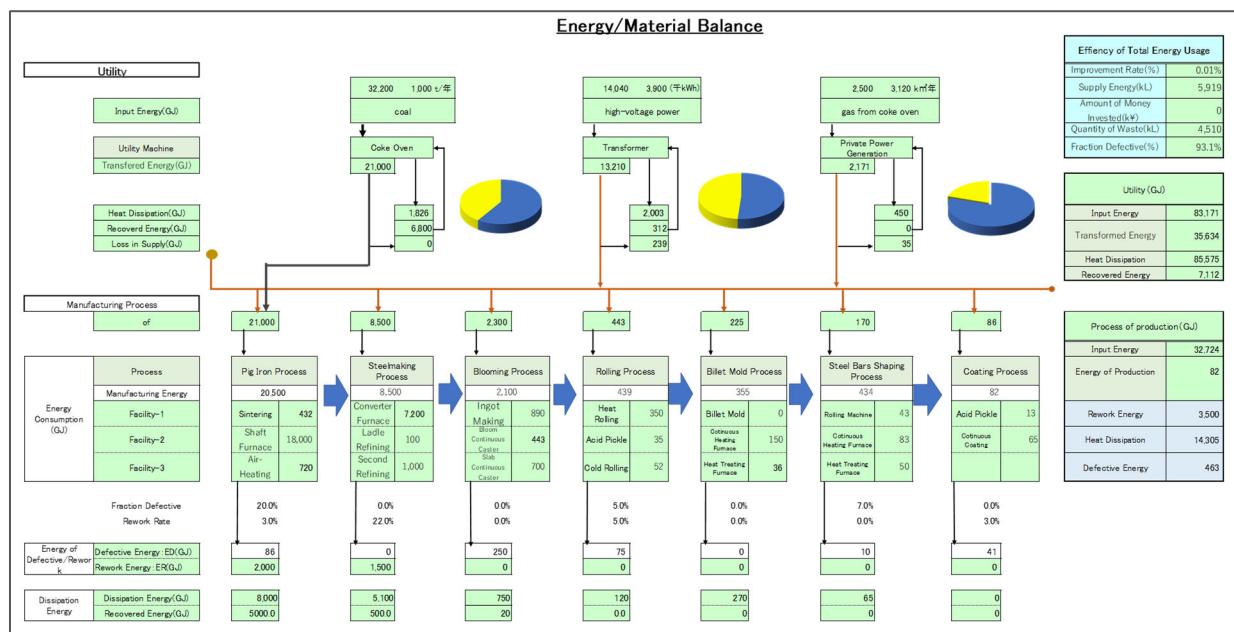


Figure 3-14 Visualization screen of energy flow

### ③ Data linkage with EMS

Currently, the number of establishments that have installed energy management systems (EMS) in commercial buildings, factories, etc. is increasing. However, there are few examples of using these huge amounts of collected data for energy saving. This is because there is no mechanism to analyze the data and link it to low carbon activities. The energy saving support tool can link data with EMS for loss analysis (see Figure 3-15) and can support a series of processes up to the visualization of loss or the formulation of an energy saving execution plan. When actually applying it to the steelmaking process, it is necessary to consider the status of local data collection, the type of acquired data, the cooperation method, etc., and local cooperation is important.

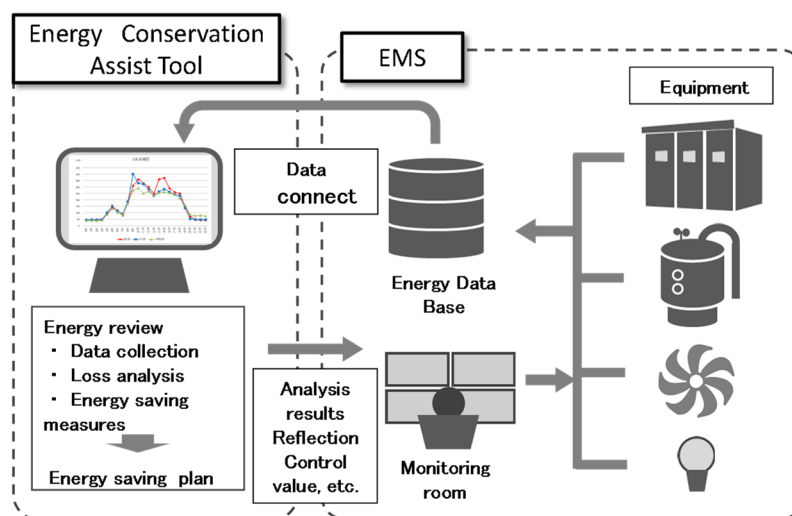


Figure 3-15 Data linkage with EMS

#### <Introduction example to factory-1>

Energy saving support was introduced to the FA processing line that manufactures elevator guide rails. As shown in Figure 3-16, the FA processing line starts with black skin removal by shot blasting, and consists of bending straightening, painting, NC processing, surface finishing, cutting, and so on. In this FA processing line, the efficiency was deteriorated due to the occurrence of defective products and correction due to warpage defects. In particular, bending correction work cannot be completed with a single correction because it is necessary to consider springback. Based on the idea that the amount of energy used to repair recycled products is a loss, workers are made aware of it by visualizing it in monetary terms as shown in Figure 3-16.

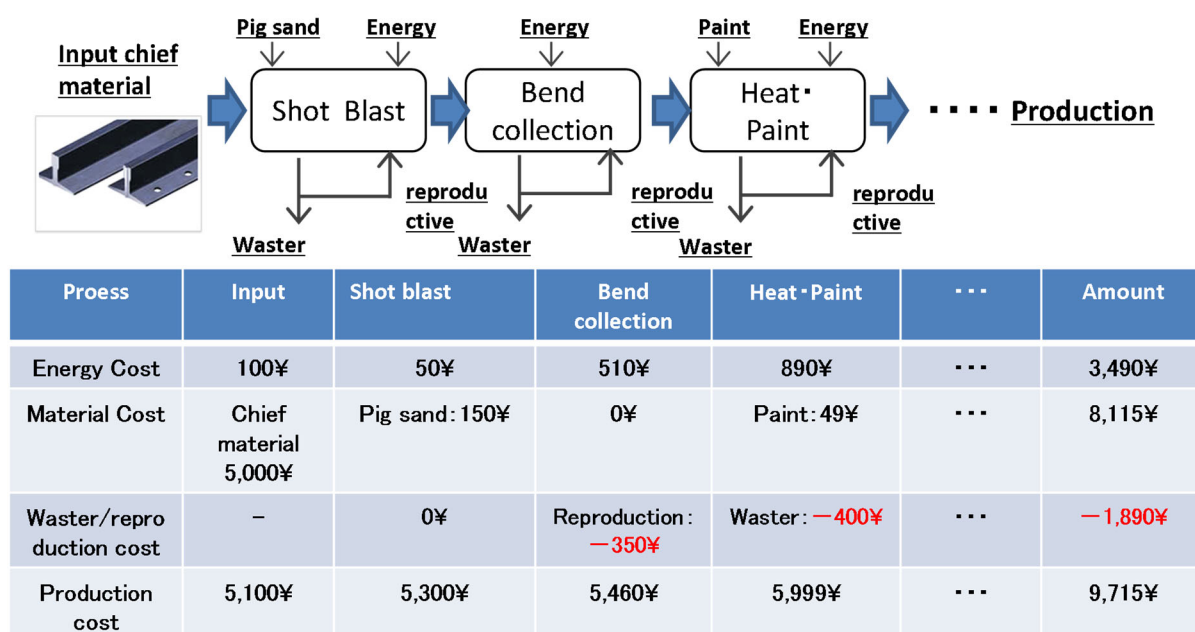


Figure 3-16 Example of application of energy saving

#### ④ Consideration of introduction to steelmaking process

In order to implement the low-carbonization of overseas steelmaking processes, it is necessary to collect energy data and formulate energy flows with respect to the Japanese steelmaking process, which is leading the way in low-carbonization. We will develop an intensity unit for comparison with overseas, and collect and study measures for low-carbon in Japan. Figure 3-17 shows examples of various measures for low carbon in Japan. On the other hand, Figure 3-18 shows the actual situation of an assumed overseas steelmaking line. It is important to compare the Japanese line with the overseas line, identify the measures for low carbon that are lacking in the overseas line, and propose the measures with the greatest effect first.

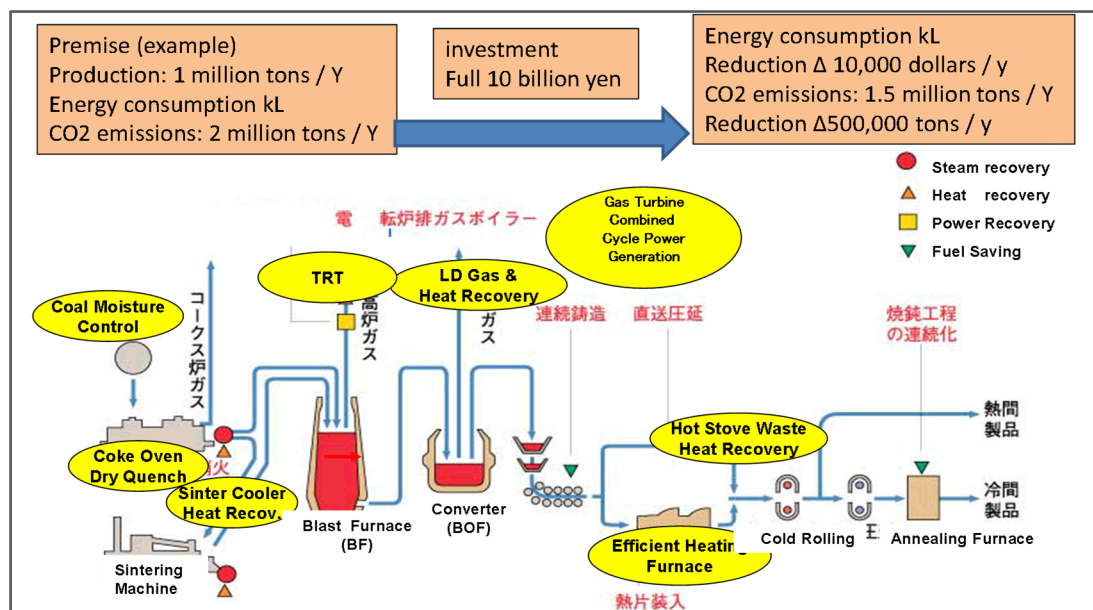


Figure 3-17 Examples of measures for low carbon (Japan)

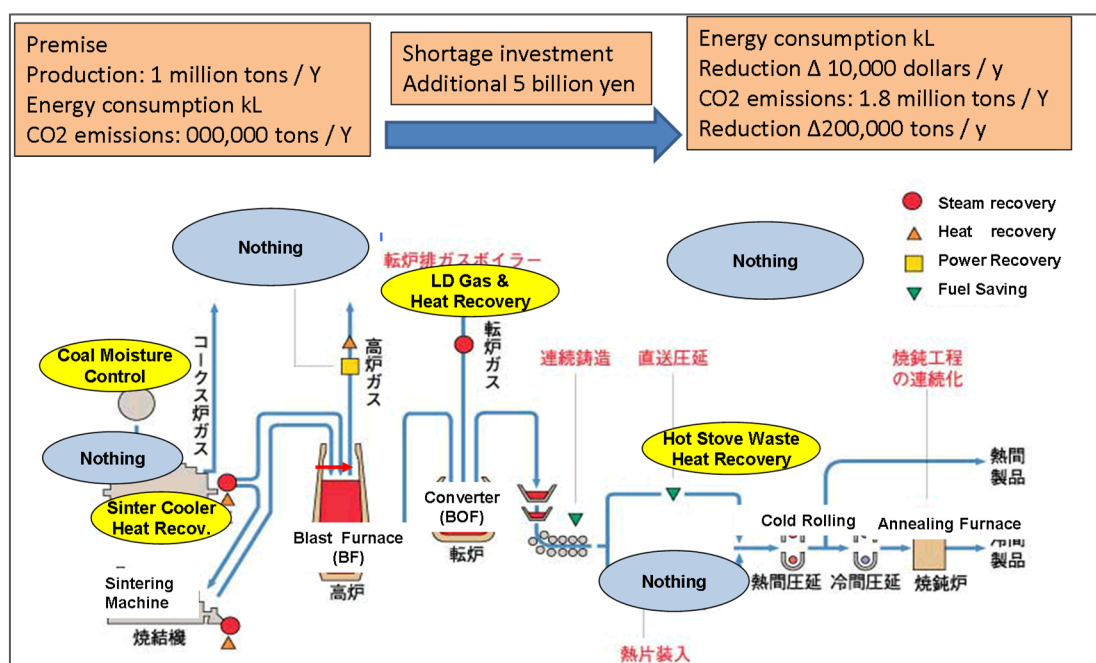


Figure 3-18 Examples of measures for low carbon (Oversea)

#### ⑤ Analysis using energy conservation assist support tool

The following is an example of analysis for achieving low carbonization using the tool for assisting energy conservation.

#### ○ Example of Analysis

Case 1: CO<sub>2</sub> reduction and cost-effectiveness of investment due to the case where the amount of electricity is reduced by introducing new equipment

Case 2: CO<sub>2</sub> reduction by switching the power system to a low-carbon power system

Prerequisites:

Installed equipment: Coke Dry Quenching system (CDQ)

Installation of CDQ (year): 2025

Power system change (year): 2027

Power emission factor: 0.45 → 0.40

Unit price of electricity: 15 yen → 20 yen/kWh

Investment amount: 100 million yen

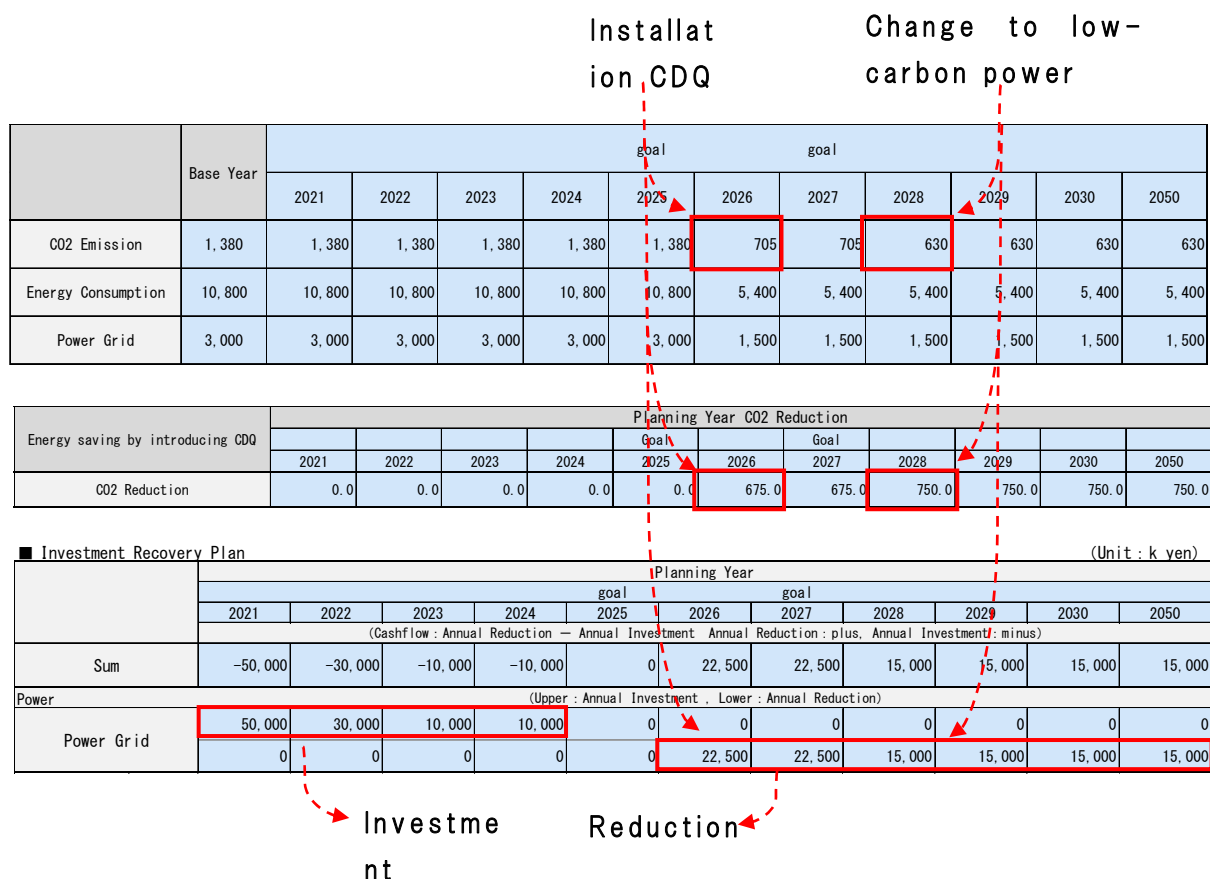


Figure 3-19 Low-carbon realization plan (eg. CDQ installation and change to low-carbon system)

## ⑥ Visualization using energy conservation assist support tool

The following is an example of visualization for achieving low carbonization using tool for assisting energy conservation.

### ○ Example of Visualization

The example compares the case where no countermeasures are taken (BAU) and the case where countermeasures are taken. In the case where measures are taken, it is desirable to provide multiple options such as general measures (Goal 1) and advanced measures (Goal 2). The effectiveness of the measures should be

confirmed by selecting a menu of measures and specifying the year of measures (completion). The tool simulates when the target reduction line should be achieved and is used as a basis for decision-making.

Menu	Year	Effect	Cost	Goal1	Goal2
Coal Moisture Control	2022	▲200	2500	✓	✓
Coke Oven Dry Quench	2022	▲300	2500	✓	✓
Sinter Cooler Heat Recov.	2024	▲500	15000	✓	✓
Hot Stove Waste Heat Recovery	2025	▲300	3500		✓
LD Gas & Heat Recovery	2027	▲700	800	✓	✓
Continuous Caster	2030	▲350	600	✓	✓
Hot Slab Charging	2035	▲200	42000		✓
Continuous Rolling	2040	▲600	1600	✓	✓
Continuous Annualing	2045	▲150	8500		✓

Figure 3-20 List of Equipment for low carbon (eg)

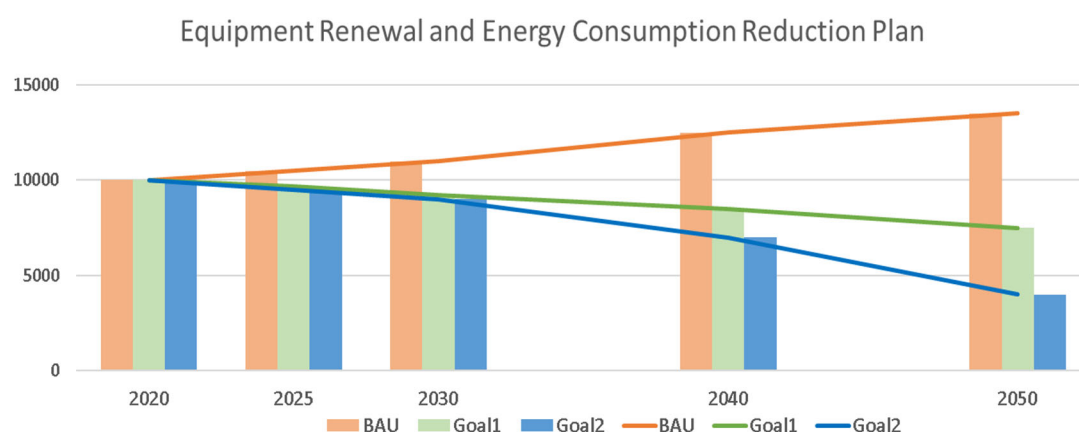


Figure 3-21 Graph: Comparison of BAU and Goals

#### 4. Proposal to JICA for low-carbon steelmaking and decarbonization worldwide

In order to implement the above cooperation programs and facilitate the spread of low-carbon initiatives in steelmaking, it is particularly important to establish an accessible funding scheme that takes into account the characteristics of the investment scale and investment objectives (overseas local private companies) for energy conservation in steelmaking projects. If this can be incorporated into technical cooperation, and if a comprehensive support can be established as a low-carbon steelmaking and decarbonization

package, it will be possible to effectively and smoothly expand this initiative to other countries in the future. Therefore, while taking into consideration the obstacles and challenges faced by local businesses in using existing financial schemes, which will be identified in detail in the course of future cooperation with Turkey, JICA should develop a financial scheme that fits the characteristics of the iron and steel industry. Furthermore, it is important to make it applicable to other countries. There are various schemes that could be envisioned, including not only overseas investments and loans, but also two-step loans and blended finance in cooperation with other international organizations and private companies. For example, in Turkey, a two-step loan from JICA could be effective in cases where energy efficiency and conservation facilities that do not meet TSKB financing conditions are introduced. Other examples include a subsidy scheme for demonstration projects under the Cooperation Program. Facilities introduced for the first time in a country are likely to be avoided by private companies for capital investment because the effects are not clear. In order to alleviate this barrier, the implementation of eco-processes in the long-term cooperation program will be regarded as a demonstration and its cost-effectiveness will be judged. It is expected that the actual verification of effectiveness will spontaneously promote further diffusion of the technology. The former is relatively long-term, and the financing is large, as it is not limited to the target company or the technology to be introduced, while the latter is characterized by the fact that once the technology has been introduced and demonstrated, it cannot be used to introduce the same technology elsewhere, so the investment funds are small, but the financing is provided, and repayment does not occur. For this reason, adjustments such as limiting the technologies to be introduced to Japanese technologies can be considered, but there is still room for further study. As the NEDO international demonstration scheme is ahead of others in terms of technology demonstration, there is a possibility that collaboration with JICA can be explored.

In order to facilitate future cooperation programs, collaboration with other JICA initiatives can be proposed. In particular, seeing and learning about the highly efficient steelmaking process on site is suitable for increasing the motivation of Turkish steelmakers. For this reason, in addition to inviting participants to Japan for the proposed cooperation program, it would be effective to invite participants from the Turkish steel sector to participate in country-specific and issue-specific training programs, and to conduct training related to decarbonization and CN policies at the same time.

In addition, it is also important to create opportunities to appeal JICA's

CN and decarbonization efforts worldwide. For example, by presenting the results of this cooperation program at a side event of the COP, it is expected that the interest of countries other than Turkey will increase.

The last one is about the linkage with the EU. Among the six countries covered in this study, Turkey has particularly strong ties with the EU and has been receiving support from the EU. If information sharing and collaboration among different donors can be established, the scope of cooperation will significantly expand. For example, if JICA can collaborate with the EBRD and other donors, it will increase the possibility of reinforcing the aforementioned financial cooperation. Therefore, it would be desirable to discuss and coordinate with the EU in the future.

## 5. Reference materials

<h1 style="text-align: center;">Tentative Agenda</h1> <h2 style="text-align: center;">Date: 2<sup>nd</sup> March 2022</h2> <p style="text-align: center;"><b>Language: English (Presentation)</b>  <b>Turkish-Japanese Interpretation (Q&amp;A and discussion)</b></p>			
Turkey Time	Agenda	Speaker	Duration
9:30-9:35	Opening Remark	Japan International Cooperation Agency (JICA)	5 min
9:35-9:40	Opening Remark	Dr. Abdullah Buğrahan KARAVELİ Director of Energy Efficiency and Environment Ministry of Energy and Natural Resources	5 min
9:40-9:55	Basic Concept of a Possible Technical Cooperation Project	Mr. Akifumi Nishihata Pacific Consultants Co., Ltd. (PCKK)	15 min
Session 1: Energy Efficient and Environmentally Sustainable Transition – Long-Term Approaches			
9:55-10:10	Effort to Address Carbon Neutrality by the Japanese Steel Industry	Dr. Shiro Watakabe JFE Steel Corporation (International Environmental Strategic Committee, JISF)	15 min
10:10-10:25	Overview of Turkish Steel Industry's Policy	Mrs. Serpil Çimen Director of Technical Affairs Turkish Steel Producers Association (TCUD)	15 min
10:25-10:45	Q&A and Discussion		20 min
Session 2: Energy Saving & Environmental Measures and Technologies – Short Term Approaches			
10:45-11:00	Overview of Technologies Customized List	Dr. Teruo Okazaki Nippon Steel Research Institute Corporation (NSRI)	15 min
11:00-11:15	Identifying Possible Energy-Saving Equipment and Process	Dr. Hirokazu Taniguchi The Energy Conservation Center, Japan (ECCJ)	15 min
11:15-11:30	Steel Industry's Efforts (and Barriers) to Low-Carbon Transition	Mr. Okan Çelik Strategic Planning and Sustainability Supervisor Erdemir	15 min
11:30-11:45	Steel Industry's Efforts (and Barriers) to Low-Carbon Transition	Mr. Banş Bora Environment Manager İçdaş	15 min
11:45-12:00	Introduction of Energy Saving Technology for EAF and RH (Steel Plant Diagnosis)	Mr. Michio Nakayama JFE Techno-Research Corporation (JFE-TEC)	15 min
12:00-12:20	Q&A and Discussion		20 min
12:20-12:25	Closing Remark	Turkish Steel Producers Association (TCUD)	5 min
12:25-12:30	Closing Remark	Dr. Hitoshi Dohnomae Nippon Steel Corporation (The Chair of International Environmental Strategic Committee, JISF)	5 min

Figure 5-1 Outline of Eco-process Webinar (2<sup>nd</sup> March 2022)