Appendix 2

Energy Reporting Guideline for Thailand Iron & Steel Industries

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Introduction

Improving energy efficiency is an important factor in determining the competitiveness of a steel plant, as energy generally forms a major cost component (about 20% to 40%) in the total manufacturing cost of steel.[1] Moreover, improvement of energy efficiency often leads to improvement in other aspects of steel production, such as productivity, product quality and safety. An effective way to improve the energy efficiency of a steel plant is to follow the Plan-Do-Check-Act (PDCA)[2] continual improvement framework, as depicted in the *Figure 1*. PDCA framework is actively utilized in manufacturing sector, successfully achieving various objectives such as improvement of product qualities.

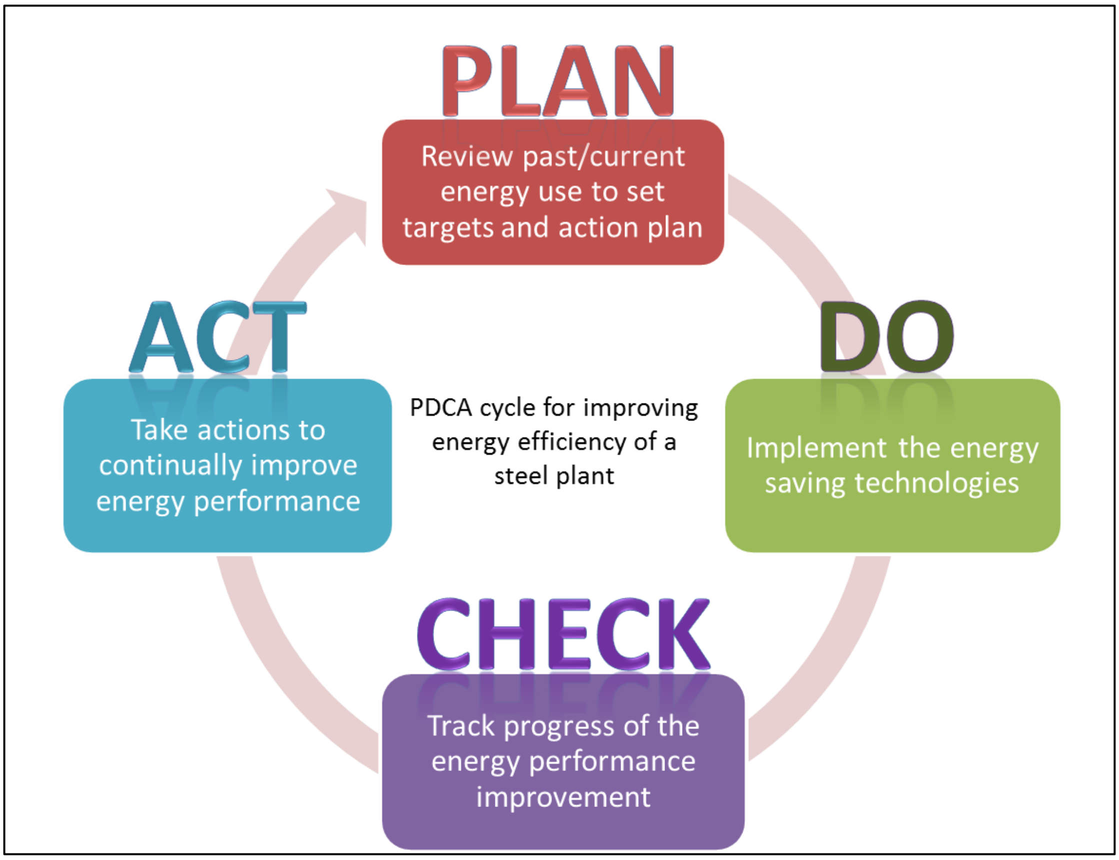

Figure 1: PDCA Cycle for improving energy efficiency of a steel plant

Energy data collection and analysis is necessary for both the "PLAN" and "CHECK" steps. The PLAN and CHECK steps are each necessary for the "DO" and "ACT" steps. It follows that energy data collection and analysis is vital for the success of the PDCA Cycle.

The PLAN step requires steel plant managers to understand their baseline energy consumption, so they can estimate potential future savings and measure how much energy they save in the future, relative to their baseline consumption. This enables plant managers to proceed to the DO step. Plant managers must understand their baseline energy use and potential savings to make decisions about the energy improvements to implement in the DO step.

The CHECK step is necessary for tracking the progress of the energy performance improvements made during the DO step. After checking the energy improvements, steel plant managers may then proceed to the ACT step. Steel plant managers must have useful energy information about changes

[1] Worldsteel Association Fact Sheet: Energy use in the steel industry 2016
[2] Also known as PDSA (Plan-Do-Study-Act) cycle. See following link for more details: <https://deming.org/explore/p-d-s-a>

to their plants' energy performance after they have made energy improvements (during the DO step) to inform their future decisions and help continually improve energy efficiency of the plant.

Annual energy reporting, and the energy data collection that enables it, is thus crucial for the success of the PDCA cycle. For the PDCA cycle to work, and for any steel plant to be able to successfully reduce its energy consumption and costs, steel plant managers must measure and report their energy consumption. This **Energy Reporting Guideline** will help steel plant managers in the Thailand iron and steel industry prepare regular reports on steel plant energy performance.

1 Scope

This **Energy Reporting Guideline** specifies the guidelines for the Thailand iron and steel industries to report their energy use and associated carbon dioxide (CO_2) emissions.

This guideline facilitates the creation of energy reports for the following 3 purposes:

(1) *Self-improvement*: energy reporting allows companies to establish baseline energy consumption, estimate savings from potential energy efficient equipment/operational upgrades, and track progress of energy efficiency improvements that have been implemented at the plant

(2) *Third party review*: energy reporting can generate important data that may be required for participation in government programs, energy audits, or as a part of a financing due diligence process; and is necessary for calculating associated greenhouse gas emissions

(3) *Industry-wide improvement*: plant-level energy reporting can generate data that can be anonymized and used in industry-level reporting and performance evaluation

2 Target Users of the Guideline

This **Energy Reporting Guideline** is intended for the use by individuals in Thailand's iron and steel companies who are responsible for monitoring and managing the energy use of the steel plant. This guideline provides the directions for those managers on how to prepare **Annual Energy Reports**.

3 References

This reporting guideline has been established based on following international standard:

- ISO 50001: 2011 (International standards for the implementation of energy management systems for the improvement of energy performance and efficiency)

- ISO 14404 series (International standards for the calculation method of CO_2 emission intensity from iron and steel production)

4 Scheme of Reporting

The proposed scheme for energy reporting in Thailand's iron and steel industry is depicted below in *Figure 2*.

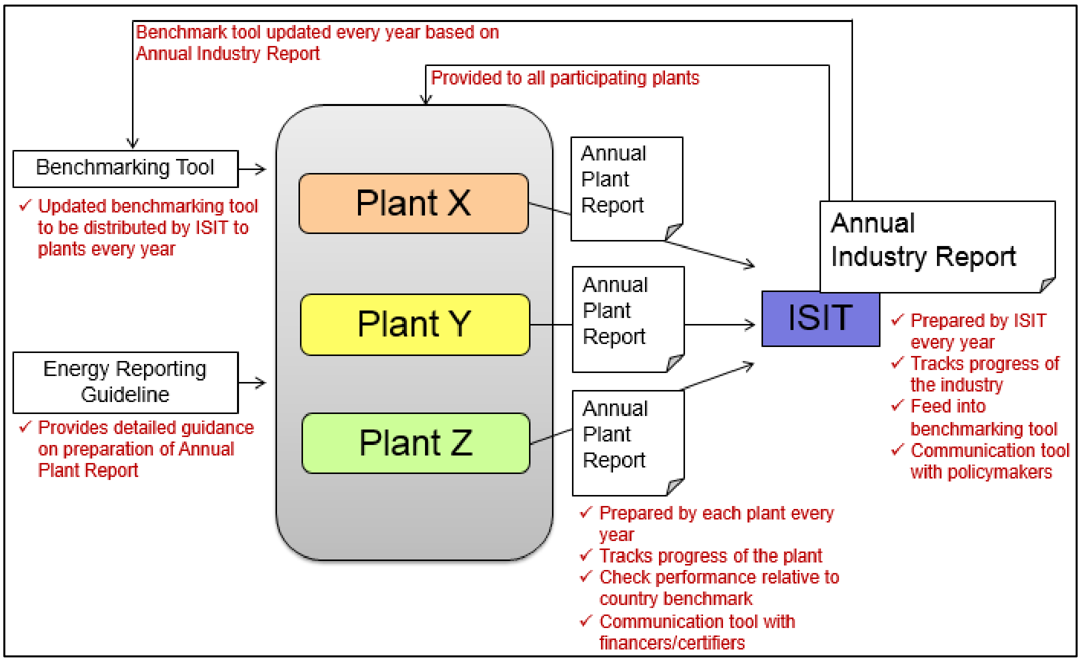

Figure 2: Overall Scheme of Reporting for the Iron & Steel Industry of Thailand

The sequence of actions in the proposed energy reporting process is as follows:

(1) An updated **Benchmarking Tool** is distributed by ISIT to all plants every year

(2) Plants fill in the **Benchmarking Tool** according to this **Energy Reporting Guideline**, and submit the relevant outputs to ISIT as their **Annual Plant Report**.

(3) ISIT (or an independent third-party) compiles and anonymizes the **Annual Plant Reports** to produce an **Annual Industry Report**

(4) Plants receive **Annual Industry Report** along with plant-specific feedback.

(5) The **Benchmarking Tool** is updated each year based on the **Annual Industry Report**

(6) Start the cycle again from step 1 next year

5 Timeline for Reporting

It is crucial that the reporting is conducted regularly to track the progress of energy efficiency improvement, and the suggested timeframe for reporting is one year.

A suggested timeline of actions is presented as *Figure 3* below. However, the timeline can be adjusted to fit the preferences of ISIT and the participating steel plants in Thailand.

#	Stakeholder	Schedule	Actions
1	ISIT	Apr	Determine the strategies, format, and updates related to Member Companies' energy reporting for the previous year
2	ISIT	Apr	Ask Member Companies to submit energy and CO_2 data and send out updated Benchmarking Tool for data submission
3	ISIT's Member Companies	June	Submit data for the previous year to ISIT using the format in the Energy Reporting Guidelines and Benchmarking Tool
4	ISIT	June-July	Aggregate of data from Member Companies and check for obvious numerical mistakes and other errors
5	ISIT	July-Aug	Analyze data reported from the Member Companies
6	ISIT	Sep	Reconfirm the data and create the Annual Industry Report
7	ISIT	Dec	Publish the Annual Industry Report for previous year and send to Member Companies and relevant to government bodies

Figure 3: Suggested Timeline of Reporting

6 Purposes of Annual Plant and Industry Reports

The **Annual Plant Report** is prepared by each plant, and serves following purposes:

(1) Establishes a baseline of energy consumption and tracks progress of energy efficiency improvements in the plant

(2) Creates an important data set and serves as a communication tool for the companies to use with third parties, such as investors, government bodies, and certifiers

(3) Provides the necessary data for the preparation of the Annual Industry Report

The **Annual Industry Report** is prepared by ISIT (or an independent third-party), and serves following purposes:

(1) Tracks progress of energy efficiency improvements in the industry and facilitates continuous improvement across the industry

(2) Creates an important data set and communication tool for the industry representatives to use with policymakers and industry stakeholders

(3) Provides information for updating the Benchmarking Tool

Technical instructions for producing the Annual Industry Report is outside the scope of this guideline.

7 Data Collection

As a basic practice for energy management of a plant, it is highly recommended that steel plant energy managers collect and record the following data on a monthly basis using the monthly data input tabs on the Benchmarking Tool.

(1) Units of energy consumed for each energy type

(2) Cost of energy for each energy type

(3) Quantity of output (crude steel for crude steel producers, final products for non-crude steel producers)

Recording this data on a monthly basis allows steel plants to identify areas of improvement and take actions, and prepares the steel plants for any types of future reporting or due diligence[3] requirements. Such detailed data will be confidential, and it is not intended for direct use in reporting. However, entering the monthly record in the monthly data input tabs in the Benchmarking Tool will automatically generate the output sheet for the Annual Plant Report.

As described further in Chapter 9.2, data collection is key for building credibility with third parties, such as investors and government bodies or their partners.

8 Preparation of Annual Plant Report

To minimize the time spent on the reporting activity, it is effective to submit the report every year in the exact same format. By filling out the updated Benchmarking Tool every year, the Annual Report will automatically be generated in the desired format.

There are two forms of the Benchmarking Tool: one Benchmarking Tool for steel plants with Electric Arc Furnaces (EAF), and one Benchmarking Tool for steel plants without Electric Arc Furnaces. Plant managers should enter their monthly (or annual) data in the appropriate Benchmarking Tool, and then submit the automatically generated Annual Plant Report to ISIT.

If the plant uses another format to collect monthly data, then the plant should enter the relevant information directly into the appropriate Benchmarking Tool, depending on the plant type.

See Chapter 10 for more information on the relationship between Benchmarking Tool and Annual Plant Report, and Chapter 11 for step-by-step guideline for preparing Annual Plant Report using the Benchmarking Tool.

9 Other Benefits of Recording Energy Data

Collecting and analysing energy data may be very useful practice for steel plant managers separate and apart from the annual industry-wide reporting scheme. In addition to using their energy data for the preparation of the Annual Industry Report, steel plant managers may want to use energy data they collect as a part of the annual reporting process for other purposes such as:

(1) Tracking the energy consumption costs related to steel production

(2) Tracking progress of specific energy efficiency improvements in the plant

(3) Participation in an energy-related government program or for compliance with future government policies

(4) Providing information to a financial institution that is considering making an investment in the steel plant

(5) For calculating associated greenhouse gas emissions and emissions reductions

The Annual Plant Report may useful for serving these other purposes. However, there may be cases where different forms of reporting are required or more desirable. Following chapters provide directions for preparing reports for different purposes.

9.1 Reporting for Internal Use

If the reporting is for internal use, the format and information can be chosen based on the purposes and preferences of the managers of the plant and the company.

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[3] "Due diligence" refers to the process of auditing all relevant factors in a deal and confirming all financial and technical details before entering an agreement or financial transaction with a counter-party. For example, banks perform due diligence on potential investments and borrowers before providing capital to them.

It is recommended that the reports are prepared and submitted at scheduled intervals, and that the reporting style is consistent over time.

9.2 Reporting for Communication with Third Parties

Other forms of energy and emissions reporting may be necessary as a communication tool with third parties, such as investors and government bodies, or their partners. In these cases, it is possible that the third party has certain requirements for the reports.

The key is to have a consistent recording of detailed monthly, process-by-process data, as recommended in Chapter 7, as such recording enables a plant to produce reports in response all types of requests from the third party in interest.

10 Summary of Benchmarking Tool Input and Output Sheets

There are two versions of the Benchmarking Tool. One version is for steel plants with EAF, and the other version is for steel plants without EAF such as re-roller plants.

Both versions of the Benchmarking Tool include the following sheets:

A) Instructions – This sheet provides detailed instructions on how to use the Benchmarking Tool.

B) Annual Data Entry – This sheet either automatically sums all monthly data entered in the Monthly Data Input Sheets, or it is where Annual Data can be manually entered.

C) Benchmarking Results – This sheet automatically generates a benchmarking analysis of energy intensity and emissions intensity of the steel produced at a given plant.

D) Annual Plant Report – This sheet automatically generates the Annual Plant Report to be submitted to ISIT.

Monthly Data Entry Sheets (from January to December) – These twelve sheets (one sheet for each month) serve as data input sheets for plant managers choosing to enter monthly data in the Benchmarking Tool.

Factor – This sheet serves as a reference for the factors used in the calculations embedded in the Benchmarking Tool.

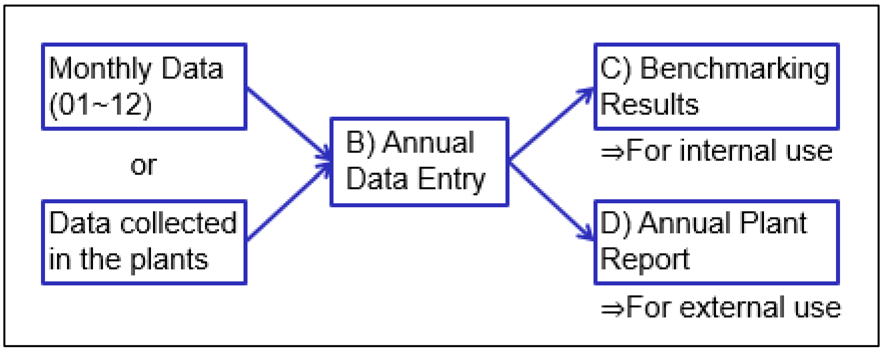


Figure 4: Diagram of Benchmarking Tool Input and Output Sheets

The Annual Data Entry sheet (Sheet B) and the Monthly Data Entry sheets (Sheets 01-12) are the *input sheets*, and plant managers can choose whether to enter annual energy data or monthly emissions data. (If monthly energy data is entered in the Monthly Data Entry sheets, it will automatically be summed and appear on the Annual Data Entry sheet.)

The Benchmarking Results sheet (Sheet C) and the Annual Plant Report sheet (Sheet D) are the *output sheets*. The Benchmarking Results sheet provides useful comparative information that plant managers can use internally. The Annual Plant Report sheet is an automatically generated report that should be sent to ISIT. ISIT will anonymize and aggregate the information in the Annual Plant Reports to create an Annual Industry Report, which will be sent to all participating steel plants, and will be used to update the Benchmarking Tool.

11 Step-by-step guideline for data entry into the Benchmarking Tool and preparation of the Annual Plant Report

The instruction provided in the Instructions sheet (Sheet A) of the Benchmarking tool should be sufficient for entering data into the Benchmarking tool. Following instructions are provided for an additional guidance only.

Data required for Benchmarking Tool are following:

(1) Basic information of plants / facilities

(2) Quantity of steel production (tonnes of crude steel for plants with EAF, and tonnes of final steel products for plants without EAF.)

(3) Quantity of net consumption for each energy source type

(4) Information on changes in operation and equipment and implementation of energy saving technologies/SOP

Step 1: Fill in the General Information of the Plants

Year of Assessment	2017
Name of person in charge of this data	*********
phone	***-****-****
E mail	***@*******
Company name	***
Site name	***
Established date	mm/dd/yyyy
Main product	***

Step 2: Fill in the Information Related to the Quantity of Steel Production

For steel plants with EAF: in tonnes of crude steel

Annual EAF production capacity	***	ton-crude steel/y
Actual annual EAF production of crude steel	600000	ton-crude steel/y
Annual purchased semi-finished steel products	***	ton/y
Annual RHF production capacity	***	ton- steel*/y
Actual annual production of final steel products	***	ton-product steel/y

*semi-finished steel products such as bloom, billet, slab, etc.

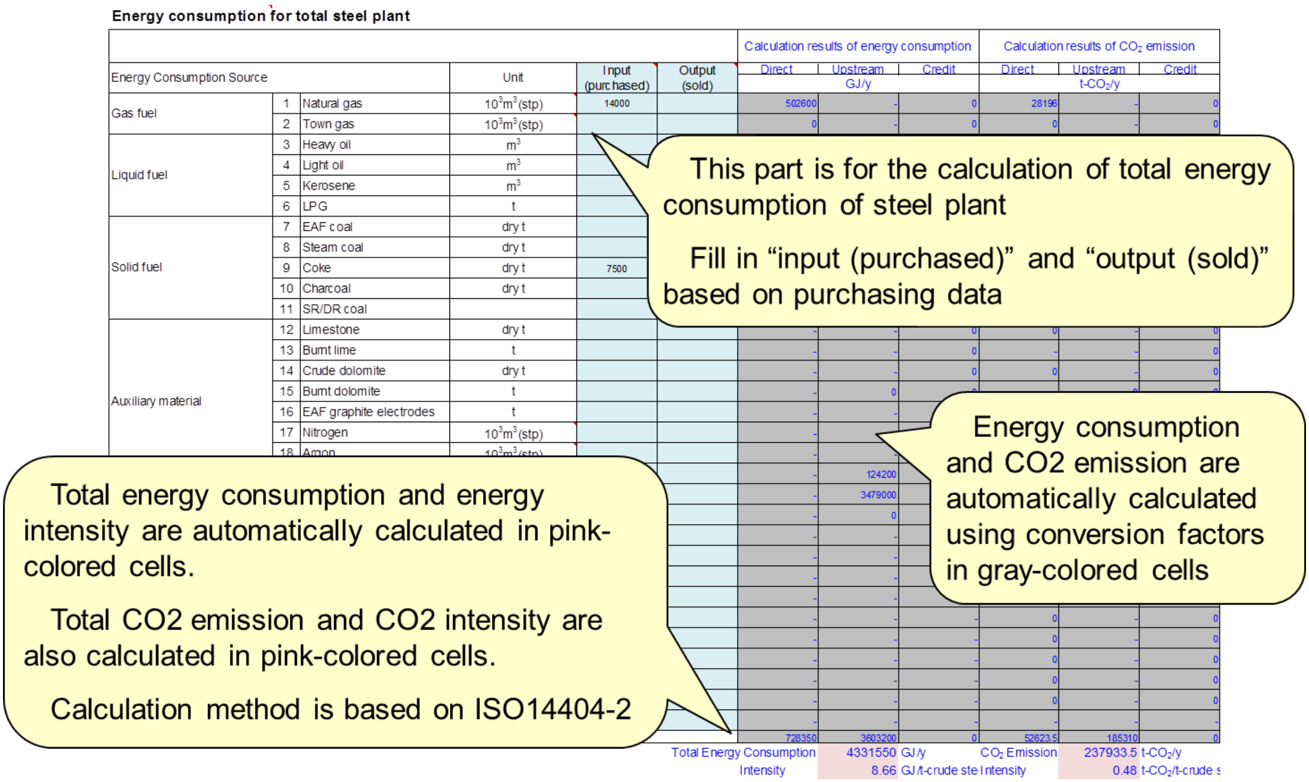
For steel plants without EAF: in tonnes of final steel products

Annual purchased semi-finished steel products	***	ton-steel/y
Annual RHF production capacity	***	ton-steel*/y
Actual annual production of final steel products	600000	ton-product steel/y

*semi-finished steel products such as bloom, billet, slab, etc.

Step 3: Fill in the Quantity of Energy Consumption for each Energy Type

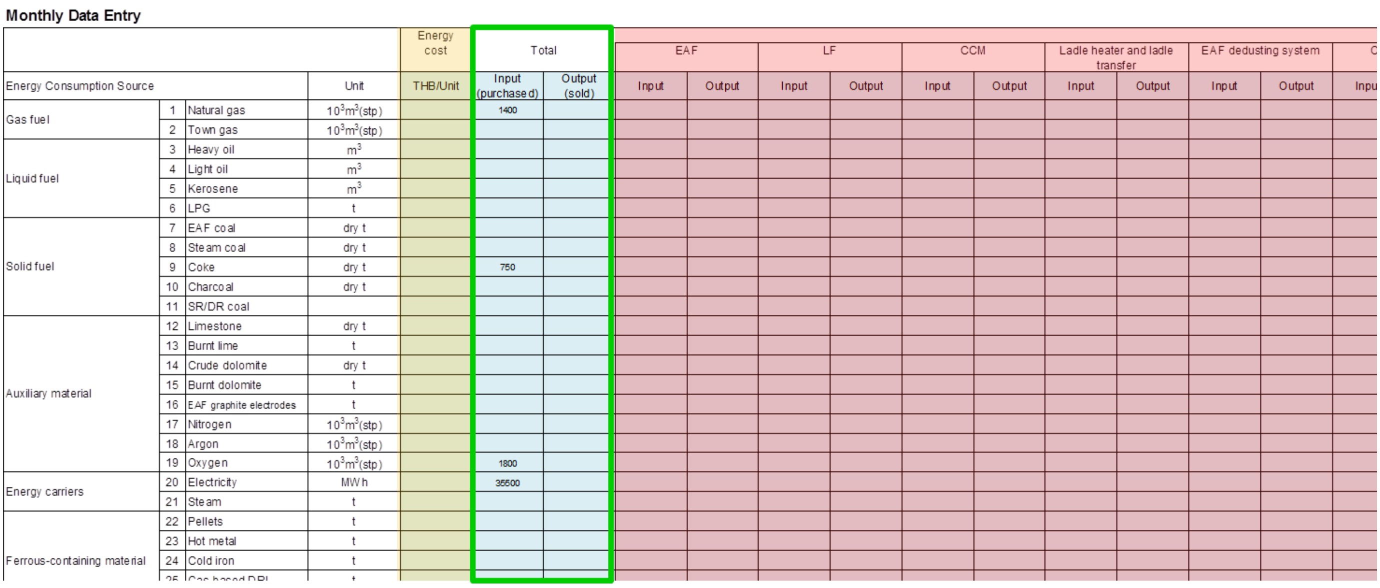
By filling in these blue-coloured cells with the purchased and sold amount of each energy type, energy consumption for total steel plant can be calculated.



Total energy consumption and intensity or total CO2 emission and intensity are automatically calculated in pink-coloured cells using conversion factor and calculation method specified in ISO 14404-2. Details of the calculation method are described in Appendix A.

As mentioned before, there are two options to fill in the data into blue-coloured cell. Option 1 is manually entering the data into the cell by reference to each company’s record. Option 2 is using the Monthly Data sheets. Monthly Data sheets are 12 sheets included in the Benchmarking Tool to enter the monthly data from Jan to Dec.

If you choose option 2, fill in the blue-coloured cells (indicated by green box in the figure below) with purchased and sold amounts of each energy type. By completing data entry into all 12 Monthly Data sheets (from Jan to Dec), the blue-coloured cells in the Annual Data Sheet will be automatically filled in.



Additional option: we provide additional option to record energy cost (indicated with yellow shade in the figure above) and facility-by-facility energy consumption data (indicated with red shade in the figure above) in the monthly sheet. These data are not intended for reporting, and will not be reflected in the Annual Plant Report sheet. Recording of this information is suggested for the purpose of internal improvement by the steel plant.

Step 4: Fill in the Energy Information for the Main Facilities (EAF and RHF)

Please fill in the annual average of unit electricity consumption for EAF & Ladle Furnace and energy intensity of RHF. Since EAF and RHF are energy intensive facilities, these factors are important as an indicator of performance.

Steel plants with EAF are asked to fill in the energy information for both EAF and RHF.

Steel plants without EAF are asked to fill in the energy information for RHF only.

Monthly average of RHF energy intensity is important indicator of total energy performance. On the other hand, RHF energy intensity at stable operation is important indicator of RHF energy performance.

Fill in energy consumption for EAF/RHF

Unit electricity consumption for EAF/LF

	No.		Unit	Input
Electric arc furnace (EAF)	1	Electricity consumption	MWh/ton-steel	0.43
Ladle furnace (LF)	2	Electricity consumption	MWh/ton-steel	0.043
			total	0.47

Energy intensity of RHF

	No.		Unit	Input
Reheating furnace for hot rolling (RHF)	1	Heat consumption (monthly average)	GJ/ton- steel*	1.5
	2	Heat consumption at stable operation (cold charge)	GJ/ton- steel*	1.3
	3	Heat consumption at stable operation (hot charge)	GJ/ton- steel*	0.9

Heat consumption (monthly average) = Annual average of energy intensity of RHF, which can be calculated by dividing the total fuel consumption of RHF by the amount of input semi-finished steel*

Heat consumption at stable operation = The energy intensity of RHF when RHF is operated under the same conditions for more than two hours

*such as bloom, billet, slab etc.

Step 5: Fill in the Information on Changes in Operation and Equipment and Implementation of Energy Saving Technologies/SOP

Since the purpose of annual plant report is to track progress of the industry, it is important to analyse the reason for the change of energy performance. Please fill in this cell if the company change the operation and equipment, or implement energy saving technology or Standard Operating Practice. Examples of information to be included are provided below.

Fill in this cell if you changed operation and equipment or implemented energy saving technologies/SOP.

Changes in operation and equipment

e.g.) Changing fuel, equipments, operation time, times of scrap charge etc.

Implementation of energy saving technologies/SOP

e.g.) Implementation of energy saving technologies such as "High temperature continuous scrap preheating EAF" or SOP such as "Good slag foaming with coherent burner" etc.

Step 6: preparation and submission of Annual Plant Report

Once the data entry into Annual Data Entry sheet is completed, Annual Plant Report sheet is automatically filled in with all necessary information. Please export this sheet as a separate excel file and send it to ISIT. There are three options for submission forms of Annual Plant Report, although option 1 is preferred.

- Option 1 (preferred): Copy Annual Plant Report sheet (sheet D), open a new Excel Workbook file, "paste special" "values and number formats" into a new Excel Workbook, save it, and email it to ISIT

If Option 1 is difficult for any reason, please choose either Option 2 or Option 3.

- Option 2: Print Annual Plant Report sheet (sheet D) as a PDF file and email it to ISIT
- Option 2: Print Annual Plant Report sheet (sheet D) as a hard copy and send to ISIT via mail.

12 Appendix A: Calculation Details of Total Energy Consumption/Intensity and Total CO2 Emission/Intensity of a Steel Plant

12.1 General

Entering the quantity of energy consumption for each energy source according to the Annual Data Entry sheet (Sheet B) automatically calculates the following:

- Net energy consumption (GJ/year) and intensity (GJ/ton-crude steel for plants with EAF and GJ/ton-final steel products for plants without EAF) of a steel plant
- Net CO2 emission (ton-CO2/year) and intensity (ton-CO2/ton-crude steel for plants with EAF and ton-CO2/ton-final steel products) of a steel plant

These calculations comply with ISO14404-2 (Calculation method of carbon dioxide emissions intensity from iron and steel production- Part 2: Steel plant with electric arc furnace (EAF)). Figure 5 demonstrates a conceptual diagram of energy and CO2 emission calculations.

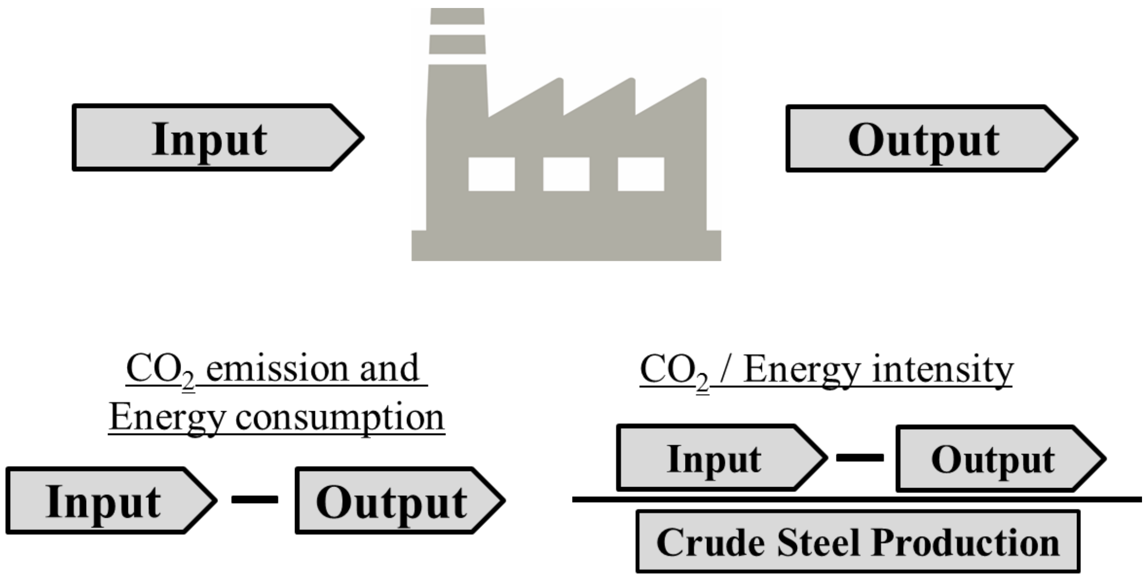


Figure 5: Conceptual Diagram of Energy and CO2 emission calculations

The annual energy consumption, $C_{E,\ annual}$, and intensity, I_E, at a steel plant can be calculated by following equations:

$$C_{E,annual} = \sum_{t=1}^{N} K_{t,d,E} \times Q_{t,d,CO2} + \sum_{t=1}^{N} K_{t,u,E} \times Q_{t,u,CO2} - \sum_{t=1}^{N} K_{t,c,E} \times Q_{t,c,CO2}$$

$$I_E = C_{E,annual}/P$$

where

$Q_{t,\ d,\ CO2}$ are the quantities of direct CO2 emission sources;

$Q_{t,\ u,\ CO2}$ are the quantities of upstream CO2 emission sources;

$Q_{t,\ c,\ CO2}$ are the quantities of credit CO2 emission sources;

$K_{t,\ d,\ E}$ is the energy consumption factor for calculation of direct energy consumption;

$K_{t,\ u,\ E}$ is the energy consumption factor for calculation of upstream energy consumption;

$K_{t,\ c,\ E}$ is the energy consumption factor for calculation of credit energy consumption;

I_E is the energy intensity;

$C_{E,\ annual}$ is the annual energy consumption;

P is the annual crude steel (or final steel product) production.

List of energy consumption factors is provided in Table 1 in Chapter 12.3.

Similarly, the annual CO_2 emissions ($E_{CO2,\ annual}$) and CO_2 intensity (I_{CO2}) of at a steel plant can be calculated by following equations:

$$E_{CO2,annual} = \sum_{t=1}^{N} K_{t,d,CO2} \times Q_{t,d,CO2} + \sum_{t=1}^{N} K_{t,u,CO2} \times Q_{t,u,CO2} - \sum_{t=1}^{N} K_{t,c,CO2} \times Q_{t,c,CO2}$$

$$I_{CO2} = E_{CO2,annual}/P$$

where

$Q_{t,\ d,\ CO2}$ are the quantities of direct CO2 emission sources;

$Q_{t,\ u,\ CO2}$ are the quantities of upstream CO2 emission sources;

$Q_{t,c,CO2}$ are the quantities of credit CO2 emission sources;

$K_{t,d,CO2}$ is the CO_2 emission factor for calculation of direct CO_2 emission;

$K_{t,u,CO2}$ is the CO_2 emission factor for calculation of upstream CO_2 emission;

$K_{t,vc,CO2}$ is the CO_2 emission factor for calculation of credit CO_2 emission;

I_{CO2} is the CO2 intensity;

$E_{CO2,vannual}$ is the annual CO_2 emissions;

P is the annual crude steel (or final steel product) production.

List of energy consumption factors is provided in Table 2 in Chapter 12.3.

12.2 Boundary for Calculation

The boundary for calculating the net energy consumption/intensity and net CO2 emission/intensity includes all production processes which are present in the site, but also the essential upstream processes, mainly the production of oxygen, electricity and steam.

Boundary for steel plants with EAF is depicted in Figure 6.

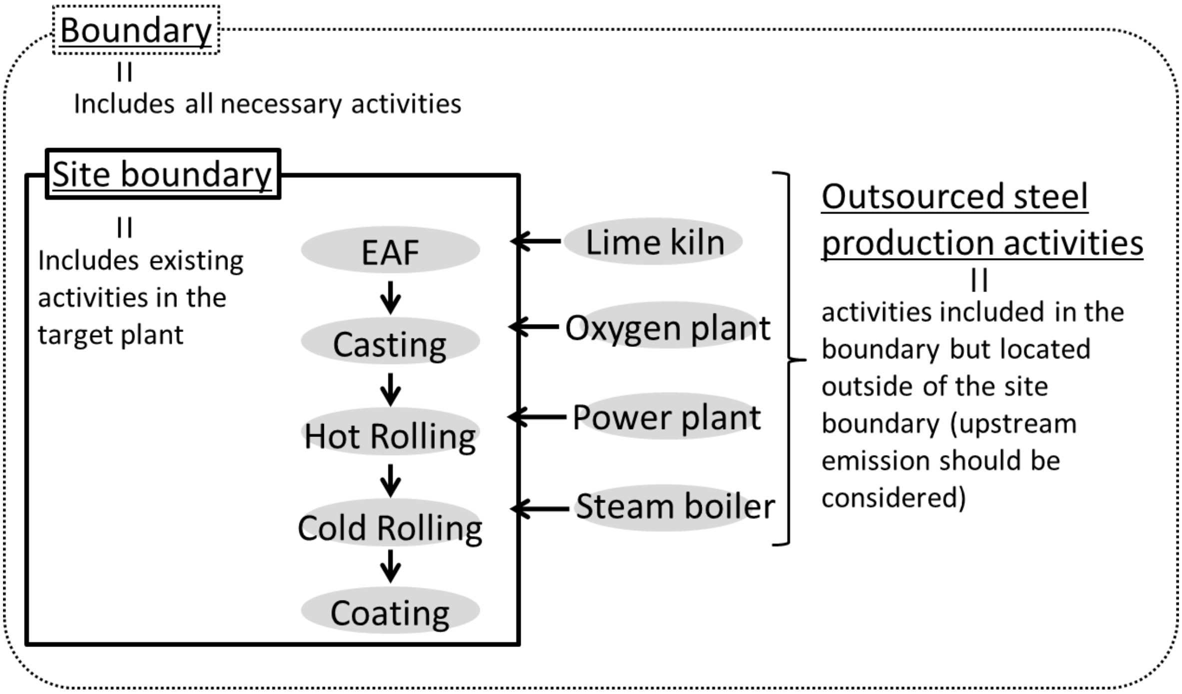


Figure 6 Boundary for steel plants with EAF

Boundary for steel plants without EAF is depicted in Figure 7.

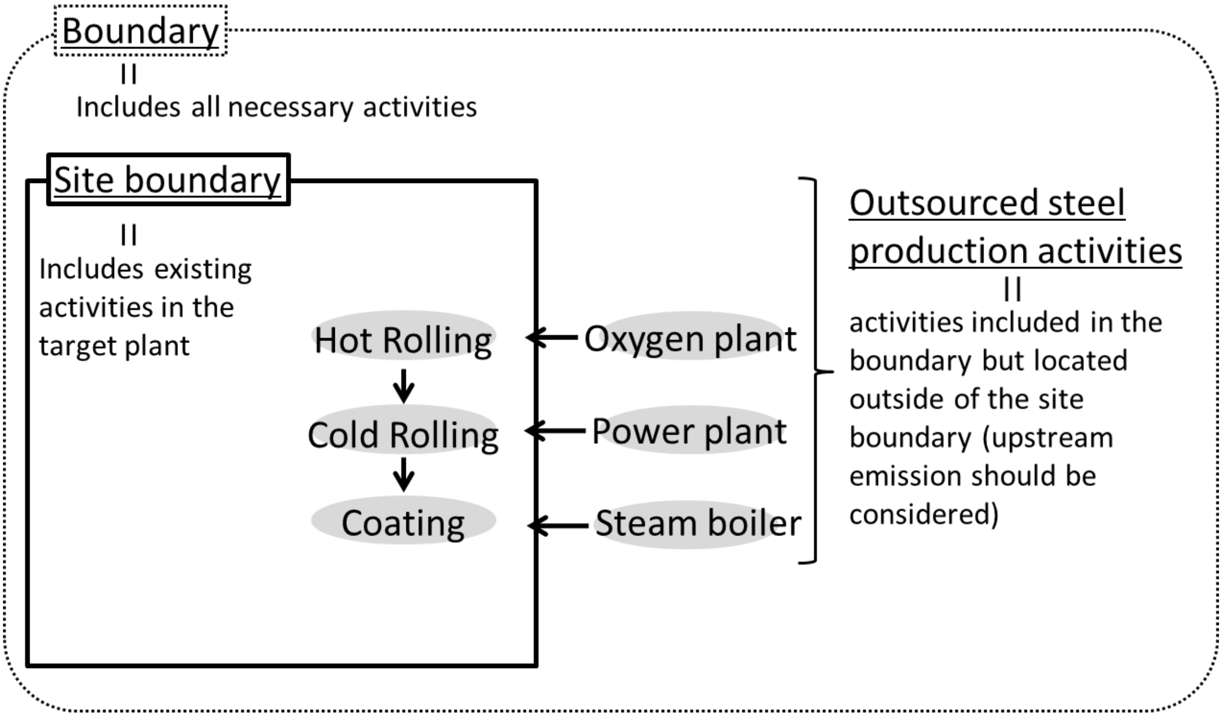


Figure 7 Boundary for steel plants without EAF

12.3 Emission Factors

The emission factors used for the calculation of net energy consumption/intensity and net CO2 emission/intensity are based on ISO 14404-2. These emission factors are based on global average data. Use of global average emission factors is appropriate for comparisons of energy performance among plants from different parts of the world, and it is sufficient for tracking relative performance over time or within Thailand steel industry.

However, when the purpose of calculation is to prepare inventories of actual energy consumption/CO2 emissions from the Thai steel plant or the industry, it is necessary to change the emission factors to Thailand-specific emission factors.

List of energy consumption factors is provided in Table 1.

Table 1: List of Energy Consumption Factors

Source			Unit	Direct energy consumption factor (Kt,d,E)	Upstream energy consumption factor (Kt,u,E)	Credit energy consumption factor (Kt,c,E)
				GJ/unit	GJ/unit	GJ/unit
Gas fuel	1	Natural gas	10^3m^3(stp)	35.900	N/A	35.900
	2	Town gas	10^3m^3(stp)	35.900	N/A	35.900
Liquid fuel	3	Heavy oil	m^3	37.700	N/A	37.700
	4	Light oil	m^3	35.100	N/A	35.100
	5	Kerosene	m^3	34.700	N/A	34.700
	6	LPG	t	47.300	N/A	47.300
Solid fuel	7	EAF coal	dry t	30.100	N/A	30.100
	8	Steam coal	dry t	25.900	N/A	25.900
	9	Coke	dry t	30.100	N/A	30.100

	10	Charcoal	dry t	18.800	N/A	18.800
	11	SR/DR coal		N/A	N/A	N/A
Auxiliary material	12	Limestone	dry t	N/A	N/A	0.000
	13	Burnt lime	t	N/A	4.500	4.500
	14	Crude dolomite	dry t	N/A	N/A	0.000
	15	Burnt dolomite	t	N/A	4.500	4.500
	16	EAF graphite electrodes	t	N/A	N/A	0.000
	17	Nitrogen	10^3m^3(stp)	N/A	2.000	2.000
	18	Argon	10^3m^3(stp)	N/A	2.000	2.000
	19	Oxygen	10^3m^3(stp)	N/A	6.900	6.900
Energy carriers	20	Electricity	MWh	N/A	9.800	9.800
	21	Steam	t	N/A	3.800	3.800
Ferrous-containing material	22	Pellets	t	N/A	N/A	N/A
	23	Hot metal	t	N/A	N/A	N/A
	24	Cold iron	t	N/A	N/A	N/A
	25	Gas-based DRI	t	N/A	N/A	N/A
	26	Coal-based DRI	t	N/A	N/A	N/A
Alloys	27	Ferro-nickel	t	N/A	N/A	N/A
	28	Ferro-chromium	t	N/A	N/A	N/A
	29	Ferro-molybdenum	t	N/A	N/A	N/A
Product and by-product	30	CO_2 for external use	t	N/A	N/A	N/A
Others	N	Other emission sources	—			

List of energy consumption factors is provided in Table 2.

Table 2: List of Energy Consumption Factors

Source			Unit	Direct CO_2 emission factor (K_{t,d,CO_2})	Upstream CO_2 emission factor (K_{t,u,CO_2})	Credit CO_2 emission factor (K_{t,c,CO_2})
				t-CO_2/unit	t-CO_2/unit	t-CO_2/unit
Gas fuel	1	Natural gas	10^3m^3(stp)	2.014	N/A	2.014
	2	Town gas	10^3m^3(stp)	2.014	N/A	2.014
Liquid fuel	3	Heavy oil	m^3	2.907	N/A	2.907
	4	Light oil	m^3	2.601	N/A	2.601

	5	Kerosene	m^3	2.481	N/A	2.481
	6	LPG	t	2.985	N/A	2.985
Solid fuel	7	EAF coal	dry t	3.257	N/A	3.257
	8	Steam coal	dry t	2.461	N/A	2.461
	9	Coke	dry t	3.257	N/A	3.257
	10	Charcoal	dry t	0.000	N/A	0.000
	11	SR/DR coal		2.955	N/A	2.955
Auxiliary material	12	Limestone	dry t	0.44	N/A	0.440
	13	Burnt lime	t	N/A	0.950	0.950
	14	Crude dolomite	dry t	0.471	N/A	0.471
	15	Burnt dolomite	t	N/A	1.100	1.100
	16	EAF graphite electrodes	t	3.663	0.650	3.663
	17	Nitrogen	10^3m^3(stp)	N/A	0.103	0.103
	18	Argon	10^3m^3(stp)	N/A	0.103	0.103
	19	Oxygen	10^3m^3(stp)	N/A	0.355	0.355
Energy carriers	20	Electricity	MWh	N/A	0.504	0.504
	21	Steam	t	N/A	0.195	0.195
Ferrous-containing material	22	Pellets	t	0	N/A	N/A
	23	Hot metal	t	0.172	N/A	0.172
	24	Cold iron	t	0.172	N/A	0.172
	25	Gas-based DRI	t	0.073	N/A	0.073
	26	Coal-based DRI	t	0.073	N/A	0.073
Alloys	27	Ferro-nickel	t	0.037	N/A	0.037
	28	Ferro-chromium	t	0.275	N/A	0.275
	29	Ferro-molybdenum	t	0.018	N/A	0.018
Product and by-product	30	CO_2 for external use	t	1	N/A	1
Others	N	Other emission sources	—			

12.4 Definitions of Energy Sources

Definitions of all energy types are provided in the table below. The definitions are also included in the Factor sheet of the Benchmarking Tool.

Energy Source	Definition

Gas fuel	1	Natural gas	mixture of gaseous hydrocarbons, primarily methane, occurring naturally in the earth and used principally as a fuel
	2	Town gas	fuel gas manufactured for domestic and industrial use
Liquid fuel	3	Heavy oil	No. 4- No.6 fuel oil defined by ASTM
	4	Light oil	No. 2- No.3 fuel oil defined by ASTM
	5	Kerosene	paraffin (oil)
	6	LPG	liquefied petroleum gas
Solid fuel	7	EAF coal	coal for EAF, including anthracite
	8	Steam coal	boiler coal for producing electricity and steam, including anthracite
	9	Coke	solid carbonaceous material
	10	Charcoal	devolatilised or coked carbon neutral materials. Ex. Trees, plants
	11	SR/DR coal	coal for SR/DRI including anthracite
Auxiliary material	12	Limestone	calcium carbonate, $CaCO_3$
	13	Burnt lime	CaO
	14	Crude dolomite	calcium magnesium carbonate, $CaMg(CO_3)_2$
	15	Burnt dolomite	$CaMgO_2$
	16	EAF graphite electrodes	net use of EAF graphite electrodes or attrition loss
	17	Nitrogen	N_2.inert gas separated from air at oxygen plant, imported from outside the boundary or exported to outside the boundary
	18	Argon	Ar. inert gas separated from air at oxygen plant, imported from outside the boundary or exported to outside the boundary
	19	Oxygen	O_2. gas separated from air at oxygen plant, imported from outside the boundary or exported to outside the boundary
Energy carriers	20	Electricity	electricity imported from outside the boundary or exported to outside the boundary
	21	Steam	pressurized water vapour imported from/exported to outside the boundary
Ferrous-containing material	22	Pellets	agglomerated spherical iron ore calcinated by rotary kiln
	23	Hot metal	intermediate liquid Iron products containing 3% to 5% by mass carbon produced by smelting iron ore with equipment such as blast furnaces
	24	Cold iron	solidified hot metal as an intermediate solid iron products
	25	Gas-based DRI	direct reduced iron (DRI) reduced by a reducing gas such as reformed natural gas
	26	Coal-based DRI	direct reduced iron (DRI) reduced by coal
Alloys	27	Ferro-nickel	alloy of iron and nickel
	28	Ferro-chromium	alloy of iron and chromium
	29	Ferro-molybdenum	alloy of iron and molybdenum
Product and by-product	30	CO_2 for external use	CO_2 exported to outside the boundary

Others	N	Other emission sources	other related emission sources such as plastics, scraps, desulfurization additives, alloys, fluxes for secondary metallurgy, dust, sludges, etc.

13 Appendix B: Benchmarking Tool

The Benchmarking Tool referenced in this document is attached here. Please note there are two versions of the Benchmarking Tool: one version for steel plants with Electric Arc Furnaces and one version for steel plants without Electric Arc Furnaces, such as re-rollers. Please be sure to use the appropriate version of the Benchmarking Tool for your steel plant.