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ISO14404 User Guide

Calculation method of CO_2 intensity from iron and steel production

Ministry of Economy,
Trade and Industry, Japan

The Japan Iron and
Steel Federation

Ministry of Economy, Trade and Industry
1-3-1 Kasumigaseki Chiyoda-ku Tokyo 100-8901 JAPAN
Tel: +81 (0)3 3501 1733
Fax: +81 (0)3 3501 0195

The Japan Iron and Steel Federation
Technology, Environment & Energy Division
3-2-10 Nihonbashi-Kayabacho Chuo-ku Tokyo 103-0023 JAPAN
Tel: +81 (0)3 3669 4837
Fax: +81 (0)3 3669 0228
Email: kankyou1@jisf.or.jp

Introduction

The International Organization for Standardization (ISO) published a standardized method to calculate CO_2 emission intensity from iron and steel production in March 2013. This is the first standard in the world to define the sector-specific calculation method of CO_2 emission.

ISO14404 is based on the Energy Performance Indicator developed under APP (Asia-Pacific Partnership on Clean Development and Climate) and worldsteel CO_2 Data Collection. Original methodology of APP and worldsteel was optimized for Blast Furnace (ISO14404-1) and Electric Arc Furnace (ISO14404-2). Besides calculating CO_2 emission, users may apply ISO14404 to evaluate energy intensity.

"ISO14404 User Guide" describes the overview of ISO14404 and offers instruction of **"ISO14404 Calculation Tool"**, which enables users to calculate CO_2 intensity based on ISO14404 methodology. In addition, by combining **"ISO14404 Technology Introduction Simulator"** and technology references, such as Technologies Customized List, users may simulate energy saving potential of technology introduction.

We believe ISO14404 will be effective especially in the emerging countries where steel production as well as energy consumption in the steel industry will increase. Once steel plants adopt ISO14404, plants will be able to regularly review energy saving condition and thereby establish energy management structure.

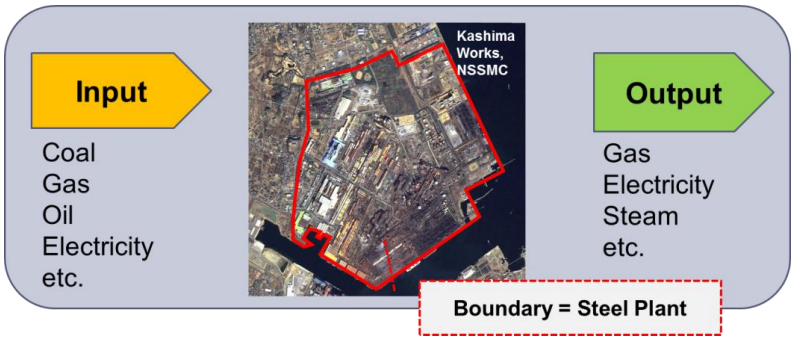
Table of Contents

1. Overview of ISO14404

The International Organization for Standardization (ISO) published a standardized method to calculate CO_2 emission intensity from iron and steel production in March 2013. This is the first standard in the world to define the sector-specific calculation method of CO_2 emission.

There are several features of ISO14404, but in short, **ISO14404 is a simple and universally applicable calculation method of CO_2 intensity from iron and steel production.** Here are the features of ISO14404;

Boundary ISO14404 defines the whole steel plant as CO_2 emission boundary. This type of boundary enables users to assess CO_2 performance regardless of the configuration of the site. Steel production processes are comprised of a lot of processes and include energy interchanges among the facilities in the site. **In order to optimize the energy use in the site, it is crucial to manage and evaluate the energy use as a whole steel plant, not by process-by-process basis.**



Calculation The calculation does not require any measurement hardware. Instead, **ISO14404 simply requires three kinds of used data that all the steel companies record regularly**;

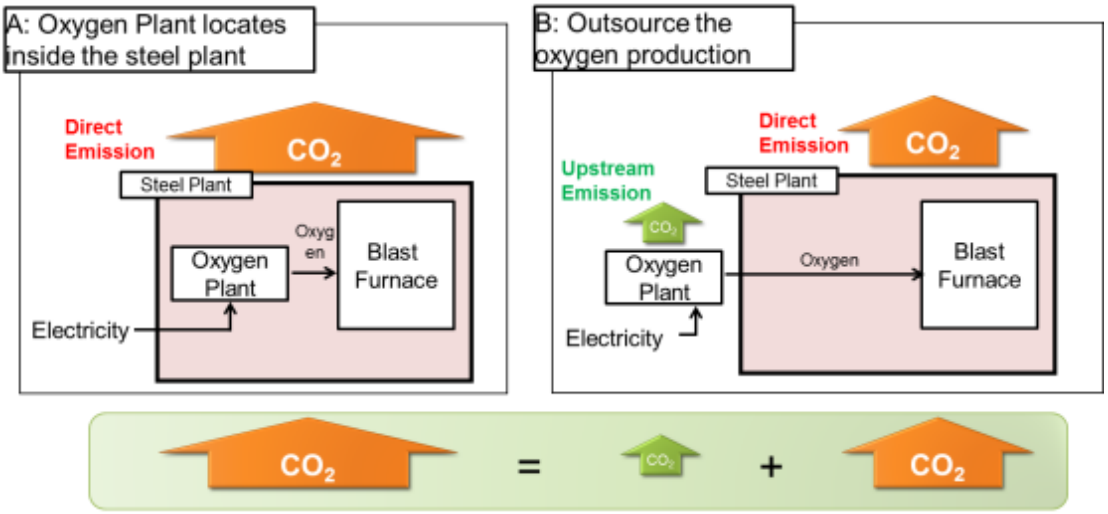
- **Input Data**: Energy source or materials which are supplied to the steel plant
- **Output Data**: Exported energy source, materials, electricity and steam
- **Crude steel production data**

CO_2 emission is calculated by multiplying energy consumption by CO_2 emission factor. By subtracting output CO_2 from input CO_2, total CO_2 emission in a whole plant is calculated. CO_2 intensity is calculated by dividing the total CO_2 emission by crude steel production. Energy conversion factors are also available to calculate total energy consumption and energy intensity.

Universal Conversion Factors **ISO14404 provides default conversion factors for each CO_2 emission source.** For electricity, ISO14404 applies a conversion factor that is equivalent to world average electricity since CO_2 emission factors of electricity depend on power supply composition of the area, which is not directly related to energy saving activities of the steel plant.

ISO14404 enables steel plants in the world to evaluate CO_2 intensity by a universally common indicator and thereby contributes to CO_2 emission reduction globally. Users are allowed to apply their own conversion factors if they are credible.

Upstream Concept ISO1440 applies three types of CO_2 emission sources – direct, credit and upstream. **Direct emission** is CO_2 emission from carbon content of the emission sources. **Credit emission** is CO_2 emission of sold materials, which will be exempted from the total CO_2 emission. ISO14404 also calculate CO_2 emission used to produce purchased materials, such as coke, oxygen etc. as "**upstream emission**". By applying upstream emission, CO_2 intensity relating to steel production is accurately evaluated regardless of quality of low material or site configuration, for example whether the plant owns oxygen plant or purchase oxygen.



2. ISO 14404 Calculation Tool

- Gap Analysis on Energy / CO_2 intensity -

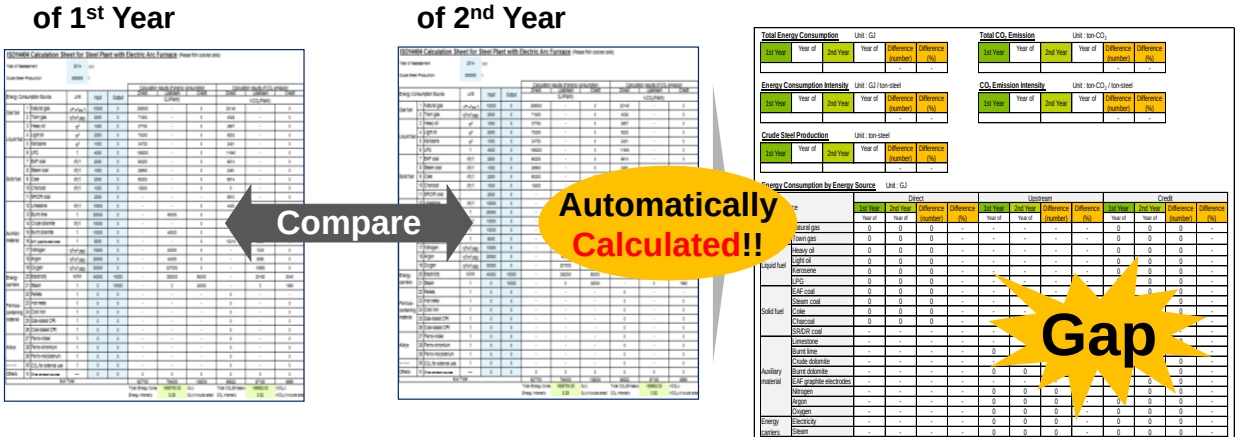
Gap Analysis illustrates timely changes of energy and CO_2 intensity, which helps users to **analyze the energy consumption trend and factors that affect to energy consumption and CO_2 emission**, such as operation ratio, production amount, production items, energy sources etc. By collecting monthly/annual data of energy consumption and CO_2 emission, **users will understand what triggers energy consumption variation and what kind of countermeasures will be effective**.

Overview

1 **Calculate Energy / CO_2 intensity of 1st Year**

2 **Calculate Energy / CO_2 intensity of 2nd Year**

3 **Analyze gap on Analysis Sheet**



Outcome

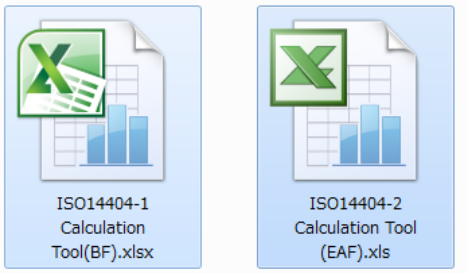
- ✓ **Data and information to conduct causal analysis on gap of energy / CO_2 intensity**
- ✓ **Data and information to assess energy saving performance**

Preparation

- **ISO14404 Calculation Tool**
- **Input Energy Data** Energy source or materials which are supplied to the steel plant
- **Output Energy Data** Energy carrier or products which are taken outside of the steel plant, such as for sales
- **Crude steel production**

1. Open ISO14404 Calculation Tool

Choose either ISO14404-1 type (BF) or ISO14404-2 type (EAF)

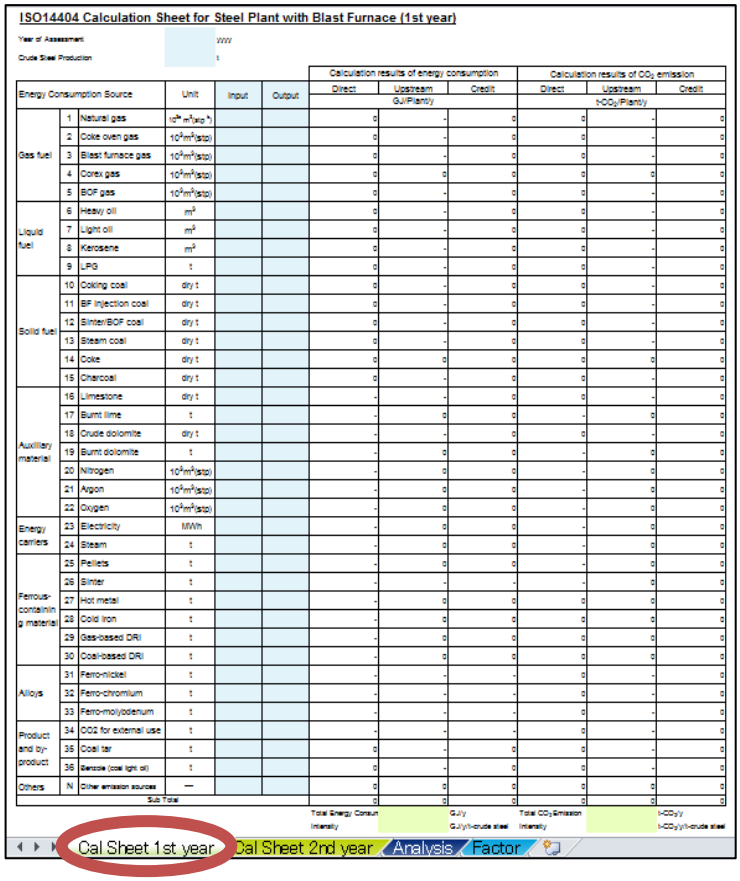


ISO14404-2 is not designed for EAF-DRI combination. ISO14404-3 (EAF-DRI) is to be developed in the near future.

ISO 14404 Calculation Tool includes four sheets

- **Cal Sheet 1st year** — Users fill in the data (input energy data, output energy data and crude steel production) in the sheet
- **Cal Sheet 2nd year** — Same as Cal Sheet 1st year
- **Analysis** — Result will be automatically shown in this sheet after the user fill in the data in Cal Sheet
- **Factor** — Emission Factors suggested in ISO14404 are already filled in this sheet for the automatic calculation. If users prefer to use their original emission factors, users need to insert their own emission factors.

2. Select "Cal Sheet 1st year"



ISO14404 Calculation Sheet for Steel Plant with Blast Furnace (1st year)

Year of Assessment: yyyy
Crude Steel Production: t

Energy Consumption Source			Unit	Input	Output	Calculation results of energy consumption			Calculation results of CO_2 emission		
						Direct	Upstream	Credit	Direct	Upstream	Credit
						GJ/Plant/y			t-CO_2/Plant/y		
Gas fuel	1	Natural gas	$10^3 m^3$(stp)			0	-	0	0	-	0
	2	Coke oven gas	$10^3 m^3$(stp)			0	-	0	0	-	0
	3	Blast furnace gas	$10^3 m^3$(stp)			0	-	0	0	-	0
	4	Corex gas	$10^3 m^3$(stp)			0	0	0	0	0	0
	5	BOF gas	$10^3 m^3$(stp)			0	-	0	0	-	0
Liquid fuel	6	Heavy oil	m^3			0	-	0	0	-	0
	7	Light oil	m^3			0	-	0	0	-	0
	8	Kerosene	m^3			0	-	0	0	-	0
	9	LPG	t			0	-	0	0	-	0
Solid fuel	10	Coking coal	dry t			0	-	0	0	-	0
	11	BF injection coal	dry t			0	-	0	0	-	0
	12	Sinter/BOF coal	dry t			0	-	0	0	-	0
	13	Steam coal	dry t			0	-	0	0	-	0
	14	Coke	dry t			0	0	0	0	0	0
	15	Charcoal	dry t			0	-	0	0	-	0
Auxiliary material	16	Limestone	dry t			-	-	0	0	-	0
	17	Burnt lime	t			-	0	0	-	0	0
	18	Crude dolomite	dry t			-	-	0	0	-	0
	19	Burnt dolomite	t			-	0	0	-	0	0
	20	Nitrogen	$10^3 m^3$(stp)			-	0	0	-	0	0
	21	Argon	$10^3 m^3$(stp)			-	0	0	-	0	0
	22	Oxygen	$10^3 m^3$(stp)			-	0	0	-	0	0
Energy carriers	23	Electricity	MWh			-	0	0	-	0	0
	24	Steam	t			-	0	0	-	0	0
Ferrous-containing material	25	Pellets	t			-	0	0	-	0	0
	26	Sinter	t			-	-	-	-	0	0
	27	Hot metal	t			-	0	0	0	0	0
	28	Cold iron	t			-	0	0	0	0	0
	29	Gas-based DRI	t			-	0	0	0	0	0
	30	Coal-based DRI	t			-	0	0	0	0	0
Alloys	31	Ferro-nickel	t			-	-	-	0	-	0
	32	Ferro-chromium	t			-	-	-	0	-	0
	33	Ferro-molybdenum	t			-	-	-	0	-	0
Product and by-product	34	CO2 for external use	t			-	-	-	0	-	0
	35	Coal tar	t			0	-	0	0	-	0
	36	Benzole (coal light oil)	t			0	-	0	0	-	0
Others	N	Other emission sources	—			0	0	0	0	0	0
Sub Total						0	0	0	0	0	0
						Total Energy Consumption	GJ/y		Total CO_2 Emission	t-CO_2/y	
						Intensity	GJ/y/t-crude steel		Intensity	t-CO_2/y/t-crude steel	

Cal Sheet 1st year | Cal Sheet 2nd year | Analysis | Factor

3. Fill in necessary information in “Cal Sheet 1st year”

ISO14404 Calculation Sheet for Steel Plant with Blast Furnace (Please fillin colored cells)

Year of Assessment	2012	yyyy
Crude Steel Production	7000000	t

Step1

Insert “Year of Assessment” and “Crude Steel Production

Energy Consumption Source			Unit	Input	Ou	Calculation results of CO_2 emission					
									Direct	Upstream	Credit
									t-CO_2/Plant/y		
Gas fuel	1	Natural gas	10^{3a} m^3(stp ^{b})	50,000					100700	-	0
	2	Coke oven gas	10^3m^3(stp)		80,000	0	-	1520000	0	-	78160
	3	Blast furnace gas	10^3m^3(stp)		100,000	0	-	330000	0	-	17000
	4	Corex gas	10^3m^3(stp)			0	0	0	0	0	0
	5	BOF gas	10^3m^3(stp)		10,000	0	-	84000	0	-	4320
Liquid fuel	6	Heavy oil	m^3	5,000		108500	-	0	14535	-	0
	7	Light oil	m^3	2,000			-	0	5202	-	0
	8	Kerosene	m^3	800						-	0
	9	LPG	t	3,000						-	0
Solid fuel	10	Coking coal	dry t	3,500,000						-	0
	11	BF injection coal	dry t	1,000,000						-	0
	12	Sinter/BOF coal	dry t	100,000						-	0
	13	Steam coal	dry t	600,000		15540000	-	0	1476600	-	0
	14	Coke	dry t	200,000		6020000	800000	0	651400	44800	0
	15	Charcoal	dry t			0	-	0	0	-	0
Auxiliary material	16	Limestone	dry t	1,500,000		-	-	0	660000	-	0
	17	Burnt lime	t	500,000		-	2250000	0	-	475000	0
	18	Crude dolomite	dry t	10,000		-	-	0	4710	-	0
	19	Burnt dolomite	t	20,000		-	90000	0	-	22000	0
	20	Nitrogen	10^3m^3(stp)	1,000,000	20,000	-	2000000	40000	-	103000	2060
	21	Argon	10^3m^3(stp)			-	0	0	-	0	0
	22	Oxygen	10^3m^3(stp)	800,000		-	5520000	0	-	284000	0
Energy carriers	23	Electricity	MWh	100,000	1,500,000	-	980000	14700000	-	50400	756000
	24	Steam	t		50,000	-	0	190000	-	0	9750
Ferrous-containing material	25	Pellets	t	1,000,000		-	2100000	0	-	137000	0
	26	Sinter	t			-	-	-	-	0	0
	27	Hot metal	t			-	0	0	0	0	0
	28	Cold iron	t			-	0	0	0	0	0
	29	Gas-based DRI	t			-	0	0	0	0	0
	30	Coal-based DRI	t			-	0	0	0	0	0
Alloys	31	Ferro-nickel	t			-	-	-	0	-	0
	32	Ferro-chromium	t			-	-	-	0	-	0
	33	Ferro-molybdenum	t			-	-	-	0	-	0
Product and by-product	34	CO2 for external use	t			-	-	-	0	-	0
	35	Coal tar	t		90,000	0	-	3330000	0	-	305010
	36	Benzole (coal light oil)	t		30,000	0	-	1217100	0	-	101460
Others	N	Other emission sources	—			0	0	0	0	0	0
Sub Total						170513360	13740000	21411100	16863986.8	1116200	1273760

Total Energy Consumption	162842260	GJ/y	Total CO_2 Emission	16706426.8	t-CO_2/y
Intensity	23.26	GJ/y/t-crude steel	Intensity	2.39	t-CO_2/y/t-crude steel

Step2

Insert "Energy & Material Input" and "Energy & Material Output" according to unit

Step3

Energy consumption / intensity and CO_2 emission / intensity of the steel plant will be automatically calculated

Here users obtain **Total CO_2 emission and intensity / Total energy consumption and intensity** by using ISO14404. If users have the data on single-year basis only, calculation ends here.

4. Select “Cal Sheet 2nd year” and fill in necessary information in “Cal Sheet 2nd year”

Required data is same as “Cal Sheet 1st year”

ISO14404 Calculation Sheet for Steel Plant with Blast Furnace (2nd year)

Year of Assessment	2013	yyyy
Crude Steel Production	6400000	t

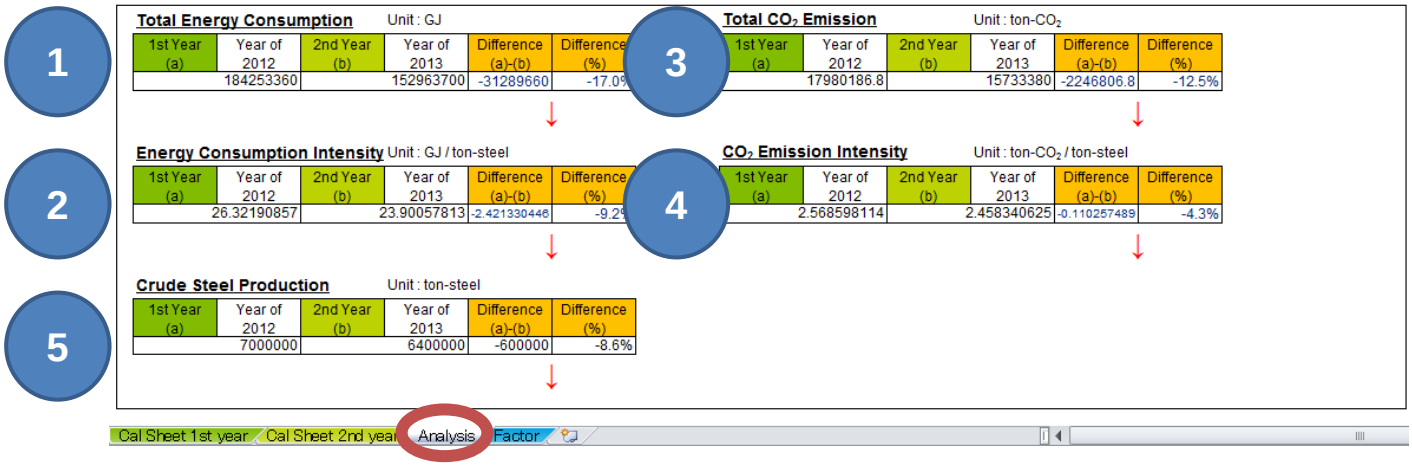
Different year

Energy Consumption Source			Unit	Input	Output	Calculation results of energy consumption			Calculation results of CO_2 emission		
						Direct	Upstream	Credit	Direct	Upstream	Credit
						GJ/Plant/y			t-CO_2/Plant/y		
Gas fuel	1	Natural gas	10^{3a} m^3(stp ^{b})	60,000		2154000	-	0	120840	-	0
	2	Coke oven gas	10^3m^3(stp)		50,000	0	-	950000	0	-	48850
	3	Blast furnace gas	10^3m^3(stp)		50,000	0	-	165000	0	-	8500
	4	Corex gas	10^3m^3(stp)			0	0	0	0	0	0
	5	BOF gas	10^3m^3(stp)		9,000	0	-	75600	0	-	3888
Liquid fuel	6	Heavy oil	m^3	4,000		150800	-	0	11628	-	0
	7	Light oil	m^3	3,000		105300	-	0	7803	-	0
	8	Kerosene	m^3	1,000		34700	-	0	2481	-	0
	9	LPG	t	3,000		141900	-	0	8955	-	0
Solid fuel	10	Coking coal	dry t	3,300,000		106260000	-	0	10094700	-	0
	11	BF injection coal	dry t	900,000		27990000	-	0	2659500	-	0
	12	Sinter/BOF coal	dry t	90,000		2637000	-	0	250560	-	0
	13	Steam coal	dry t	700,000		18130000	-	0	1722700	-	0
	14	Coke	dry t	150,000		4515000	600000	0	488550	33600	0
	15	Charcoal	dry t			0	-	0	0	-	0
Auxiliary material	16	Limestone	dry t	1,300,000		-	-	0	572000	-	0
	17	Burnt lime	t	450,000		-	2025000	0	-	427500	0
	18	Crude dolomite	dry t	11,000		-	-	0	5181	-	0
	19	Burnt dolomite	t	22,000		-	99000	0	-	24200	0
	20	Nitrogen	10^3m^3(stp)	1,200,000	40,000	-	2400000	80000	-	123600	4120
	21	Argon	10^3m^3(stp)			-	0	0	-	0	0
	22	Oxygen	10^3m^3(stp)	70,000		-	483000	0	-	24850	0
Energy carriers	23	Electricity	MWh	130,000	1,400,000	-	1274000	13720000	-	65520	705600
	24	Steam	t		30,000	-	0	114000	-	0	5850
Ferrous-containing material	25	Pellets	t	1,000,000		-	2100000	0	-	137000	0
	26	Sinter	t			-	-	-	-	0	0
	27	Hot metal	t			-	0	0	0	0	0
	28	Cold iron	t			-	0	0	0	0	0
	29	Gas-based DRI	t			-	0	0	0	0	0
	30	Coal-based DRI	t			-	0	0	0	0	0
Alloys	31	Ferro-nickel	t			-	-	-	0	-	0
	32	Ferro-chromium	t			-	-	-	0	-	0
	33	Ferro-molybdenum	t			-	-	-	0	-	0
Product and by-product	34	CO2 for external use	t			-	-	-	0	-	0
	35	Coal tar	t		60,000	0	-	2220000	0	-	203340
	36	Benzole (coal light oil)	t		20,000	0	-	811400	0	-	67640
Others	N	Other emission sources	—			0	0	0	0	0	0
Sub Total						162118700	8981000	18136000	15944898	836270	1047788

Total Energy Consumption	152963700	GJ/y	Total CO_2 Emission	15733380	t-CO_2/y
Intensity	23.90	GJ/y/t-crude steel	Intensity	2.46	t-CO_2/y/t-crude steel

5. Results of “Gap Analysis” will be automatically provided in “Analysis” sheet

“Gap Analysis” is conveyed for 5 items; Energy Consumption and Intensity, CO_2 Emission and Intensity and Crude Steel Production

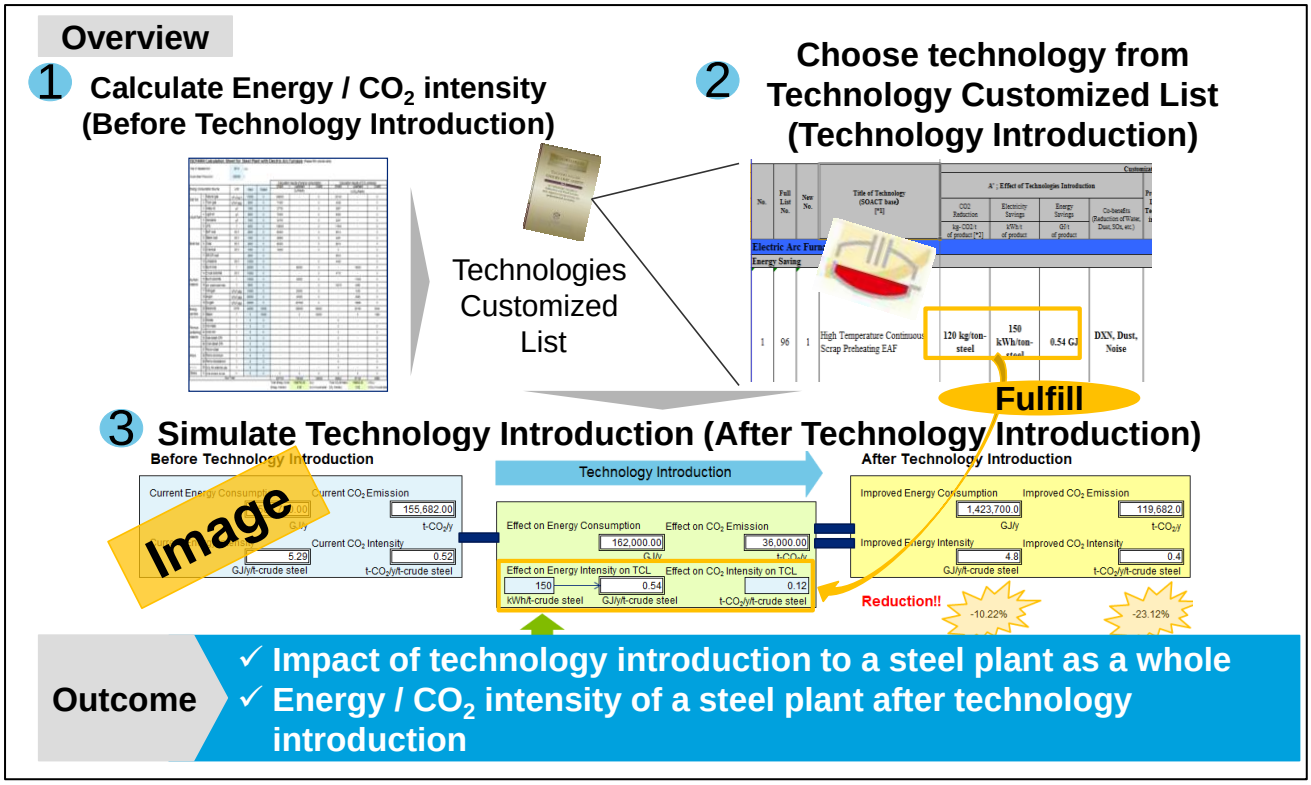


6. Analyze energy consumption trend and factors that affect to energy consumption and CO_2 emission

There are many factors that affect to energy consumption and CO_2 emission, such as operation ratio, production amount, production items, energy sources etc. By collecting monthly/annual data of energy consumption and CO_2 emission, **users will understand what triggers energy consumption variation and what kind of countermeasures will be effective**.

3. ISO14404 Technology Introduction Simulator

Users may consider applying energy saving technologies to enhance energy efficiency in a steel plant. In that case, **ISO14404 Technology Introduction Simulator** will be a great help. With this tool, users will be able to visualize an impact of effects of technology introduction at a steel plant.

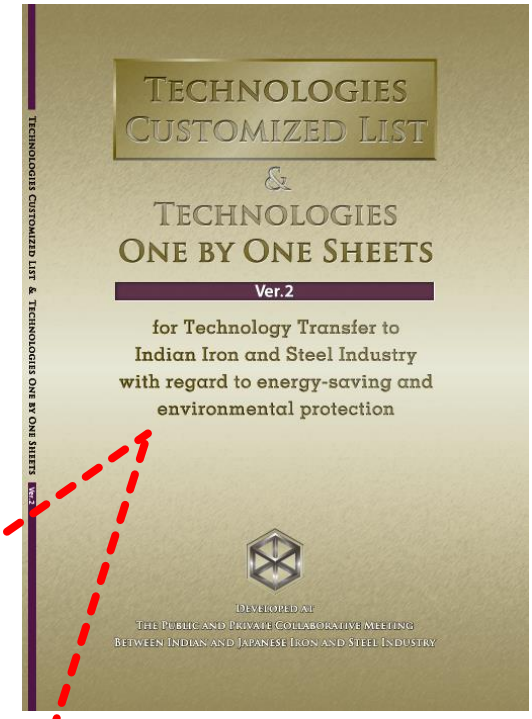


Preparation

- **ISO14404 Technology Introduction Simulator**
- **Technology References** such as **Technologies Customized List**
- **Reference value of input energy, output energy and crude steel production**

1. Choose an energy saving technology from technology references (ex. Technologies Customized List) and confirm energy saving and CO_2 reduction effect provided in the reference.

Example:
Technologies Customized List for India ver.2

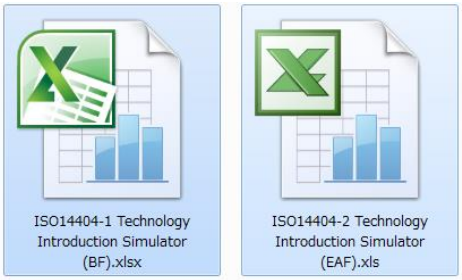


No.	Title of Technology	Customization Conditions for Indian Steel Industry																
		A ; Effect of Technologies Introduction				B ; Proficiency Level of Technology in Japan [*1]	C; Conditions in India [*2]											
		Electricity Savings	Fuel Savings	CO2 Reduction	Co-benefits		Diffusion Rate of Technology in 7 Major Steel Companies ,% [*4]	Needs for Technologies Introduction					Barrier against Technologies Introduction			Counter measures expected		
		kWh/t of product	GJ/t of product	kg- CO2/t of product				Electricity Saving	CO2 Reduction	Productivity	Quality	Water Saving	Financial	Technical	Retrofitting	Financial	Technical
10	Ecological and Economical Arc Furnace	**150 kWh/t-steel**	-	**135 /t-steel**	DXN, Dust, Noise	F	**0**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Energy saving potential is provided either as **kWh/t of product** or **GJ/t of product**

2. Open ISO14404 Technology Introduction Simulator

Choose either ISO14404-1 type (BF) or ISO14404-2 type (EAF)



ISO 14404 Calculation Tool includes three sheets

- **Cal Sheet** Users fill in the data (input energy, output energy and crude steel production) in this sheet
- **Simulation** Result will be automatically shown in this sheet after the user fill in the data in Cal Sheet
- **Factor** Emission Factors suggested in ISO14404 are already filled in this sheet for the automatic calculation. If users prefer to use their original emission factors, users need to insert their own emission factors.

3. Select “Cal Sheet”

4. Fill in necessary information in “Cal Sheet”

Same as “ISO14404 Calculation Tool” (page7)

ISO14404 Calculation Sheet for Steel Plant with Blast Furnace (Please fillin colored cells)

Year of Assessment	2012	yyyy
Crude Steel Production	7000000	t

Step1

Insert “Year of Assessment” and “Crude Steel Production

Energy Consumption Source			Unit	Input	Output	Calculation results of CO_2 emission					
									Direct	Upstream	Credit
									t-CO_2/Plant/y		
Gas fuel	1	Natural gas	10^{3a} m^3(stp ^{b})	50,000					100700	-	0
	2	Coke oven gas	10^3m^3(stp)		80,000	0	-	1520000	0	-	78160
	3	Blast furnace gas	10^3m^3(stp)		100,000	0	-	330000	0	-	17000
	4	Corex gas	10^3m^3(stp)			0	0	0	0	0	0
	5	BOF gas	10^3m^3(stp)		10,000	0	-	84000	0	-	4320
Liquid fuel	6	Heavy oil	m^3	5,000		[illegible]	-	0	14535	-	0
	7	Light oil	m^3	2,000			-	0	5202	-	0
	8	Kerosene	m^3	800						-	0
	9	LPG	t	3,000						-	0
Solid fuel	10	Coking coal	dry t	3,500,000						-	0
	11	BF injection coal	dry t	1,000,000						-	0
	12	Sinter/BOF coal	dry t	100,000						-	0
	13	Steam coal	dry t	600,000		15540000	-	0	1476600	-	0
	14	Coke	dry t	200,000		6020000	800000	0	651400	44800	0
	15	Charcoal	dry t			0	-	0	0	-	0
Auxiliary material	16	Limestone	dry t	1,500,000		-	-	0	660000	-	0
	17	Burnt lime	t	500,000		-	2250000	0	-	475000	0
	18	Crude dolomite	dry t	10,000		-	-	0	4710	-	0
	19	Burnt dolomite	t	20,000		-	90000	0	-	22000	0
	20	Nitrogen	10^3m^3(stp)	1,000,000	20,000	-	2000000	40000	-	103000	2060
	21	Argon	10^3m^3(stp)			-	0	0	-	0	0
	22	Oxygen	10^3m^3(stp)	800,000		-	5520000	0	-	284000	0
Energy carriers	23	Electricity	MWh	100,000	1,500,000	-	980000	14700000	-	50400	756000
	24	Steam	t		50,000	-	0	190000	-	0	9750
Ferrous-containing material	25	Pellets	t	1,000,000		-	2100000	0	-	137000	0
	26	Sinter	t			-	-	-	-	0	0
	27	Hot metal	t			-	0	0	0	0	0
	28	Cold iron	t			-	0	0	0	0	0
	29	Gas-based DRI	t			-	0	0	0	0	0
	30	Coal-based DRI	t			-	0	0	0	0	0
Alloys	31	Ferro-nickel	t			-	-	-	0	-	0
	32	Ferro-chromium	t			-	-	-	0	-	0
	33	Ferro-molybdenum	t			-	-	-	0	-	0
Product and by-product	34	CO2 for external use	t			-	-	-	0	-	0
	35	Coal tar	t		90,000	0	-	3330000	0	-	305010
	36	Benzole (coal light oil)	t		30,000	0	-	1217100	0	-	101460
Others	N	Other emission sources	—			0	0	0	0	0	0
Sub Total						170513360	13740000	21411100	16863986.8	1116200	1273760

Step2

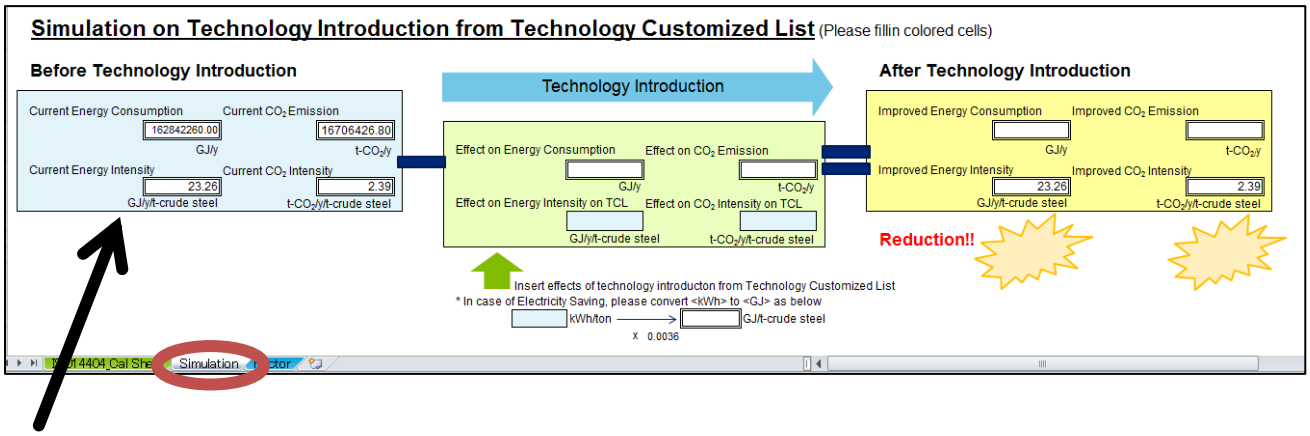
Insert "Energy & Material Input" and "Energy & Material Output" according to unit

Total Energy Consumption	162842260	GJ/y	Total CO_2 Emission	16706426.8 t-CO_2/y
Intensity	23.26	GJ/y/t-crude steel	Intensity	2.39 t-CO_2/y/t-crude steel

Step3

Energy consumption / intensity and CO_2 emission / intensity of the steel plant will be automatically calculated

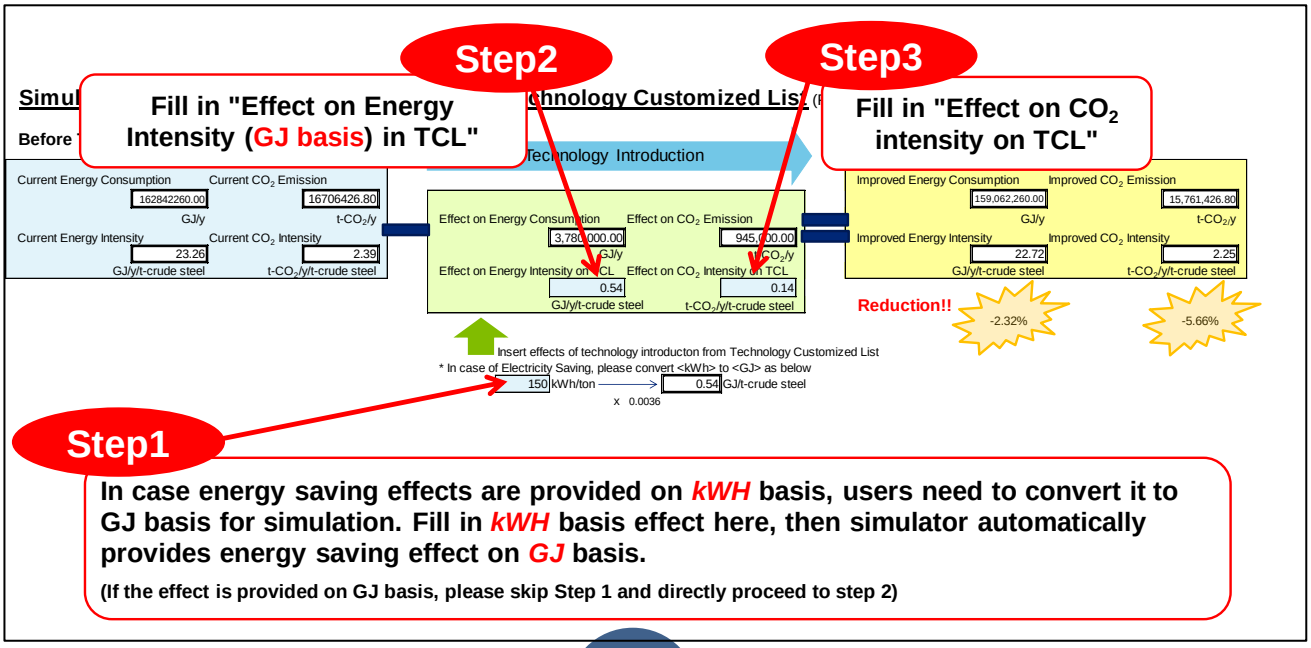
5. Open “Simulation” sheet



After users fill in the data in “ISO14404 Cal Sheet”, data are automatically reflected to “Before Technology Introduction”.

6. Fill in energy saving effect provided in the technology reference (also refer to page 11)

No.	Title of Technology	Customization Conditions for Indian Steel Industry														
		A ; Effect of Technologies Introduction				B ; Proficiency Level of Technology in Japan [*1]	C; Conditions in India [*2]									
		Electricity Savings	Fuel Savings	CO2 Reduction	Co-benefits		Diffusion Rate of Technology in 7 Major Steel Companies ,% [*4]	Needs for Technologies Introduction					Barrier against Technologies Introduction			Counter measures expected	
		kWh/t of product	GJ/t of product	kg- CO2/t of product				Electricity Saving	CO2 Reduction	Productivity	Quality	Water Saving	Financial	Technical	Retrofitting	Financial	Technical
10	Ecological and Economical Arc Furnace	**150 kWh/t-steel**	-	**135 /t-steel**	DXN, Dust, Noise	F	**0**	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA



7. Results of “Gap Analysis” will be automatically provided in “Analysis” sheet