Activities of Japanese Steel Industry to Combat Global Warming

Report of "JISF's Commitment to a Low Carbon Society"

February 2018

The Japan Iron and Steel Federation

Index

On February 20, 2014, JISF became the first industry association in the world to receive ISO50001 certification (energy management system). This certification recognizes measures to combat global warming in the Voluntary Action Plan/Commitment to a Low Carbon Society as well as activities for conserving energy.

QUALITY ASSURANCE
JIC
REGISTERED ORGANIZATION
No. N001-ISO 50001

登録証

一般社団法人 日本鉄鋼連盟

東京都中央区日本橋茅場町３－２－１０ 鉄鋼会館内

ISO 50001:2011/JIS Q 50001:2011

N001

2014年 2月20日

2014年 5月29日

2017年 2月19日

日本検査キューエイ株式会社

高崎 誠

JICQA

Certificate of Registration

This is to certify that
the Energy Management System of

The Japan Iron and Steel Federation

3-2-10, Nihonbashi-Kayaba-cho, Chuo-ku, Tokyo, Japan

having been assessed by JIC Quality Assurance Ltd.,
conforms to the requirements of applicable standard:

ISO 50001:2011/JIS Q 50001:2011

Scope of Certification:
JISF's energy management based on the energy use for producing steel products by the companies which participate in JISF's Voluntary Action Plan, represented by the following main processes
- Establishment and following up of the Energy Policy by JISF's Executive Board Meeting
- Analysis of the energy data and planning and following up the Voluntary Action Plan by JISF's Energy and Technology Committee
- Survey, calculation, and examination of the energy data through a person in charge of investigation of the energy data in each company which participates in JISF's Voluntary Action Plan
[JISF: The Japan Iron and Steel Federation]

Certification No.: N001
Date of Certification: February 20, 2014
Date of Revision: May 29, 2014
Date of Expiry: February 19, 2017

JIC Quality Assurance Ltd.

JICQA

Initial registration: February 20, 2014
Extension: February 2, 2017

0. FY2020 Targets (reexamined in FY 2016)

Reexamination of Stance for Targets Established in FY2017

In FY2017, the following reexamination took place concerning the eco process target in the JISF's Commitment to a Low Carbon Society. An explanation of this reexamination was given at the steel working group and the Keidanren third-party evaluation committee.

Eco Process Before reexamination

The target is a CO_2 emission reduction of 5 million tons by FY2020 vs. expected emissions for each production volume (BAU) by fully implementing state-of-the-art technologies.

Interim- Review

1. **Properly determine BAU by reflecting changes in steel production mix**
2. **Include actual emission reductions resulting from the use of waste plastics and other recycled materials**

Eco Process After reexamination

The target is a CO_2 emission reduction of 5 million tons by FY2020 vs. expected emissions for each production volume (BAU) by fully implementing state-of-the-art technologies. Of this reduction, JISF prioritizes 3 million tons of reduction arising from energy conservation and other voluntary actions by steelmakers. For waste plastics and other recycled materials, the emission reduction includes only a decrease resulting from the increase in the volume of these materials collected vs. the FY2005 level.

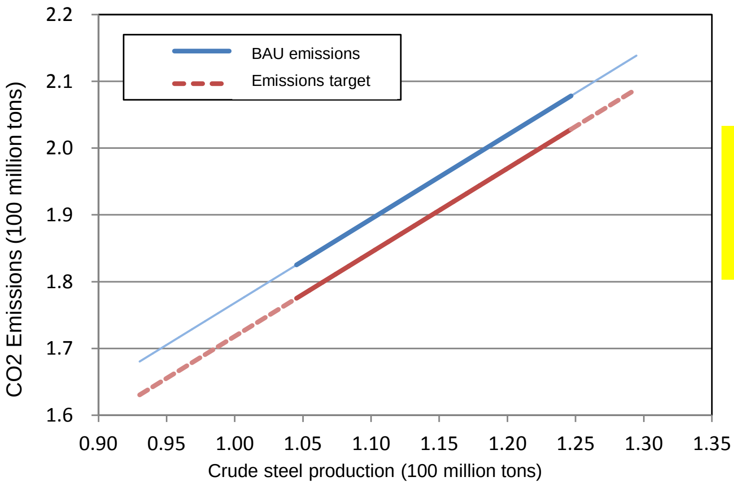
Reexamination of BAU by reflecting changes in steel production mix (1)

- Up to FY2014, the JISF's Commitment to a Low Carbon Society used evaluations with a BAU line (left graph) incorporating the assumption that the FY2005 production mix will not change.
- Currently, changes are taking place in the production mix. For example, as Japanese steelmakers move production to Southeast Asia and other overseas locations, the shift of some final production processes has raised the percentage of intermediate products (such as hot-rolled sheets). Also, the percentages of some finished products (such as galvanized sheets) are decreasing. Pig iron production has increased in proportion to these changes and CO_2 emissions are rising as a result.
- Incorporating these changes was not possible with the previous BAU line. Consequently, the change in CO_2 associated with the production mix change was calculated by using the production mix index produced by RITE (the RITE index). Starting in FY2015, emissions have been evaluated by using the adjusted BAU line, which incorporates the BAU line.

Until FY2014

Assumes no change in production mix from FY2005 level

BAU and Target Lines (before production mix index adjustment)



* This target assumes that Japan's crude steel output will be 120 million tons, with a variance of no more than 10 million tons.

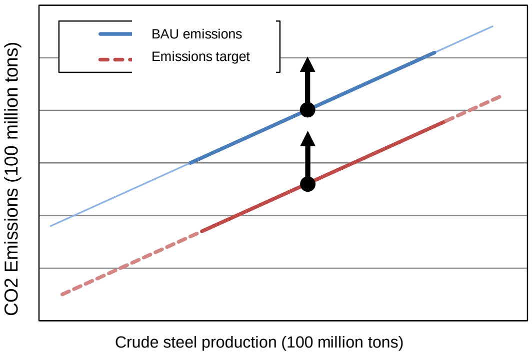
* The colored sections of the graphs on this page show the range of production at companies participating in the Commitment to a Low Carbon Society when Japan's crude steel output is between 110 million and 130 million tons.

Used for FY2016

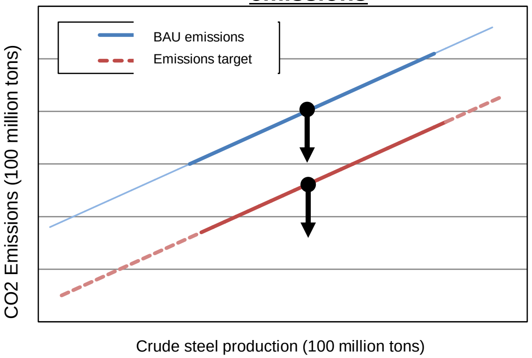
Since FY2015

Adjusted to reflect production mix change since FY2005

When production mix change increases CO_2 emissions



When production mix change reduces CO_2 emissions



Reexamination of BAU by reflecting changes in steel production mix (2)

- When determining the RITE index, the total change in CO_2 emissions caused by a production mix change is evaluated by adding the changes in emissions associated with a change in the pig iron ratio for upstream processes and a change in the product mix for downstream processes.
- The BAU line uses a production mix that remains the same as in FY2005. As a result, it is possible to perform a proper evaluation with the BAU line in which the changes in the production mix are incorporated by shifting the line according to the changes.

Share of Pig Iron (Upstream processes)

	2005	2015	2016	16-05	16/05 (%)	16-15	16/15 (%)
Crude steel (1000t)	112,718	104,229	105,166	-7,551	-6.7	937	0.9
BF-BOF (1000t)	83,645	80,647	81,294	-2,352	-2.8	646	0.8
EAF(1000t)	28,595	23,263	23,545	-5,051	-17.7	282	1.2
Pig Iron (1000t)	82,937	80,535	79,829	-3,107	-3.7	-705	-0.9
BF-BOF (%)	74.2	77.4	77.3	3.1	-	-0	-
EAF (%)	25.4	22.3	22.4	-3.0	-	0	-
Pig Iron (%)	73.6	77.3	75.9	2.3	-	-1	-

- An increase of 2.3 percentage point in pig iron's share from FY2005 to FY2016

Share of Long and Flat Products (Downstream processes)

		2005	2015	2016	16-05	15-15
		ratio (%)	ratio (%)	ratio (%)		
Long	Shape	7.5	6.8	6.8	-0.9	-0.2
	Bar	12.3	9.9	9.8	-2.5	-0.1
	total	**23.5**	**20.0**	**19.8**	**-3.6**	**-0.2**
Flat	Plate	11.3	10.4	10.2	-1.1	-0.1
	HRS	11.3	19.7	19.3	8.0	-0.3
	Cold-rolled flat products	8.6	7.8	7.9	-0.8	0.1
	Galvanized sheet	14.6	12.3	12.5	-2.1	0.2
	total	**46.3**	**50.7**	**50.5**	**4.2**	**-0.2**

- Between FY2005 and FY2016 the share of long products decreased and the share of flat products increased.
- In flat products, HRS (hot-rolled strips) increased and cold-rolled flat products and galvanized sheets decreased.

CO_2 conversions using the RITE index to incorporate the above changes

Upstream: +3.370 $mmtCO_2$

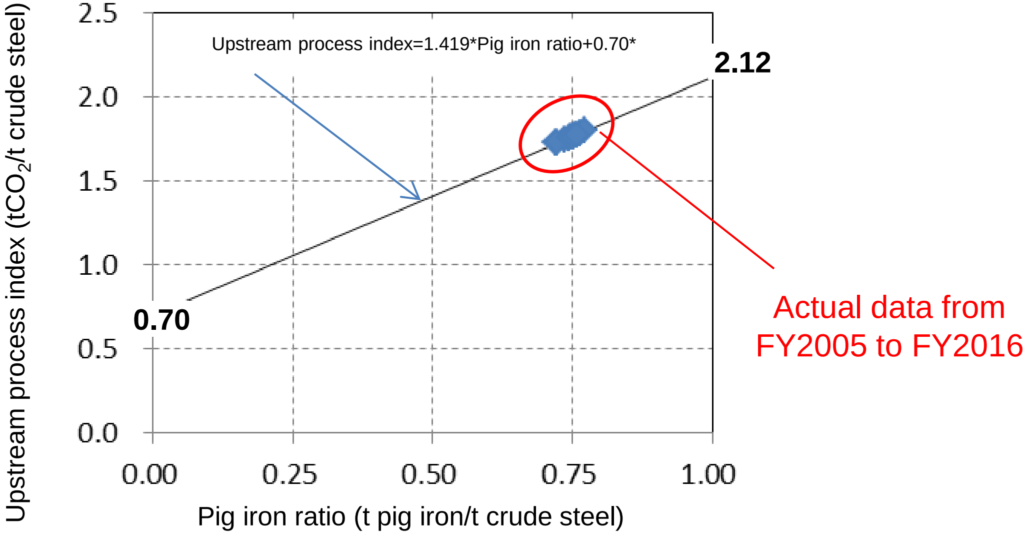
Downstream: -1.944 mmt-CO_2

Total: +1.426 mmt-CO_2

Summary of the Upstream Process Index

- Crude steel is made by reducing natural resources to make pig iron or by using steel scrap that has already been reduced. The pig iron ratio is the amount of pig iron produced in relation to the production of crude steel (pig iron output divided by crude steel output). Variations in this ratio also affect unit CO_2 emissions.
- To evaluate this effect properly, a primary coefficient is established that includes (1) comprehensive energy statistics, (2) IEA energy balance table, (3) environmental reports of steelmakers, (4) international peer-reviewed papers and other items.
- The number obtained by using this primary coefficient is the upstream process index. The formula is: y (Upstream index) = 1.419 x (Pig iron ratio) +0.70.
- Changes in CO_2 emissions caused by changes in the pig iron ratio are calculated multiplying the difference between the upstream process index for FY2005 and each subsequent year by crude steel output.

Relationship between Pig Iron Ratio and Upstream Process Index



* This equation incorporates (1) comprehensive energy statistics, (2) IEA energy balance table, (3) environmental reports of steelmakers, (4) international peer-review papers and other items.

Actual data (FY2005 and FY2016)

	Pig iron ratio	Upstream process index
FY2005	0.736	1.743
･ ･ ･	･ ･ ･	･ ･ ･
FY2016	0.759	1.776

FY2005: 1.419×0.736+0.70=1.743
FY2016: 1.419×0.759+0.70=1.776

Change in CO_2 emissions due to change in pig iron ratio (FY2016)

(1.776-1.743)×101.95mnt = 3.37mnt
⇒Assessed as a 3.37 million ton increase in CO_2 emissions

Summary of the Downstream Process Index

Unit CO_2 emissions per ton of production* have been established for different shapes of ordinary steel and types of specialty steel, a total of 35 product categories, for which general statistics are accessible. Using FY2005 as the reference year, the change in CO_2 emissions caused by the change in the production mix in each year is then calculated. This calculation is performed as follows.

A. The product mix ratio for each steel product in each year (Table 1) and unit CO_2 emissions (Table 2) are multiplied (Table 3).

B. All the numbers obtained from the step A are added (which yields a composite unit emission value weighted for the production mix): 0.846 in FY2005 and 0.827 in FY2016 in the table below

C. Multiply the difference between the composite unit emission value for the year being evaluated and the reference year (FY2005), which is the composite unit emission difference) and crude steel output (convert the unit difference into a total volume).

For FY2016: (0.827-0.846) x 101.95mnt = -1.94mnt

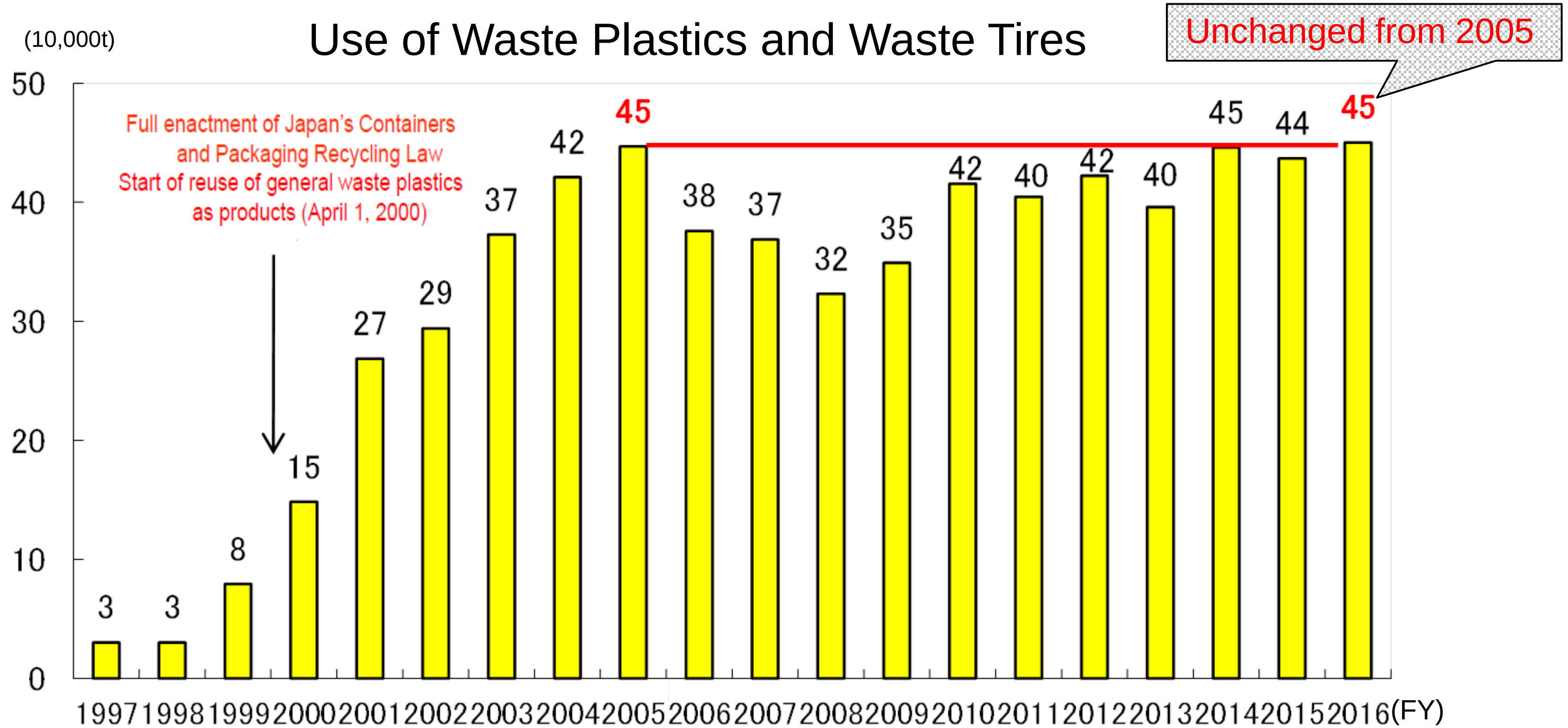
*Unit CO_2 emissions for each steel product category for all years are based on the worldsteel LCI data collection. Averages for Japan calculated by using actual FY2014 data are used when available for these products. For products where there is no Japan average, unit emissions are estimated by using the relationship between unit emissions for steel for which Japan averages exist and selling prices (FY2010 export prices using trade statistics).

		Steel bars	Hot-rolled strips	Cold-rolled sheets	Galvanized sheets	......	Total
Product mix ratio (1)	FY2005	12.3%	9.9%	6.6%	12.0%		100%
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	FY2016	9.8%	16.9%	6.4%	9.8%		100%
Unit CO_2 emissions per ton of production (2) (common figures)		0.73	0.67	0.71	0.96		—
(3) = (1) x (2)	FY2005	0.09	0.07	0.05	0.11		0.846
	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	FY2016	0.07	0.11	0.05	0.09		0.827

A composite unit emission figure that reflects the product mix in each year

Include actual emission reductions resulting from the use of waste plastics and other recycled materials

- Assuming that the government establishes collection systems, JISF was aiming for a CO_2 emission reduction of 2 million tons by increasing the use of chemical recycling (waste plastics, etc.) to 1 million tons at steel mills.
- The May 2016 Report on the Assessment and Study of Implementation of a Container and Packaging Recycling System established the policy of maintaining the 50% material recycling priority and the review resulted the goal of reaching this target in five years.
- Due to the current level of recycling, achieving the FY2020 goal of increasing the use of used plastics and other recycled materials to 1 million tons will be almost impossible. Consequently, only the amount of the increase in the collection of waste plastics and other recycled materials in relation to the FY2005 level is included in the reduction in CO_2 emissions.



Source: The Japan Iron and Steel Federation

JISF's Commitment to a Low Carbon Society - Phase I

Japanese steel industry is supporting the Commitment to a Low Carbon Society by fighting global warming with the "three ecos" created during the Voluntary Action Plan along with COURSE50.

2020←2013

Eco Process

The target is a CO_2 emission reduction of 5 million tons by FY2020 vs. expected emissions for each production volume (BAU) by fully implementing state-of-the-art technologies. Of this reduction, JISF prioritizes 3 million tons of reduction arising from energy conservation and other voluntary actions by steelmakers. For waste plastics and other recycled materials, the emission reduction includes only a decrease resulting from the increase in the volume of these materials collected vs. the FY2005 level.

Eco Solution

Contribute worldwide by transferring the world's most advanced energy-saving technologies to other countries (especially to developing countries)and increasing the use of these technologies. (Estimated emission reduction contribution of about 70 million tons in FY2020)

Eco Product

By supplying the high-performance steel that is essential to create a low-carbon society, contribute to lowering emissions when finished products using this steel are used (Estimated emission reduction contribution of about 34 million tons in FY2020)

2050←

Development of revolutionary steelmaking processes (COURSE50)

Cut CO_2 emissions from production processes about 30% by using hydrogen for iron ore reduction and collecting CO_2 from blast furnace gas. The first production unit is to begin operations by about 2030*. Goal is widespread use of these processes by about 2050 in line with timing of updates of existing blast furnace facilities.

* Assumes establishment of economic basis for CO_2 storage infrastructure and creation of a practical unit using these processes.

1. Eco Process

FY2016 Results of JISF's Commitment to a Low Carbon Society

Progress toward targets *Totals for companies participating in the Commitment to a Low Carbon Society

- Crude steel production: 101.95 million tons (down 5.7% from FY05)
- BAU emissions for FY16 crude steel production: 182.06 million tons of CO_2 - (1)
- CO_2 emissions (using FY05 electricity coefficient): 179.60 million tons (down 4.7% from FY05) - (2)
- Reduction vs. BAU ((1) – (2)): 2.46 million tons of CO_2 (540,000 tons above the target)

FY2016 Energy Consumption and CO_2 Emissions

- Energy consumption: 2,172PJ (down 5.1% from FY05)
- CO_2 emissions (using electricity coefficient with FY16 credit): 182.57 million tons (down 3.1% from FY05)

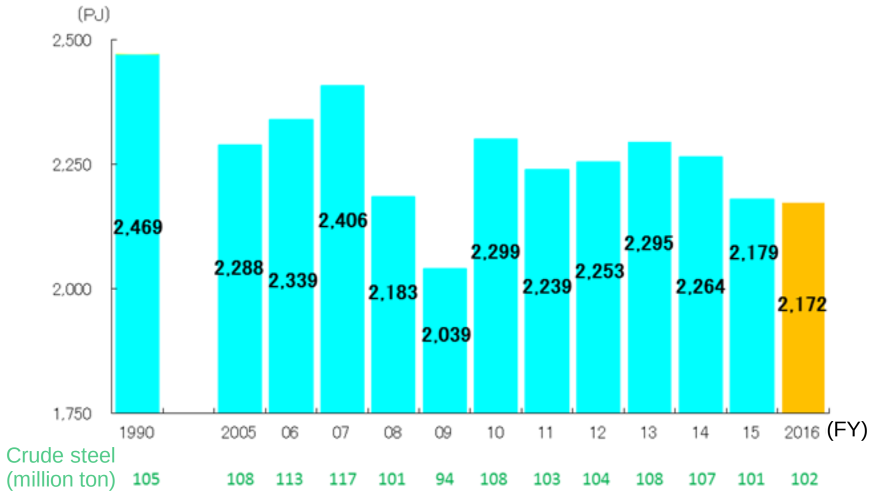
Reference: Japanese steel industry total

- Crude steel production: 105.17 million tons (down 4.7% from FY05)
- Energy consumption: 2,241PJ (down 5.1% from FY05)
- CO_2 emissions (using electricity coefficient with FY16 credit): 186.75 million tons (down 3.0% from FY05)

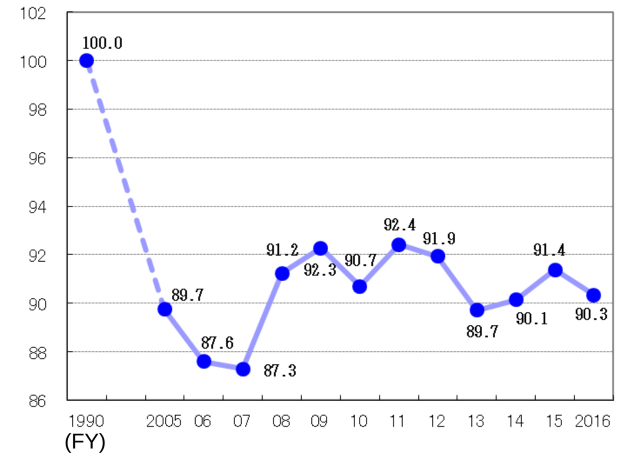
* Energy consumption and CO_2 emissions for the Japanese steel industry are estimates based on statistics for the use of petroleum and other energy sources.

Annual Trend of Energy Consumption and CO_2 Emissions

Total Energy Consumption

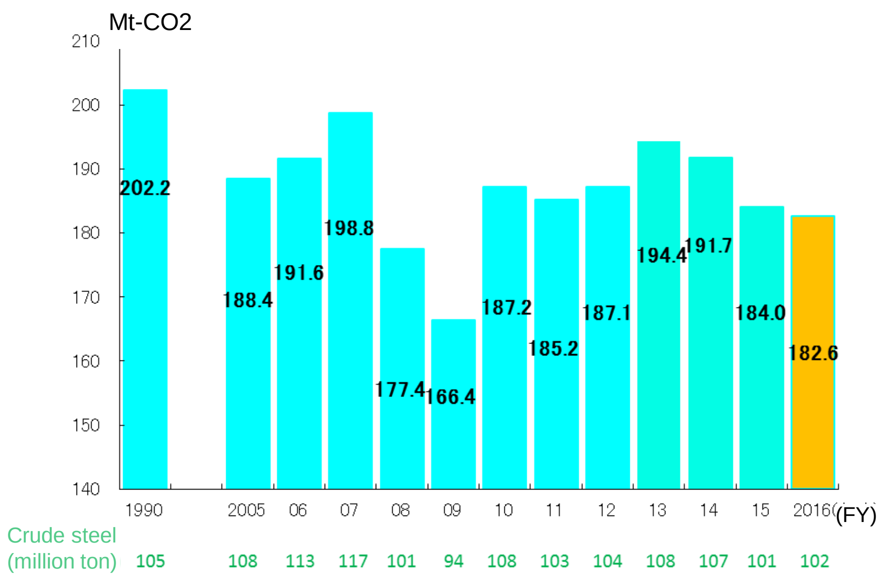


Unit Energy Consumption (FY1990 level=100)



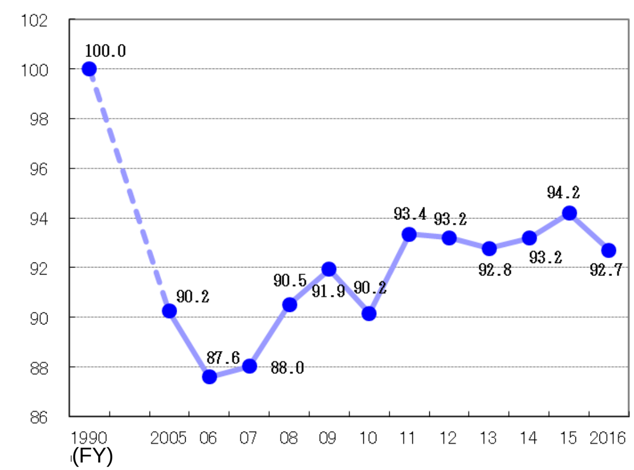
CO_2 Emissions from Fuel Combustion

(Incorporate improvement by emission credit)



Unit CO_2 Emissions (FY1990 level=100)

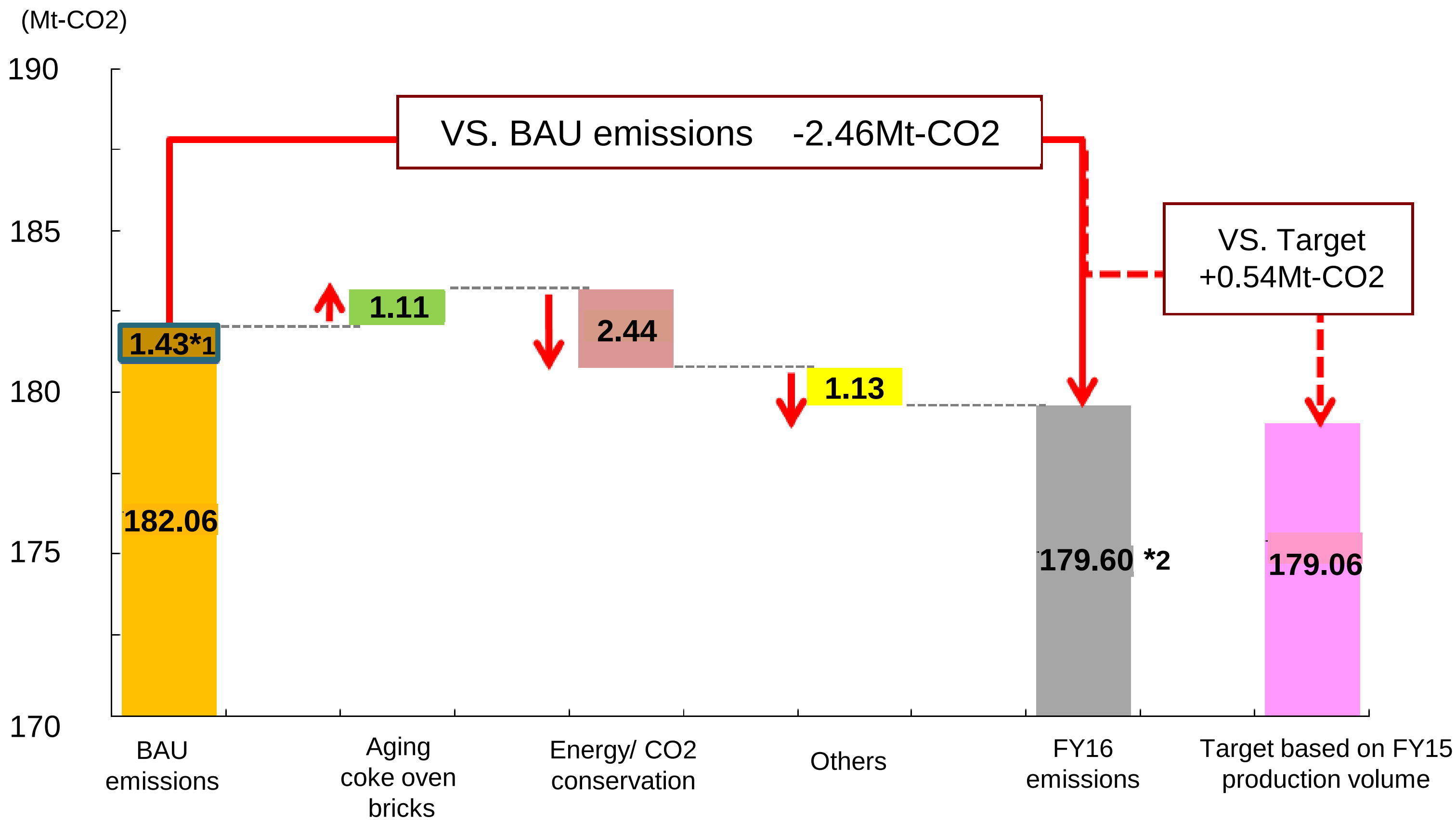
(Incorporate improvement by emission credit)



*PJ is a petajoule (10^{15} joules). One joule is 0.23889 calories. 1PJ is equivalent to about 2.58 million kiloliters of crude oil.

Components of Changes in FY2016 CO_2 Emissions

- In FY2016, CO_2 emissions were 2.46 million tons below the BAU level. Energy and CO_2 conservation measures cut emissions by 2.44 million tons, aging bricks in coke ovens raised emissions by 1.11 million tons, and other measures cut emissions by 1.13 million tons.
- 0.54 million tons below the target.



*1 182.06 Mt-CO2 BAU emissions have been adjusted by 1.43 Mt-CO2 using RITE index.

*2 FY2016 CO_2 emissions use the FY2005 electricity coefficient.

Evaluation of FY2016 Performance

- Despite a number of factors unforeseen when targets were established, the emissions continued to decrease steadily in FY2016 as numerous voluntary actions took effect.

1. Progress with measures incorporated in the target

	Expected target	FY2016	
(1) Reductions from energy saving actions ● Higher coke oven efficiency ● More efficient power generation ● More energy conservation	-3.00Mt	-2.44Mt	• Progress of about 80% toward the target between FY05-FY16 (12 years)
(2) Increase use of waste plastics and other recycled materials	—	0.00Mt	• Reported as zero since the volume collected in 2016 remained unchanged compared to 2005.

2. Factors affecting emissions that were unforeseen when targets were established

	Expected target	FY2016	
Aging coke oven bricks	—	+1.11Mt	• Aging coke oven bricks caused unit energy consumption to climb. Probable causes are the aging of bricks (especially significant in ovens above a certain age) and the impact of the Tohoku earthquake and tsunami of 2011. • JISF member companies have started replacing coke oven bricks.
Other issues	—	-1.13Mt	• Difficult to analyze causes, but one probable cause is efforts by operational improvement in steel mills.
Total	Not included	-0.02Mt	

VS. adjusted BAU emissions: 2.46 Mt (0.54Mt below the target)

Coke Oven Updates

- JISF member companies have started replacing aging bricks in coke ovens, which is one cause of the increase in CO_2 emissions. Improvements at six coke ovens were already completed during Phase I of the Commitment to a Low Carbon Society.
- As shown below, although work has started, it will not be possible to update all coke ovens quickly because of the limited availability of workers (coke oven construction specialists) and the high cost of updates (tens of billions of yen for each oven).

JISF Member Company Coke Oven Update Plans (Company and newspaper announcements as of February 2018)

(1) Completed Updating Projects (6 ovens as of Feb. ’18)

Year	Steel works	Cost
FY2013	JFE Steel, West Japan Works, Kurashiki	About ¥15 billion
FY2015	JFE Steel, West Japan Works, Kurashiki	About ¥20 billion
FY2016	Nippon Steel & Sumitomo Metal, Kashima Works	About ¥18 billion
	JFE Steel, East Japan Works, Chiba	
	Nippon Steel & Sumitomo Metal, Kimitsu Works	About ¥29 billion
FY2017	JFE Steel, West Japan Works, Kurashiki	About ¥18.4 billion

(2) Planned Updating Projects (6 ovens as of Feb. ’18)

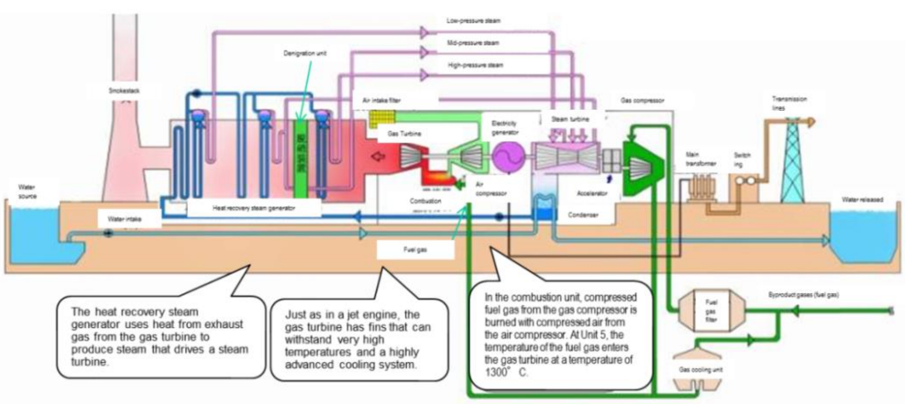
Year	Steel works	Cost
FY2018	Nippon Steel & Sumitomo Metal, Kashima Works	About ¥31 billion
	Nippon Steel & Sumitomo Metal, Kimitsu Works	About ¥33 billion
	JFE Steel, East Japan Works, Chiba	
FY2019	Nippon Steel & Sumitomo Metal, Muroran Works	About ¥13 billion
	JFE Steel, West Japan Works, Fukuyama	About ¥27 billion
FY2021	JFE Steel, West Japan Works, Fukuyama	

Major Initiatives implemented or planned since FY2005

1. Next-generation coke oven (SCOPE21)
Nippon Steel & Sumitomo Metal Oita Works (2008)
Nippon Steel & Sumitomo Metal Nagoya Works (2013)

2. More efficient power
Kobe Steel Kakogawa Station No. 1 Gas turbine combined cycle unit (2011)
Kimitsu Joint Thermal Station No. 6 Advanced combined cycle unit (2012)
Kashima Joint Thermal Station No. 5 Advanced combined cycle unit (2013)
Wakayama Joint Thermal Station No. 1 Advanced combined cycle unit (2014)
Oita Joint Thermal Station No. 3 Advanced combined cycle unit (2015)
Kobe Steel Kakogawa Station No. 2 Gas turbine combined cycle unit (2015)
JFE Steel Chiba Station West-No. 4 Gas turbine combined cycle unit (2015)
Nisshin Steel Kure Power Station No. 6 Boiler, turbine and generator (planned for 2017)
JFE Steel Ohgishima Thermal Station No. 1 Gas turbine combined cycle (planned for 2019)
Fukuyama Joint Thermal Station No. 2 Gas turbine combined cycle (planned for 2020, assessment under way)

Advanced Combined Cycle Power Generation



Source: Kimitsu Cooperative Thermal Power Company, Inc.

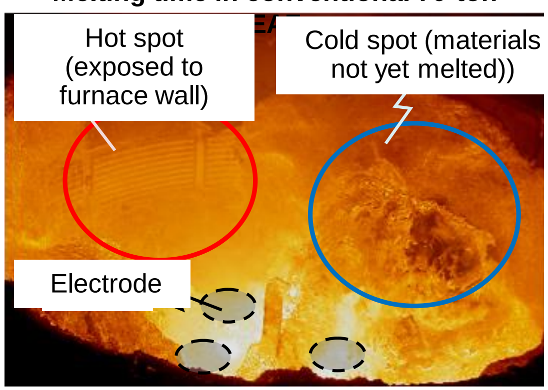
Energy Conservation in Electric Arc Furnace (EAF)

- As part of measures to streamline steel production, Daido Steel constructed and began operating in November 2013 a large EAF at its Chita Plant with technologies to achieve the highest possible uniformity of scrap melting. The new furnace raised capacity from 70 to 150 tons.
- Three-phase AC EAFs normally require three electrodes. Melting can be uneven due to differences in how far each electrode is from the furnace wall. To solve this problem, most companies place an auxiliary burner in locations far from electrodes (cold spots).
- Although burners improve melting performance, unit energy consumption is higher and flame rebound damages the furnace, which boosts maintenance expenses. Daido developed a rotating EAF that uses the spinning motion to move cold spots closer to the electrodes. This dramatically improves melting uniformity and cuts the amount of energy required.

EAF Problems

- Triangular configuration of three electrodes in a round furnace results in different electrode-wall distances
- Materials near electrodes (hot spots) melt before materials farther from electrodes (cold spots). This causes a big energy loss in hot spots if the furnace continues to operate.

Melting time in conventional 70-ton

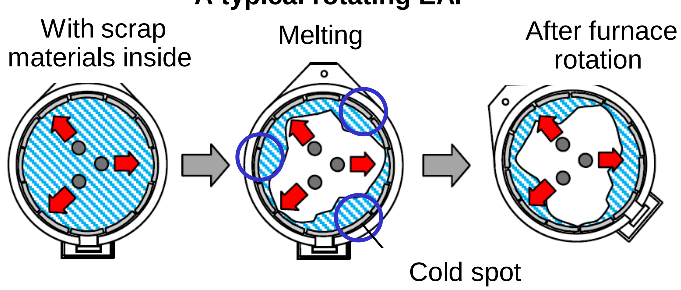


Source: Daido Steel

Rotating Furnace Technology

- Maximum furnace rotating angle is 50˚

A typical rotating EAF

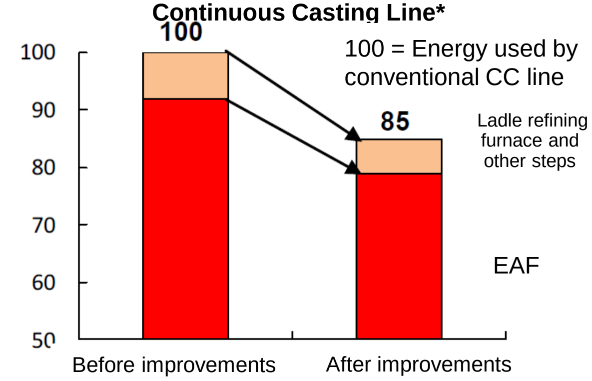


A rotating electric arc furnace

Benefits of the Rotating EAF

- Lower EAF unit energy consumption (including benefit of the larger furnace volume)
- In addition to EAF improvements, Daido Steel's improvements shortened processing time by creating a separate ladle transport line, greatly reduced variations in steel quality, and lowered the temperature required by the ladle refining furnace.
- Overall, Daido Steel cut unit energy consumption by about 15%.

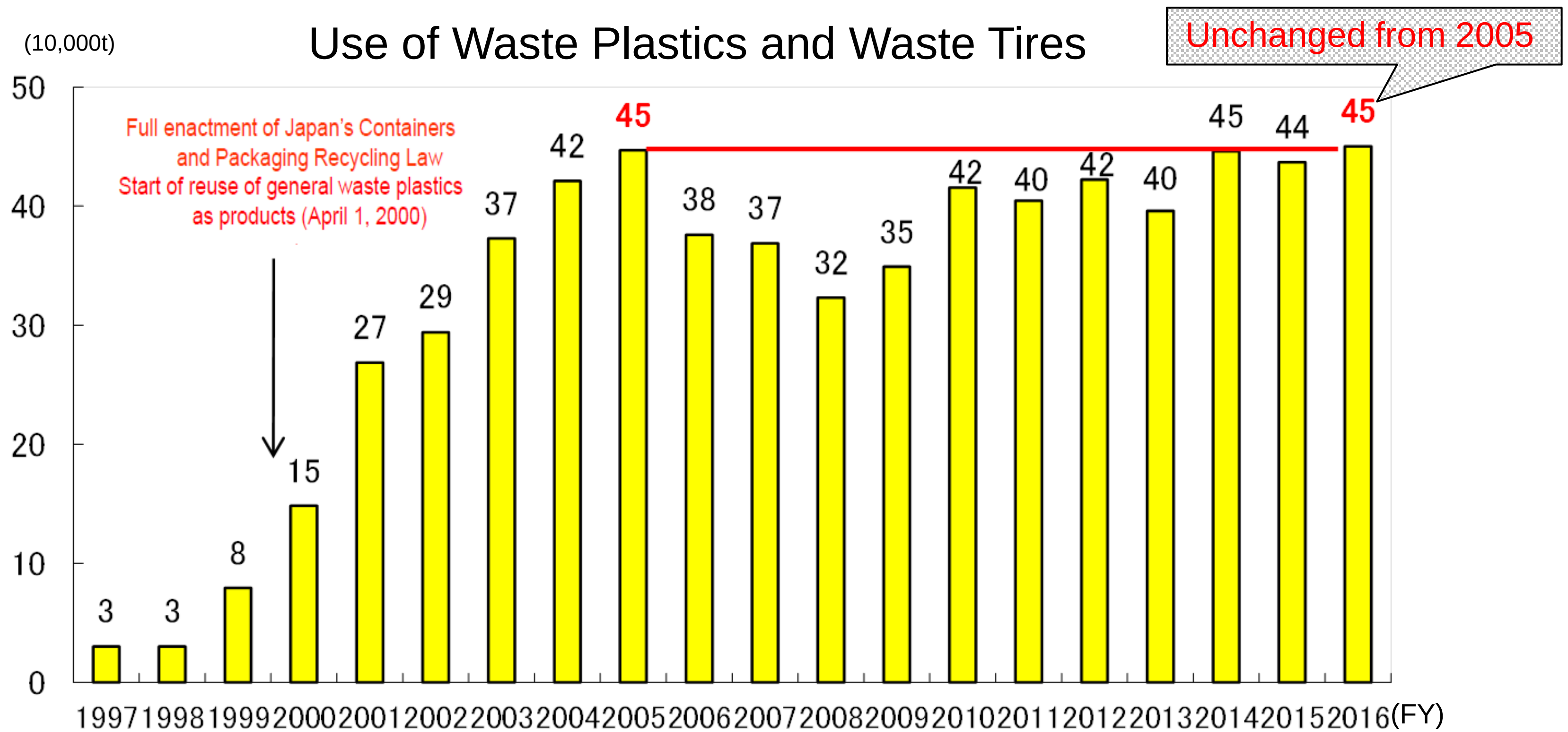
Energy Saving Due to Streamlined Continuous Casting Line*



* Continuous casting covers all steps from the EAF through casting.

Use of Waste Plastics and Other Recycled Materials

- JISF's commitment to a Low Carbon Society has the goal of raising the use of waste plastics and other recycled materials to 1 million tons, assuming the government establishes the necessary collection infrastructure. However, collections totaled 450,000 tons in FY2016, unchanged from FY2005 collections of recycled materials.
- A great amount of CO_2 emission reduction is possible by reexamining associated policies for the use of waste plastics and other materials. At government councils and other opportunities, JISF constantly ask for reviews of the current recycling system and revisions as soon as possible.



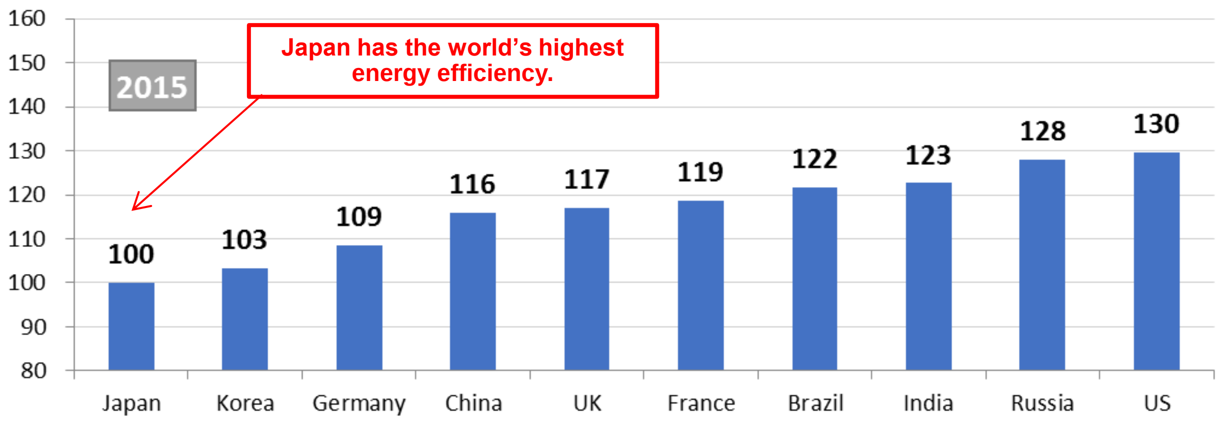
Source: The Japan Iron and Steel Federation

Japan's steel industry (BF-BOF) maintains the world's highest energy efficiency

- The Research Institute of Innovative Technology for the Earth (RITE) issued an report in January 2018 on international comparison of energy efficiency level in steel industry (BF-BOF*). The report revealed that Japan maintains the world's highest energy efficiency in 2015, as in 2005 and 2010.

*A RITE survey is now under way for the energy efficiency of EAF steelmakers in 2015. Japan was first in 2005 and 2010.

Estimate of Steel Industry (BF-BOF) Energy Efficiency (2015, Japan=100)



Why is Japan's steel industry the most efficient?

- The **penetration rate of energy-saving technologies** is very high in Japan's steel industry.
- All steelmakers are working on achieving the goals of the JISF's Commitment to Low Carbon Society and **sharing best-practice knowledge** among themselves.

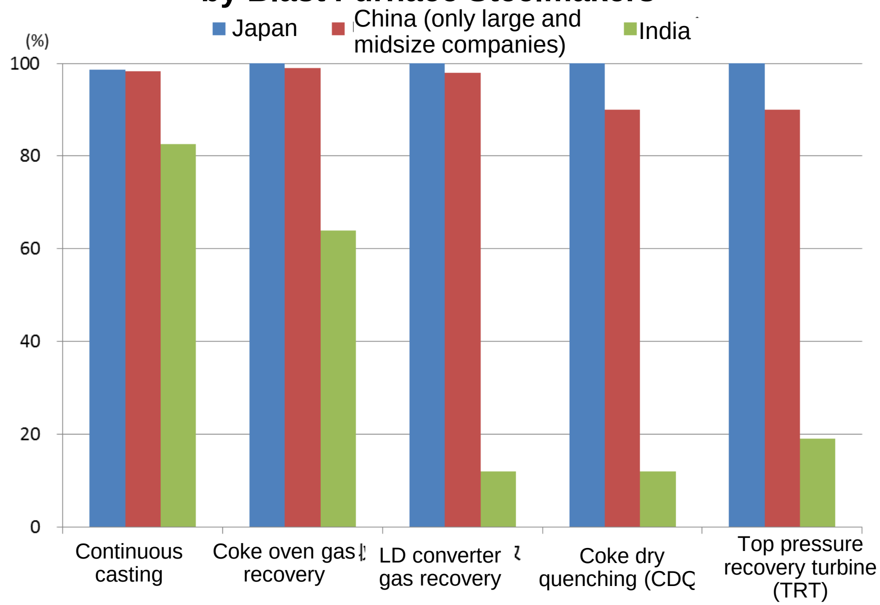
In addition to actions in Japan, increasing the use of energy-saving measures and technologies worldwide will be an effective way to further lower CO_2 emissions in the steel industry.

2. Eco Solution

Eco Solution: CO_2 Emission Reduction from Increasing Use of Technologies

- There is much potential for increasing the use of major energy conservation technologies in China, which accounts for almost half of global crude steel production, and India, where steel production is expected to continue to grow.
- Major energy conservation technologies developed and used in the Japanese steel industry are already lowering CO_2 emissions overseas as Japanese companies provide these technologies to other countries. CDQ, TRT and other major types of equipment alone are already lowering annual aggregate CO_2 emissions in China, Korea, India, Russia, Ukraine, Brazil and other countries by approximately 6.0 million tons.

Utilization Rates of Major Energy Conservation Equipment by Blast Furnace Steelmakers



Emission Reductions in Other Countries from Japanese Energy-conserving Equipment (FY2016)

(Mt/year)

	No. of units	Reduction
Coke dry quenching (CDQ)	96	18.16
Top-pressure recovery turbines (TRT)	62	11.02
Byproduct gas combustion (GTCC)	52	21.18
Basic oxygen furnace OG gas recovery	21	7.92
Basic oxygen furnace sensible heat recovery	7	0.85
Sintering exhaust heat recovery	6	0.88
Total emission reduction		60.01Mt

CDQ：Coke Dry Quenching
TRT：Top Pressure Recovery Turbines
GTCC：Gas Turbine Combined Cycle system

Ref: Total emission reduction in FY2015 was 54.58Mt - CO_2/year

Note: Continuous casting figures for all three countries include blast furnace and EAF steelmakers (Total continuous casting production/Total crude steel production in 2013). For other equipment, figures are for FY2014 in Japan, 20134for coke oven gas recovery and LD converter gas recovery and 2010 for CDQ and TRT in China, and 2000 for all other categories in India.

Sources
Japan: JISF
China: Coke oven/LD converter gas recovery = China Iron and Steel Association; CDQ = Metallurgy report (Nov. 27, 2012); TRT = Wang Wei Xing (China Metallurgy Association, *Information on Major Steel Companies in 2010, World Metals Report (March 8, 2011)*
India: Steel edition of Diffusion of energy efficient technologies and CO_2 emission reductions in iron and steel sector (Oda etal. Energy Economics, Vol. 29, No. 4, pp 868-888, 2007)

International cooperation to support Eco Solution

2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

Bilateral Activities

- **Japan-China Steel Industry Environmental Protection and Energy Conservation Technology Conference (2005~)**
- **The Public and private collaborative meeting between Indian and Japanese Iron and Steel Industry (2011~)**
- **ASEAN-Japan Steel Initiative (2014~)**

Multilateral Activities

- **APP Steel TF (2006~2010)**
  APP: Asia Pacific Partnership
- **GSEP Steel WG(2010~2015)**
  GSEP: Global Superior Energy Performance Partnership

worldsteel etc.

- ENCO (~2009)
  Environment Committee
- EPCO (2010~2013)
  Environmental Policy Committee
- ECO (2014~)
  Environment Committee
- "CO_2 Breakthrough Program": Participating with COURSE50 (2003~)
- CO_2 data collection (2007~)
- Development of ISO14404* (2009~)
  Versions for integrated steel plants and EAF issued in 2013, version for DRI-EAF in 2017
  *International standard for the calculation of CO_2 emission from steel plants

3. Eco Product

Eco Product: Japanese Industrial Products that Conserve Energy and Cut CO_2 Emissions

- Japanese manufacturers have taken the lead in developing and commercializing many highly efficient industrial products. Examples include fuel-efficient automobiles and highly efficient power generation equipment and transformers. These products have made a big contribution to conserving energy and cutting CO_2 emissions in Japan and worldwide.
- The Japanese steel industry has established a close relationship with these manufacturers by developing and supplying steel that has a variety of characteristics. This high-performance steel is a vital to achieving the outstanding functions of advanced products and has earned a reputation for reliability among manufacturers.

➢**Airplane components**

Strong and durable jet engine shafts further boost maximum thrust = Longer range, better fuel efficiency

➢**Motors for hybrid/electric cars**

High-efficiency non-oriented electrical sheets for higher fuel efficiency, more power, smaller size and lower weight

➢**Automotive and industrial machinery parts**

Strong gear steel increases gears and reduces size and weight – higher fuel efficiency

➢**Boiler tubes**

Steel tubes that resist high temperatures and corrosion make power generation more efficient

➢**Suspension springs**

Higher strength steel for valve and suspension springs used in punishing applications makes vehicles lighter and lowers fuel consumption

➢**Generator parts**

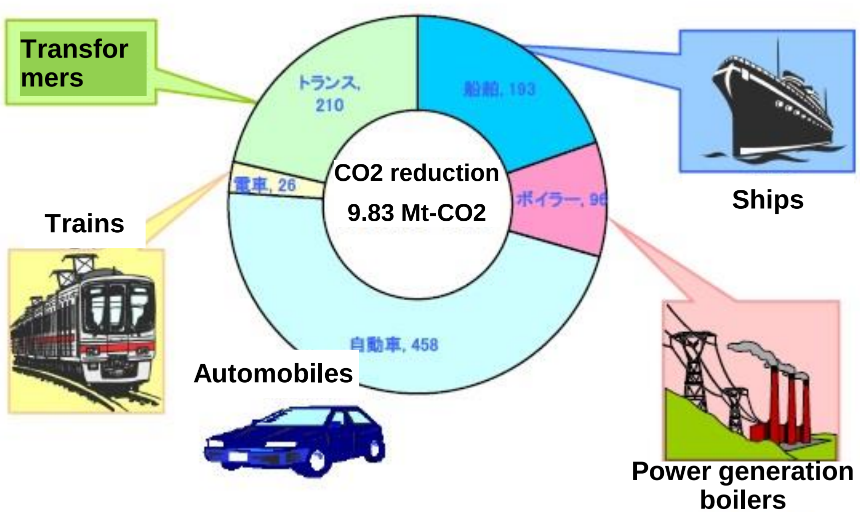
Steel for high-efficiency power plant turbines can withstand high temperatures and high rotation speeds

Eco Product Contribution: Quantitative Evaluations – Contributions of Major High-performance Steel Products

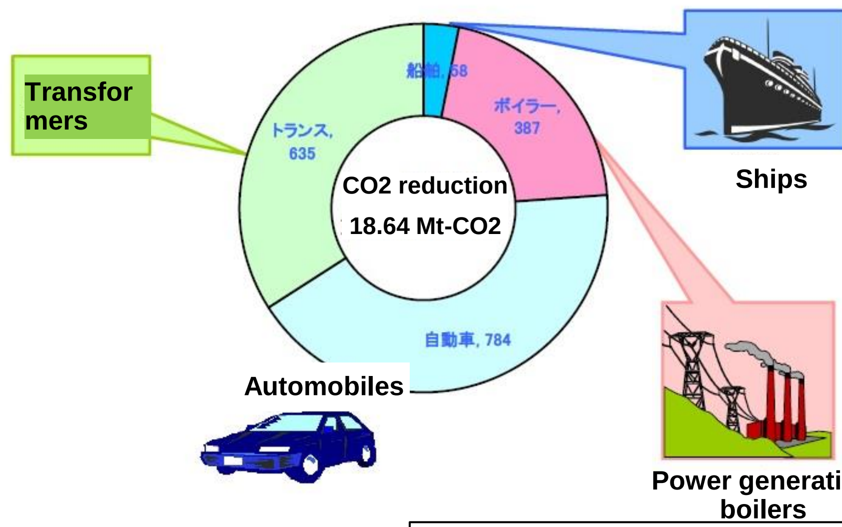
- To establish a method to determine the quantitative contribution of high-performance steel, JISF established in FY2001 a committee with the participation of associations of steel-consuming industries, The Institute of Energy Economics, Japan and the Japanese government. The committee has been monitoring contributions every year since then.
- Statistics are for the five major types of high-performance steel for which quantitative data are available (FY2016 production of 7.36 million tons, 6.9% of Japan's total crude steel output). The use of finished products made of high-performance steel cut FY2016 CO_2 emissions by 9.83 million tons for steel used in Japan and 18.64 million tons for exported steel, a total of 28.47 million tons of CO_2.

CO_2 Emission Reductions by the five major types of high-performance steel (FY2016)

1. Domestic



2. Export



CO_2 Emission Reductions: 28.47 million tons CO_2 in total (7.36 million tons of high-performance steel)

Ref:
CO_2 Emission Reductions: 27.51 million tons CO_2 by the end of FY2015
(7.24 million tons of high-performance steel)

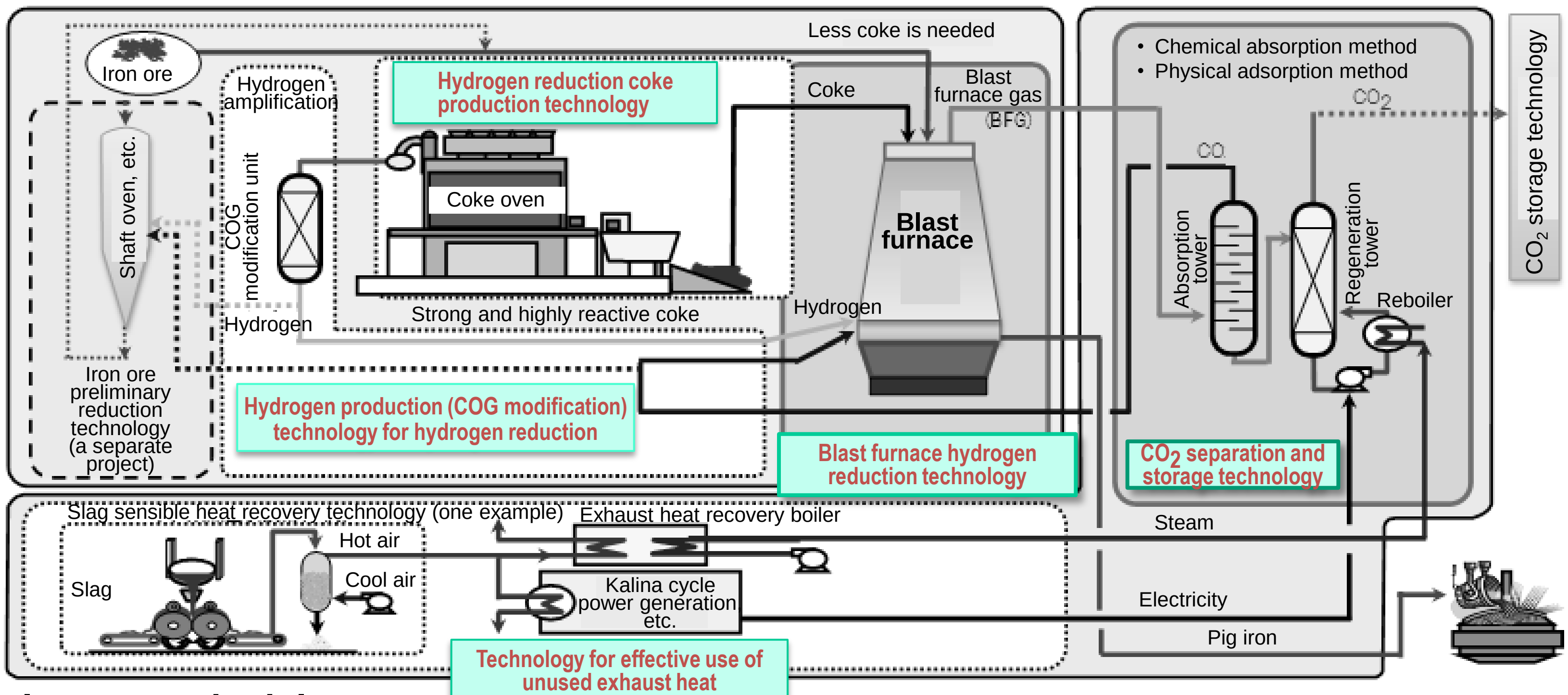
Source: The Institute of Energy Economics, Japan
*The five categories are automotive sheets, oriented electrical sheets, heavy plates for shipbuilding, boiler tubes and stainless steel sheets. In FY2016, use of the five categories of steel products in Japan was 3.79 million tons and exports were 3.57 million tons for a total of 7.36 million tons.
*Assessments in Japan started in FY1990 and for exports assessments started in FY2003 for automobiles and shipbuilding, in FY1998 for boiler tubes, and in FY1996 for electrical sheets.

4. Promotion of Environmentally Harmonized Steelmaking Process Technology Development (COURSE50)

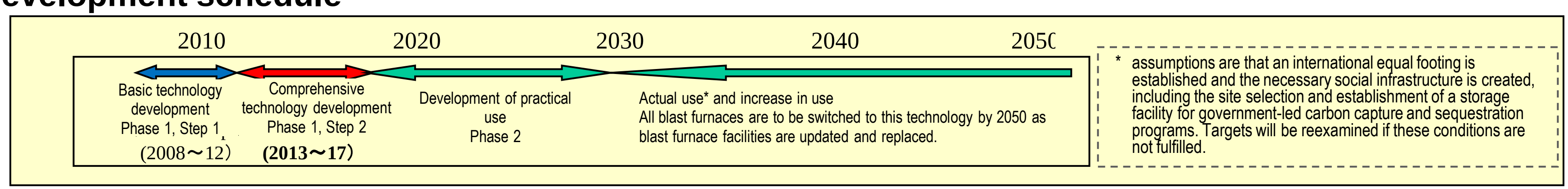
Development of Environmentally Responsible Steelmaking Processes (COURSE50)

Project summary

Work is under way on developing a technology for using hydrogen for the reduction of iron ore (method for lowering blast furnace CO_2 emissions). Hydrogen in the very hot coke oven gas (COG) generated during coke production is amplified and then used to replace some of the coke. Furthermore, for the separation of CO_2 from blast furnace gas (BFG), a revolutionary CO_2 separation and collection technology (technology for separating and collecting CO_2 from blast furnaces) will be developed that utilizes unused heat at steel mills. The goal is to use these technologies for low-carbon steelmaking that cuts CO_2 emissions by about 30%. (a project for NEDO)



Development schedule



5. Reference

Eco Solution: ISO50001 Certification

- ISO50001 is an international standard for energy management systems that was issued in June 2011.
- On February 20, 2014, JISF became the first industrial association in the world to receive ISO50001 certification, the result of global warming and energy conservation measures associated with the voluntary action plan and the Commitment to a Low Carbon Society.
- This certification is proof that the voluntary actions of the steel industry are sufficiently transparent, reliable and effective in relation to the requirements of international standards.

JISF Energy Management System

Plan

JISF establishes the highest possible goals based on available technologies

Suitability of the plan is confirmed by providing explanations during the target establishment process to the government advisory council and the Keidanren third-party evaluation committee.

Do

Member companies take actions for conserving energy and cutting CO_2 emissions based on JISF targets

JISF checks progress by receiving reports from company presidents at its Executive Board Meeting

Check

Performance is evaluated every year by a government advisory council (steel working group) and Keidanren third-party evaluation committee

Action

The plan is revised as needed based on assessments and instructions from the government advisory council (steel working group) and Keidanren third-party evaluation committee

ISO50001 Certificate

Effective Use of Waste Plastics (Containers and Packaging Recycling)

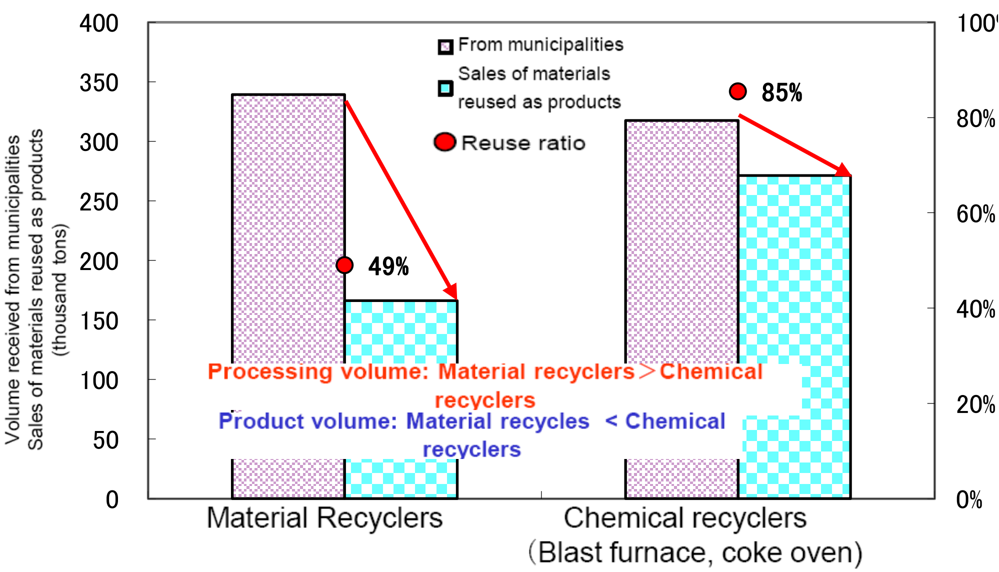
- Due to priority on recycling materials, purchased 260,000 tons of waste plastics in FY2016 under the container and packaging recycling system; current waste plastic processing capacity in the steel industry is about 400,000 tons, leaving significant unused capacity (utilization rate is slightly over 60%)
- A review of policies can produce a big drop in CO_2 emissions through the effective use of waste plastics, etc. JISF hopes to see a quick reexamination of recycling systems from the following standpoints.

(1) From the standpoint of efficiently and effectively using waste materials (recycling waste materials that are highly effective at cutting CO_2 emissions and have a low social cost), the container and packaging recycling system should stop placing priority on recycling materials that produce only small reductions in CO_2 emissions.

(2) A payment system should be considered to provide incentives to local governments that cut costs below a certain level or make big improvements; this would lower the social cost of recycling by encouraging local governments to improve efficiency of collecting and storing waste materials in separate categories

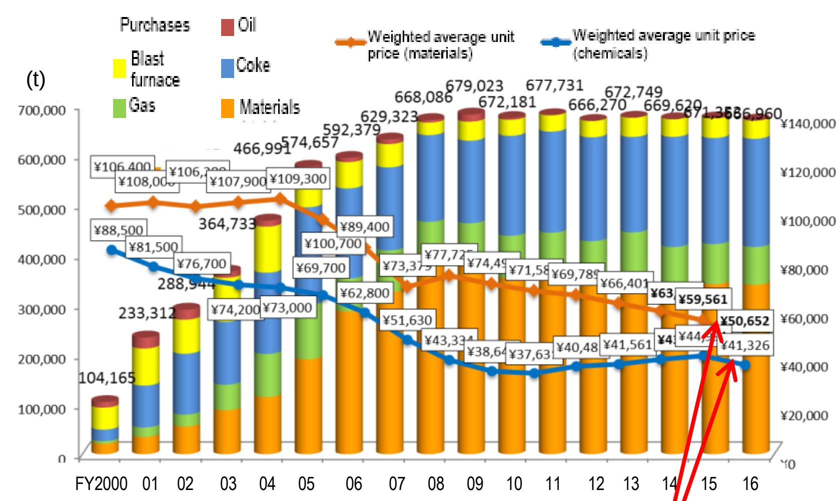
(3) Collection of waste materials should not be restricted to items covered by the Container and Packaging Recycling Law; collecting product plastic waste and other materials too could reduce the need for consumers to discard trash by category and reduce the trash classification expenses for local governments. The government should thus consider enlarging recycling activities to include more types of materials.

Materials Received, Products Sold and Reuse Ratio by Method (FY2016)



Source: The Japan Containers and Packaging Recycling Association

Volume Purchased and Unit Price by Method for Recycling Container and Packaging Plastics

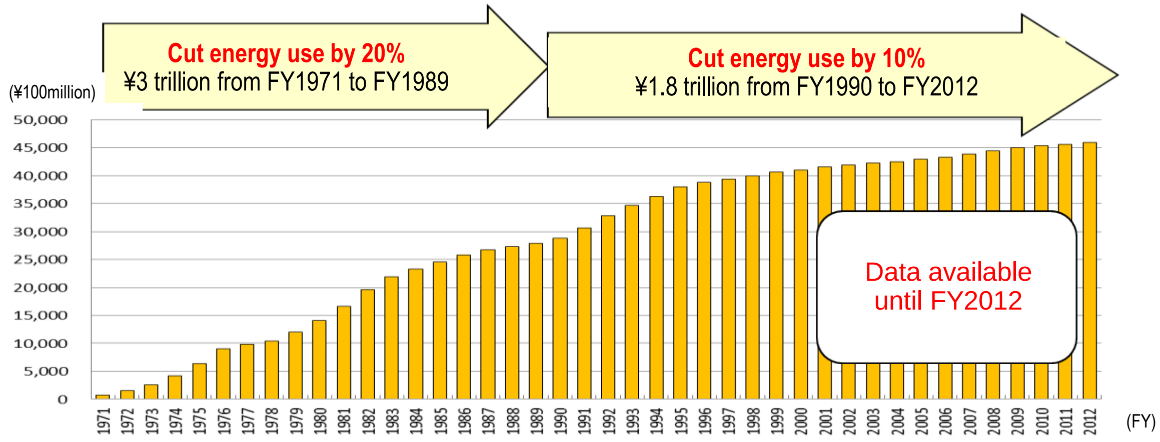


FY16 unit purchase price for recycled materials was ¥51,000/ton and ¥41,000/ton for chemicals

Investments for Environmental Protection and Energy Conservation

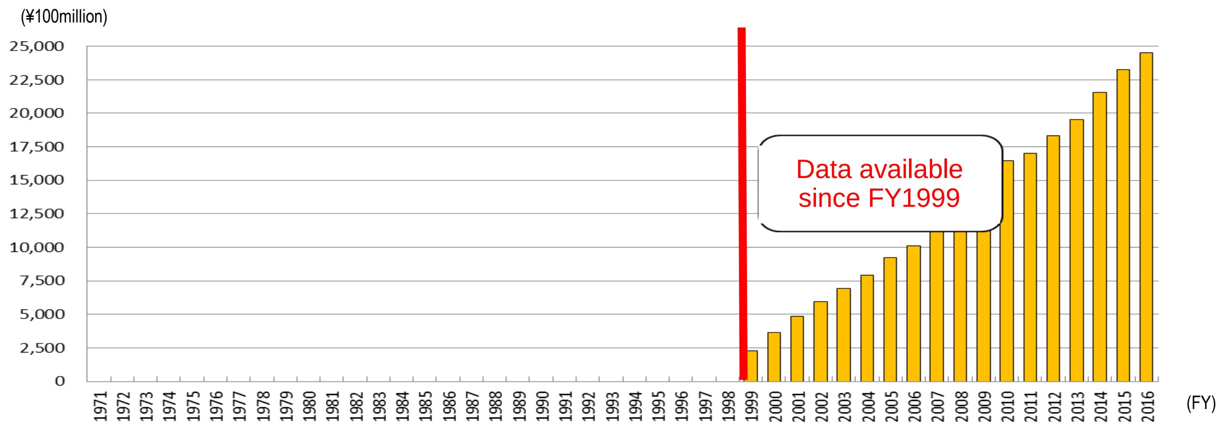
- Japanese steel industry made investments of about ¥3 trillion between FY1971 and FY1989 for environmental protection and energy conservation. These investments totaled about ¥1.8 trillion between FY1990 and FY2012.
- Investments for rationalization and labor-saving totaled about ¥1.6 trillion between FY2005 and FY2016.

Fig. Accumulative investment for environmental facilities since FY1971



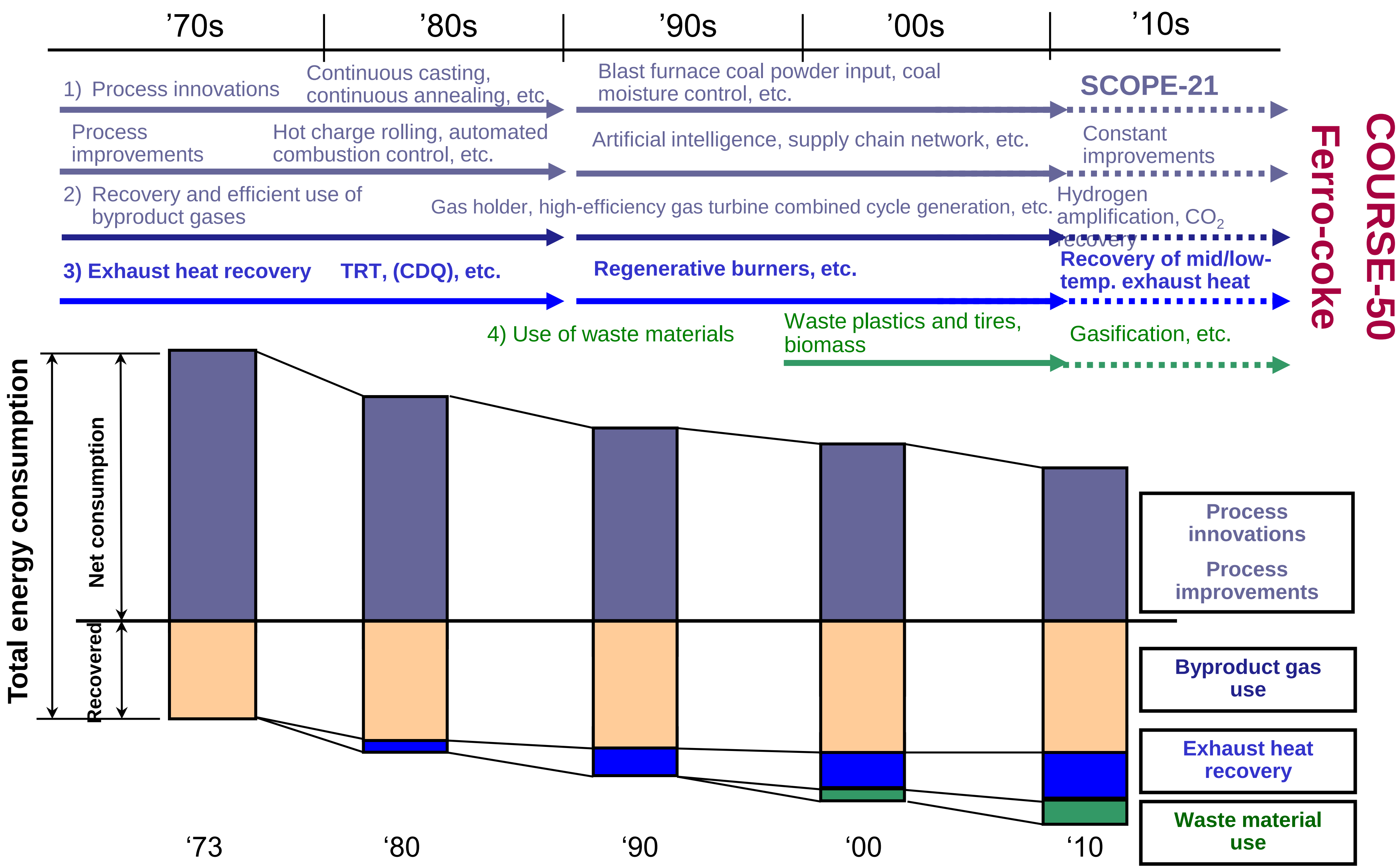
Source: ~FY2011: METI Survey on Capital Investments of Major Industries, FY2002~: METI Survey on Corporate Finance (former Survey on Capital Investments)

Fig. Accumulative investment for rationalization and labor-saving since FY1999



Source: Development Bank of Japan Inc

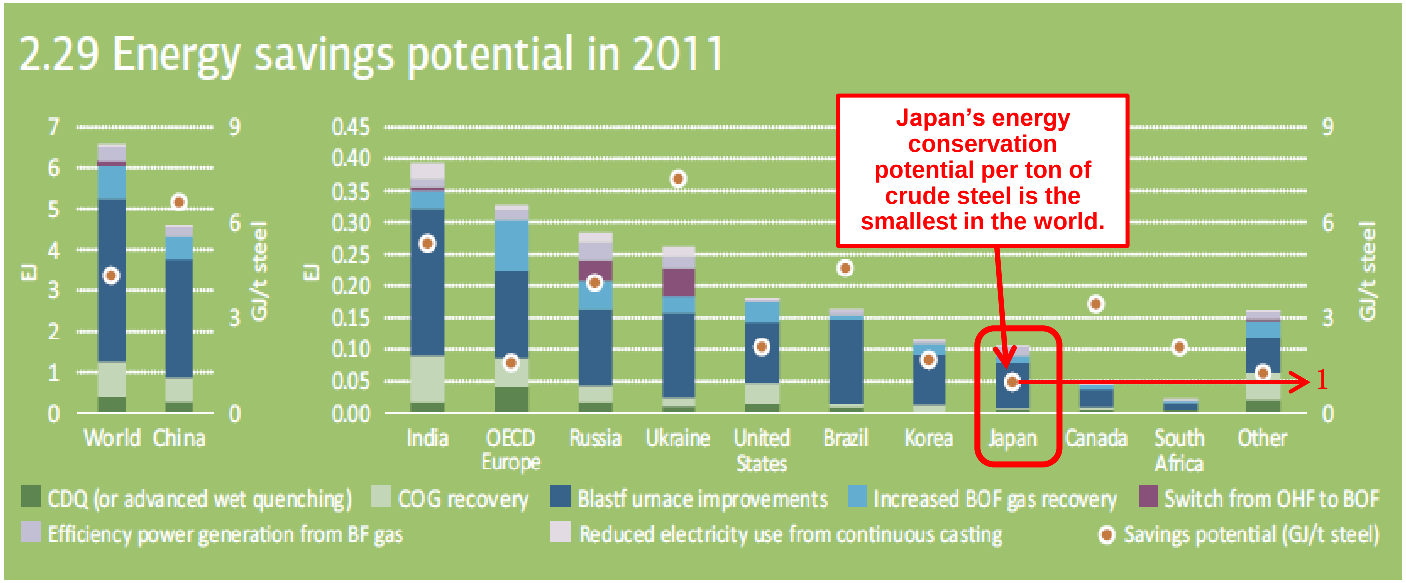
Energy Conservation Initiatives of the Steel Industry



International Comparison of Energy Efficiency in the Steel Industry

- According to the IEA, Japan has world's smallest potential for energy conservation per ton of crude steel. According to RITE, Japan has the world's most energy efficiency steel industry. These figures demonstrate that virtually all steel mills in Japan use existing technologies and that there is very little potential for further energy-conservation measures.

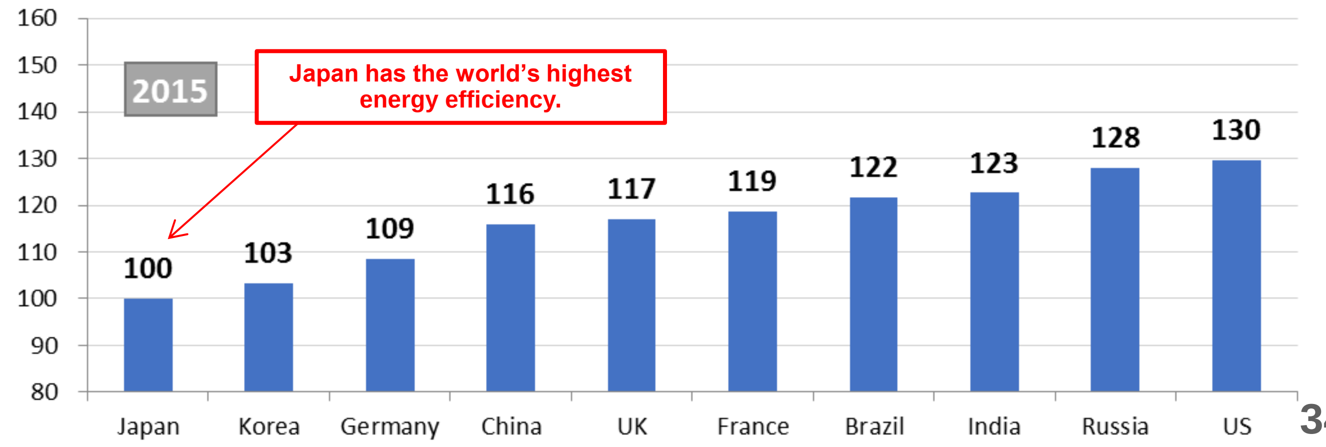
Energy Saving Potential from Transferring and Promoting Energy Conservation Technologies (2011)



Source: IEA "Energy Technology Perspective 2014"

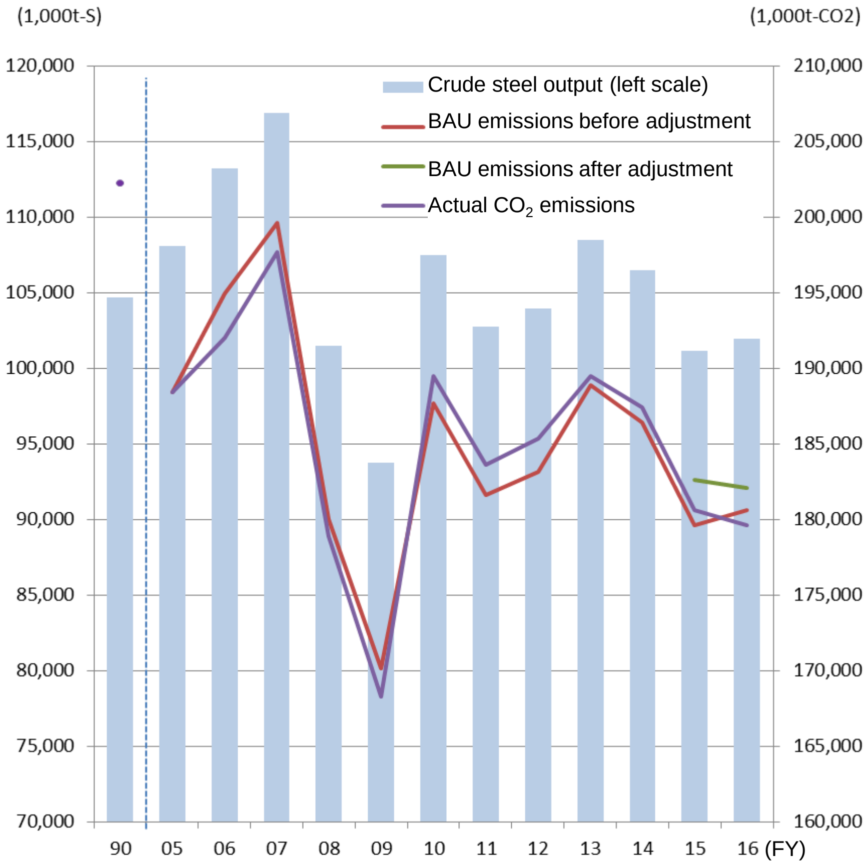
Estimate of Steel Industry (BF-BOF) Energy Efficiency

(2015, Japan=100)

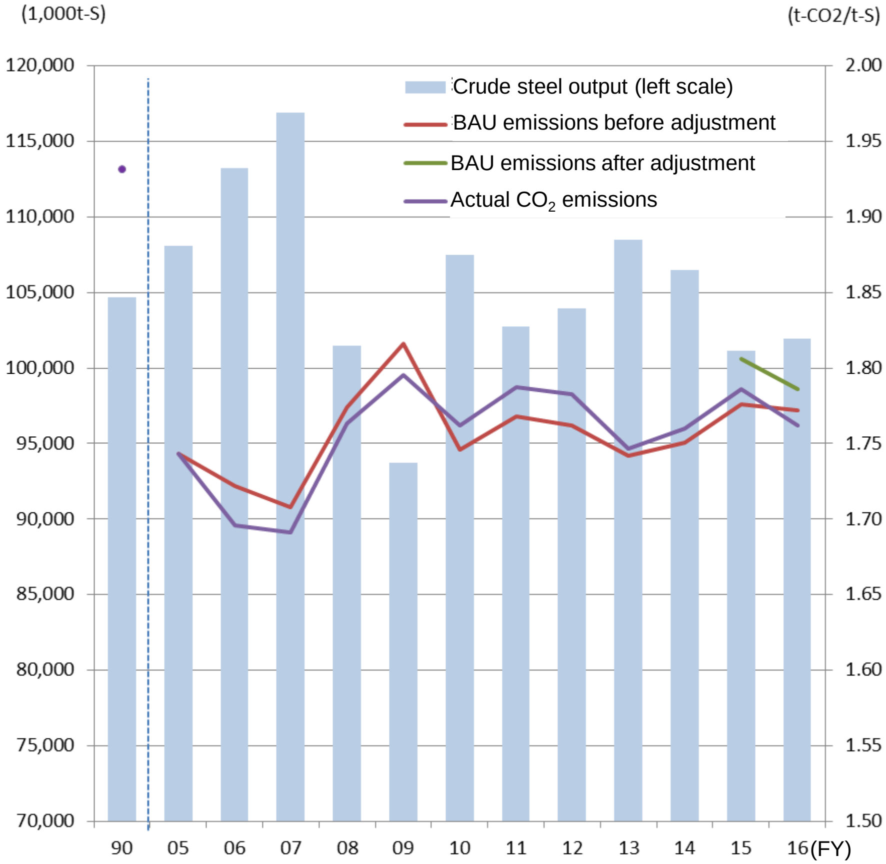


Source: RITE "Estimated Energy Unit Consumption in 2015"

Crude Steel Output and Total and Unit CO_2 Emissions



Crude Steel Output and CO_2 Emissions
(constant FY2005 electric power emission coefficient)



Crude Steel Output and Unit CO_2 Emissions
(constant FY2005 electric power emission coefficient)

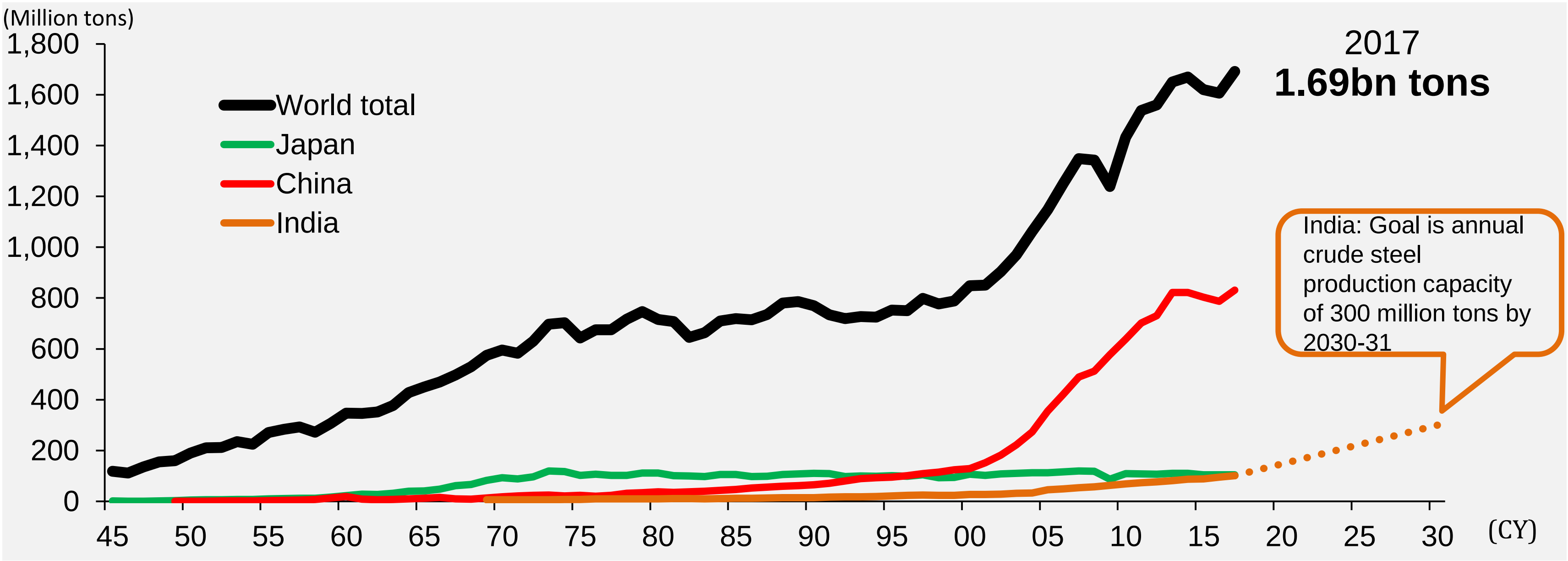
Eco Solution: Growth of Global Crude Steel Output

- As of end of 2015, the per capita steel stock in Japan was 10.7 tons compared with 4.0 tons worldwide.
- Steel stock per capita is an indicator of the penetration of social infrastructure and industrial products, which are a measure of prosperity. The steel stock is expected to grow steadily in emerging countries as these countries become more prosperous and accomplish Sustainable Development Goals (SDGs).

Global crude steel output will increase for many more years

India's steel industry plans to approximately triple crude steel output to 300 million tons by 2030.

Global Crude Steel Output



Source: worldsteel

The Japanese Steel Industry's Overseas Contributions to Energy Conservation

1. China: Japan-China Steel Industry Environmental Protection and Energy Conservation Technology Conference (2005~)

- This conference has been held periodically since steel industry leaders of the two countries signed an MoU in July 2005. Providing a forum for exchanges of information about steel technologies, this conference plays a key role in international steel industry cooperation.
- The ninth conference took place in October 2017 in Zhanjiang, China. This event confirmed that major advances in the environmental protection and energy conservation measures have been made by Chinese steel mills during the decade since these conferences started. Participants also recognized the contribution of these conferences to the actions for steel mills in China.

2. India: Public and Private Collaborative Meeting between the Indian and Japanese Steel industries (2011~)

- Started in 2011, this meeting has been held eight times, bringing together public and private-sector energy conservation experts in the two countries.
- The Japanese steel industry has provided assistance concerning the introduction of its energy conservation technologies in India. Activities include steel plant diagnosis using ISO14404, the establishment of a Technologies Customized List containing energy conservation technologies suitable for India, and technology seminars held by Japanese manufacturers of energy conservation equipment.

3. ASEAN: ASEAN-Japan Steel Initiative (2014~)

- Started in February 2014, this initiative brings together steel industry energy conservation professionals from Japan and six ASEAN countries. Since the start of this initiative, workshops for specific themes have been held for the ASEAN region and individual countries to support energy conservation measures in the ASEAN steel industry.
- There have been steel plant diagnosis at 13 ASEAN steel mills in order to provide advice for improving operations and using new technologies.

Technologies Customized List

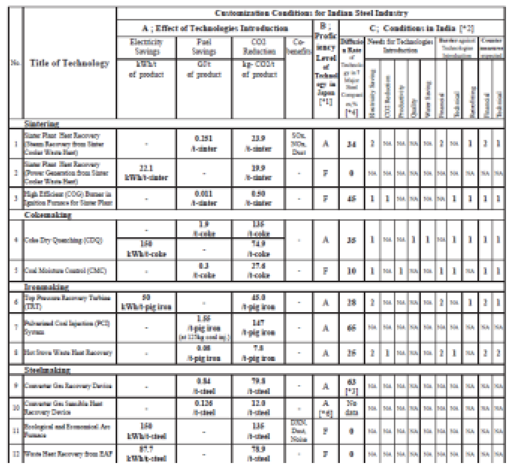
The Technologies Customized List contains information about technologies involving energy conservation and protecting the environment that are recommended for specific countries and regions. These lists have been prepared for India and the ASEAN region.

The Technologies Customized List for India

35 recommended technologies

(19 energy and 16 environmental technologies)

Energy conservation benefits, technology suppliers and other information



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 kWh/t of product	Fuel Savings GJ/t of product	CO2 Reduction kg-CO2/t of product	Co-benefits		Diffusion Rate of Technology in 7 Major Steel Companies (%) [*4]	Needs for Technologies Introduction					Barrier against Technologies Introduction			Counter measures expected	
	Sintering																
1	Sinter Plant Heat Recovery (Steam Recovery from Sinter Cooler Waste Heat)	-	0.181 /t-sinter	23.9 /t-sinter	SOx, NOx, Dust	A	34	2	NA	NA	NA	NA	2	NA	1	2	1
2	Sinter Plant Heat Recovery (Power Generation from Sinter Cooler Waste Heat)	22.1 kWh/t-sinter	-	19.9 /t-sinter	-	F	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
3	High Efficient (COG) Burner in Ignition Furnace for Sinter Plant	-	0.011 /t-sinter	0.90 /t-sinter	-	F	45	1	1	NA	NA	NA	NA	1	1	1	1
	Cokemaking																
4	Coke Dry Quenching (CDQ)	-	1.9 /t-coke	136 /t-coke	-	A	38	1	NA	NA	1	1	NA	1	1	1	1
		160 kWh/t-coke	-	74.9 /t-coke													
5	Coal Moisture Control (CMC)	-	0.3 /t-coke	27.6 /t-coke	-	F	10	1	NA	1	NA	NA	1	1	NA	1	1
	Ironmaking																
6	Top Pressure Recovery Turbine (TRT)	50 kWh/t-pig iron	-	45.0 /t-pig iron	-	A	28	2	NA	NA	NA	NA	2	NA	1	2	1
7	Pulverized Coal Injection (PCI) System	-	1.55 /t-pig iron (at 123kg coal inj.)	147 /t-pig iron	-	A	66	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
8	Hot Stove Waste Heat Recovery	-	0.08 /t-pig iron	7.8 /t-pig iron	-	A	26	2	1	NA	NA	NA	2	1	NA	2	2
	Steelmaking																
9	Converter Gas Recovery Device	-	0.84 /t-steel	79.8 /t-steel	-	A	63 [*2]	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
10	Converter Gas Sensible Heat Recovery Device	-	0.126 /t-steel	12.0 /t-steel	-	A [*6]	No data	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
11	Ecological and Economical Arc Furnace	150 kWh/t-steel	-	136 /t-steel	DXN, Dust, Noise	F	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
12	Waste Heat Recovery from EAF	87.7 kWh/t-steel	-	78.9 /t-steel	-	F	0	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Technology Explanation Sheets

Thorough explanations of individual technologies

India Technology Customized List: http://www.jisf.or.jp/business/ondanka/eco/documents/TechnologiesCustomizedListIndiav3.pdf
ASEAN Technology Customized List: http://www.jisf.or.jp/business/ondanka/eco/documents/ASEANTechnologiesCustomizedListv2.pdf

Steel Plant Diagnosis

Objective

1. **Evaluate energy efficiency level of the steel plant using ISO14404*.**
2. **Recommend energy saving technologies from Technologies Customized List (TCL) based on the equipment diagnosis to encourage technology transfer from Japan**

***ISO14404 is an international standard for calculating CO_2 emissions from a steel plant .**

The steel plant diagnosis has been performed at 23 locations.

- ✓ 10 plants in India
- ✓ 13 plants in the ASEAN region in 6 countries*

*Indonesia, Singapore, Thailand, Philippines, Vietnam, Malaysia

Day1~3

1. **Operation observation of BF-BOF, EAF, reheating furnace and other facilities**
2. **Energy data collection by using ISO14404**

Day4

3. **Reporting session**

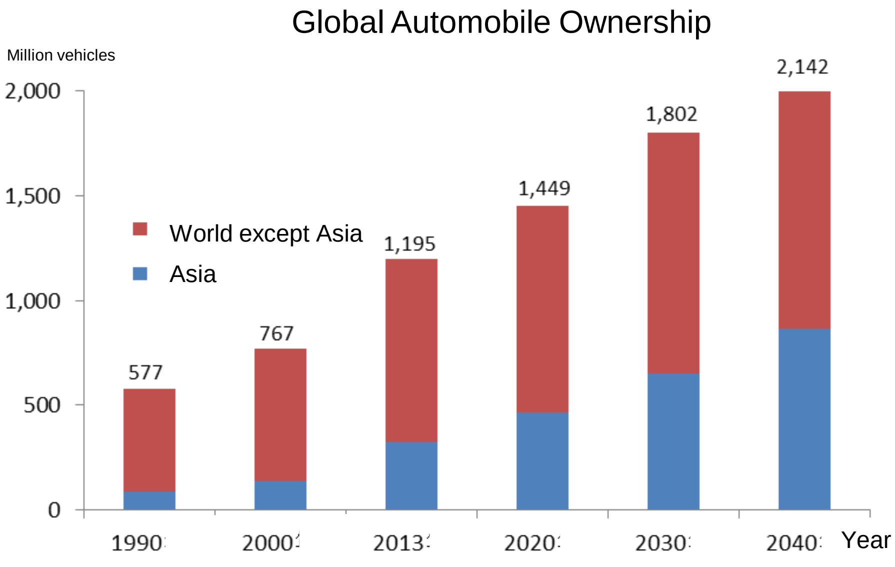
Based on ISO14404, Japanese experts

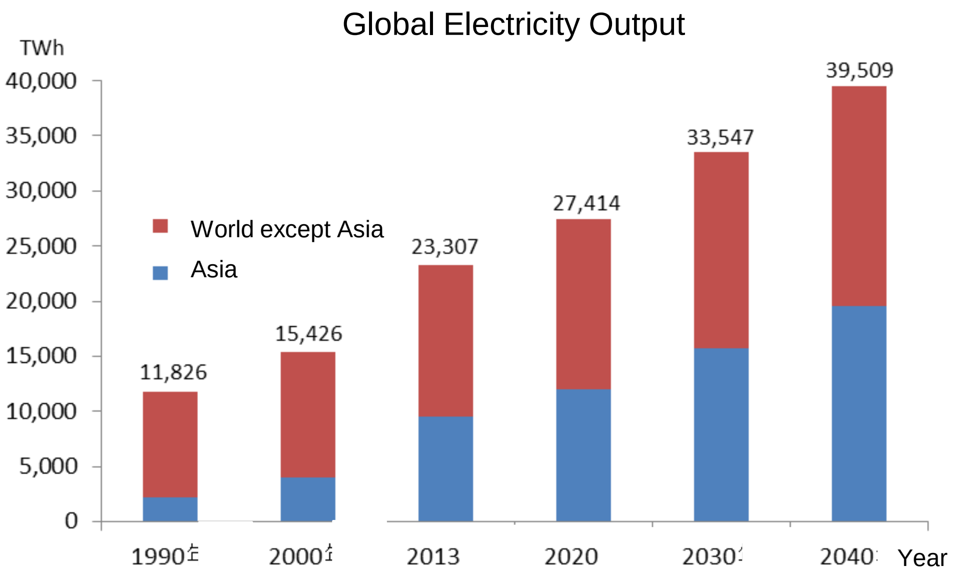
1. *analyze energy consumption trend*
2. *recommend suitable energy saving technologies mainly from TCL*
3. *provide advice for operational improvement*

The Importance of Increasing the Use of Eco Product

- High-performance steel generally has higher CO_2 emissions than ordinary steel does during the manufacturing stage. But high-performance steel is an eco product because it greatly lowers CO_2 emissions when used by making finished products more energy efficient.
- By supplying high-performance steel, the Japanese steel industry is making a big contribution to energy conservation and cutting CO_2 emissions in Japan and around the world. Furthermore, this steel supports “green” economic growth in Japan and creates jobs as the steel is exported to users worldwide.
- Global demand for electricity and motor vehicles is certain to increase as economic growth continues, chiefly in emerging countries. Demand for high-performance steel is expected to become even greater as a result. Meeting the need for high-performance steel will therefore be critical from the standpoints of supporting Japan’s economic growth and protecting the global environment.

Asia/Global Energy Outlook 2015 by The Institute of Energy Economics, Japan

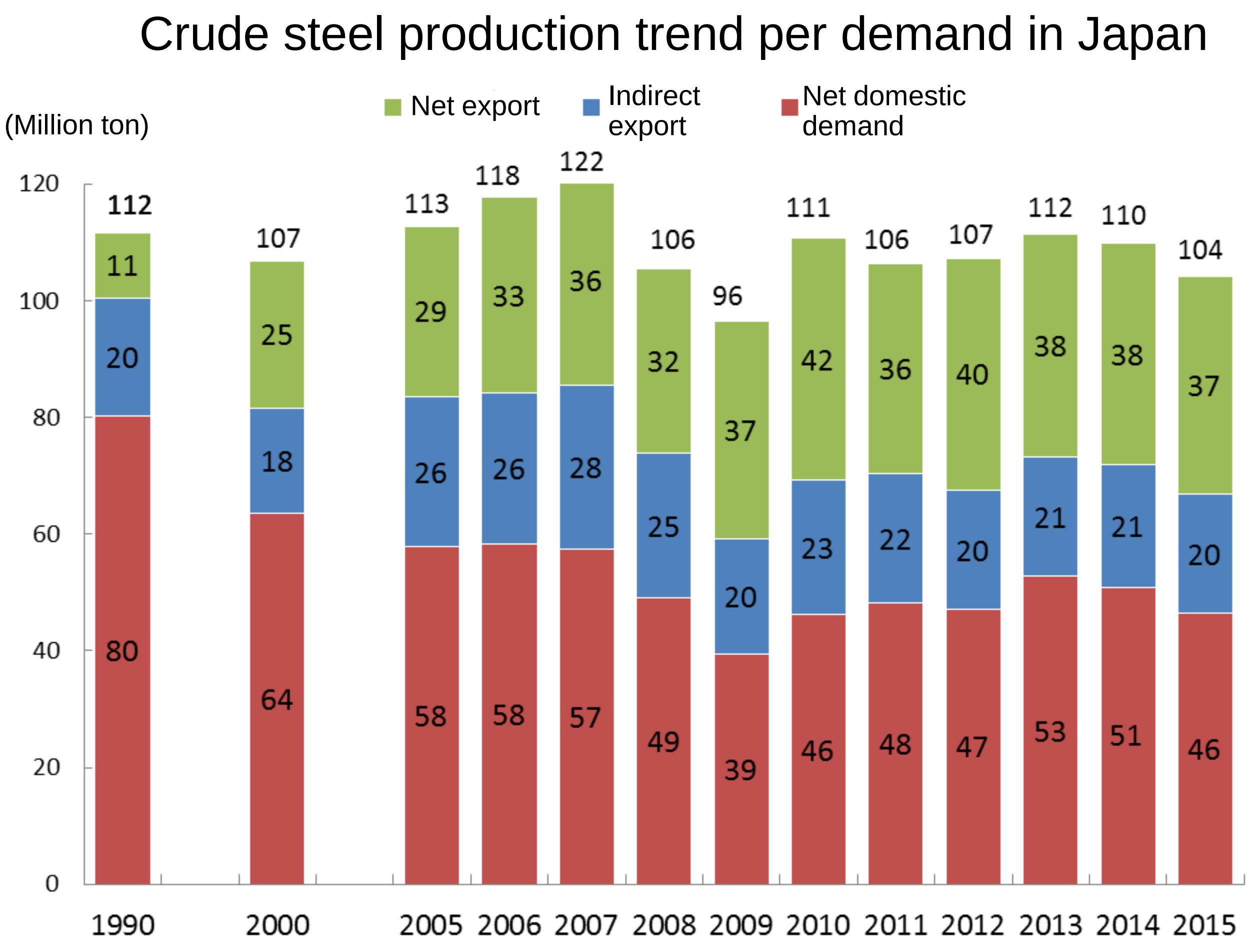




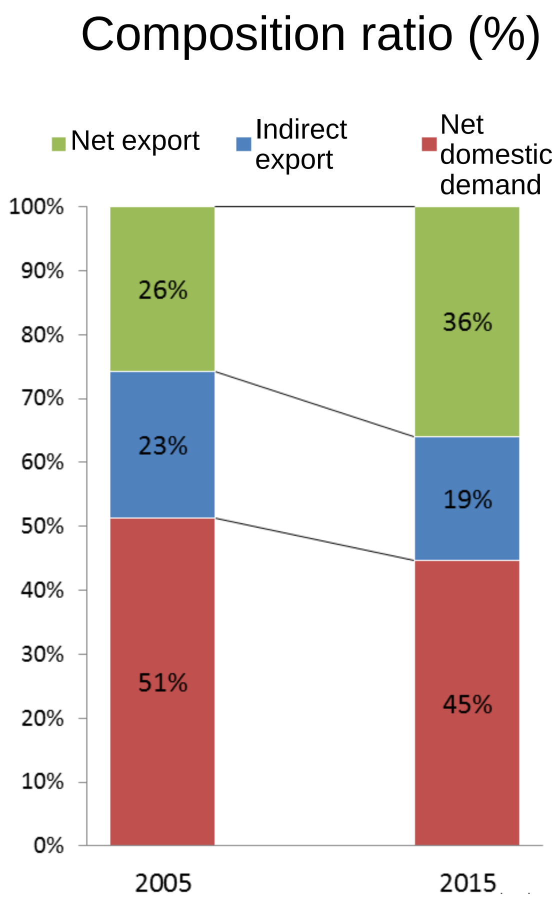
Source: The Institute of Energy Economics, Japan

Crude steel production trend per demand in Japan

- Steel exports from Japan have been increasing. The main reason is strong demand overseas for high-performance steel backed by global economic growth, primarily in Asia.
- In recent years, external demand (direct and indirect exports) has accounted for more than half of Japan's crude steel production.



Source: JISF

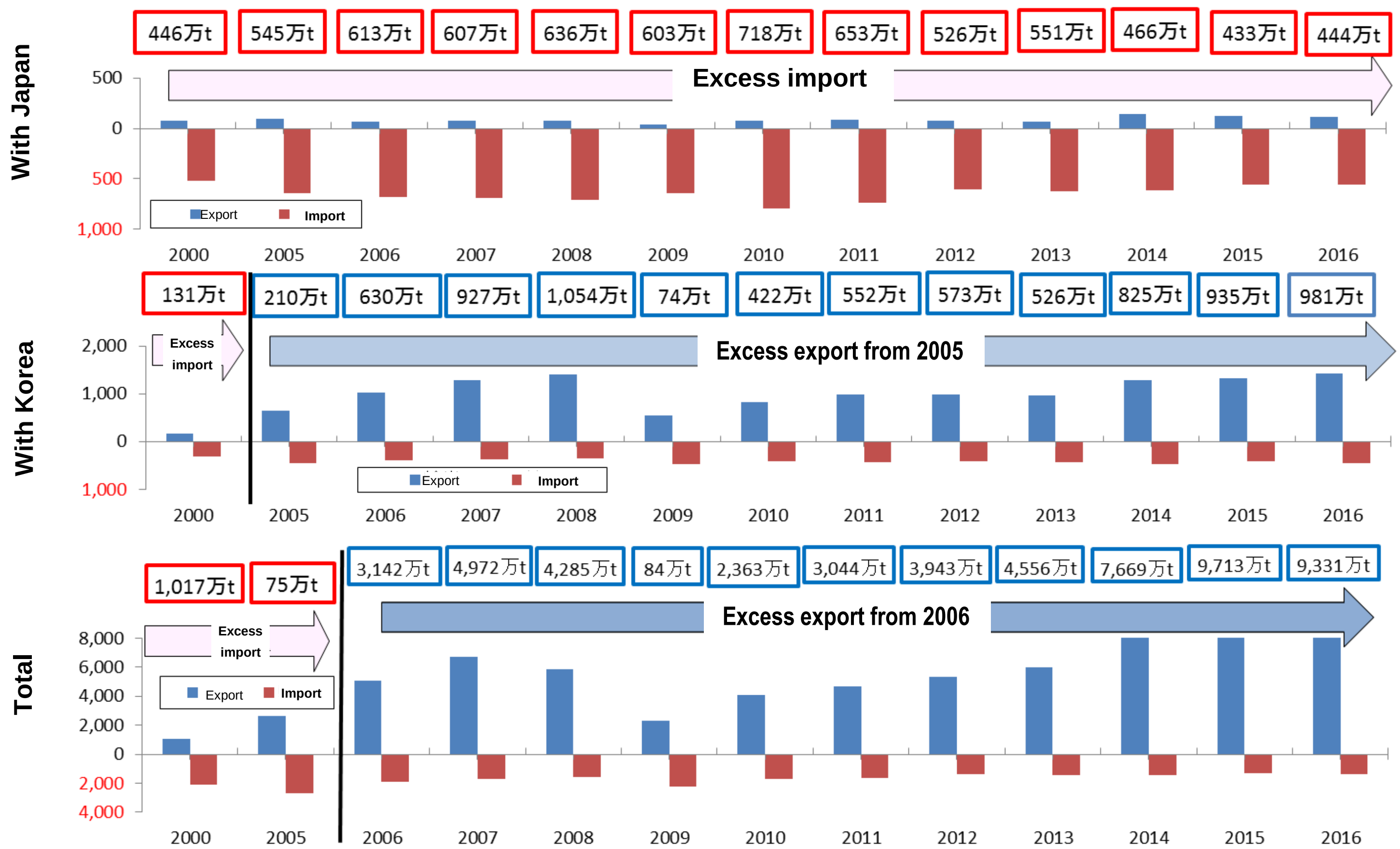


Eco Product: The global competitive edge of the Japanese steel industry, mainly for high-performance steel

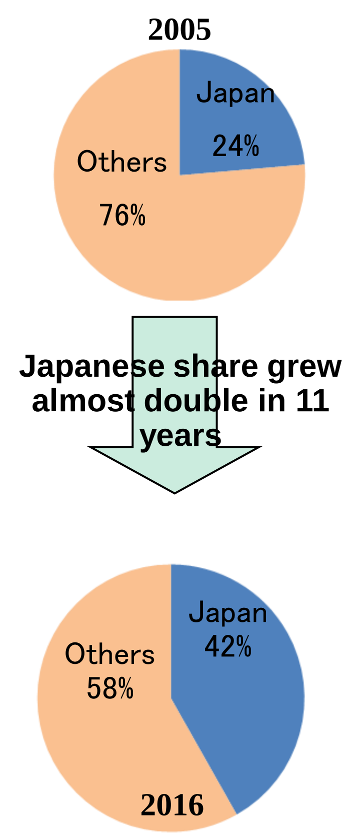
- Steel from other countries cannot match Japan's high-performance steel in terms of performance, quality, supply and other attributes. High-performance steel is the core element of the international competitive edge of the Japanese steel industry.
- China, the world's largest steel producer, became a net exporter of steel in 2006. Only Japan is the only net exporter of steel to China now.

Steel Trade of China (Total)

(10,000 tons)



Japan's share of China's steel imports



Source: Customs statistics China

Quantitative Assessment of High-performance Steel Benefits
(1) Background/Objectives

Study groups and activities

(1) FY1996 Energy Evaluation Survey for Use of Steel Products from an LCA Perspective

- Established a JISF committee headed by a university professor to study this issue.

(2) FY2001 Survey for Contribution of Steel Products to Energy Conservation in Society from an LCA Perspective

- Under the supervision of this JISF committee chairman, a study was conducted with the participation of associations of steel-consuming industries (construction, automobiles, machinery, shipbuilding, electrical equipment) and The Institute of Energy Economics, Japan. Results of this survey are in a paper posted on this institute's website.
- Following up on the FY1996 study, methods were determined for the quantitative measurement of contributions of high-performance steel.

(3) Added exported steel to evaluations in FY2009

- Up to 2008, the survey covered only steel used in Japan. Starting in FY2009, these evaluations have also included emission-reduction benefits of the use of exported steel in finished products in other countries.

Objectives

- Japan's steel industry significantly cut energy use following the oil shocks of the 1970s. But in the 1990s, the pace of efficiency improvements slowed due to increase in processes and treatments for high-performance steel, smaller lots and upgrading of environmental equipment.
- But high-performance steel has a greater energy conservation benefit than ordinary steel does when used in finished products. Also, energy is conserved because producing high-performance steel requires a smaller amount of raw materials. Therefore, high-performance steel must be evaluated by using all characteristics to determine its effect on energy consumption.
- Determining the energy conservation benefit of high-performance steel requires analysis and assessments using an LCA perspective in order to encompass both the manufacturing and utilization stages.
- The LCA approach is critical with regard to viewing measures to fight global warming as rational initiatives for society as a whole. As a result, this method is used to perform a comprehensive analysis and evaluation.

Quantitative Assessment of High-performance Steel Benefits
(2) Calculation Scope/Stages

Scope of calculations

Quantitative assessments cover the following high-performance steel products for which supplementary figures, manufacturing energy use and other data are available.

(1) Automotive high-strength sheets

(2) High tensile strength sheets for shipbuilding

(3) Stainless steel sheets for railway cars

(4) Oriented electrical sheets for transformers

(5) Heat-resistant high-strength pipes for boilers

* High-strength H-beams for building construction were included in the FY2001 survey. But emission-reduction benefits do not appear during a building's use. Benefits are during the manufacture and transport due to using a smaller amount of raw materials for production. Consequently, this steel was excluded from the evaluation of contributions during the use of steel.

Calculation stages

- In most cases, evaluations need to cover the entire life cycle, extending from the mining of natural resources to the discarding of end-of-life products. The FY2001 survey was centered on social benefits of high-performance steel. The survey covered the analysis and assessment of steel production, steel transport, finished product manufacture and finished product use.
- Reports produced by JISF every year place priority on emission reduction figures showing the quantitative benefits to society when products with high-performance steel are used. Therefore, data are only for the finished product use stage.

* The mining and transport of raw materials are only a negligible component of the life cycle of steel. In addition, there was a difficulty in data collection for these stages in the study at that time. Furthermore, the amount of steel used decreases when high-performance steel lowers the weight of a product. As a result, the mining and transport portions fall below the baseline. Regarding assessments other than lighter weight, high-performance transformer electrical sheets and boiler pipes do not reduce the amount of steel used. As a result, the mining and transport portions are the same as the baseline. Excluding the mining and transport portions from evaluations thus prevents an excessive evaluation of the total energy conservation benefit.

* Due to the difficulty of obtaining data concerning steel transport and finished product manufacturing, which are included in the scope of the evaluation, and for other reasons, there are instances where it was not possible to perform adequate analysis.

Quantitative Assessment of High-performance Steel Benefits
(3) Boundaries/Period/Baseline

Boundaries

- Steel used in Japan and exported (exported steel was included starting in FY2009)
- Steel manufactured in Japan and not steel manufactured overseas
- (No Japanese steelmaker has an integrated plant in another country.)

Evaluation period

- Stock (individual years) is evaluated from the standpoint of making comparisons with CO_2 emissions from manufacturing processes in each year.

Steel used for baseline comparisons

- In principle, differences with high-performance steel are evaluated by using steel with no functions (ordinary steel) as the baseline.

  In product categories that do not use ordinary steel, differences with high-grade products are evaluated by using products assumed to be suitable for replacement as of FY2001.

	Baseline	Steel used for comparison	Benefit evaluated
Automobiles	Ordinary steel	High tensile strength sheets (YP340)	Energy saving due to lighter weight
Ships	Ordinary steel	High tensile strength sheets (YP315/YP355)	Energy saving due to lighter weight
Railway cars	Ordinary steel	Stainless steel sheets (SUS301L)	Energy saving due to lighter weight
Trans-formers	Electrical sheets used 30 years ago*	Electrical sheets used now	Energy saving due to lower eddy current loss
Boilers	Boiler pipe for 566ºC steam power plants	High-alloy steel pipes (modified 9Cr-5Mo pipes/heat-resistant pipes)	Energy saving due to high heat resistance and strength (higher generating efficiency resulting from higher temperature of steam)

*Assumes a 30-year life for transformers

(Reference) Methodology Announcements

Overview

http://eneken.ieej.or.jp/data/pdf/462.pdf

1. H-beams for Buildings

http://eneken.ieej.or.jp/data/pdf/463.pdf

2. Power Plant Boilers (Heat-resistant pipes)

http://eneken.ieej.or.jp/data/pdf/464.pdf

3. Automobiles (High-strength sheets)

http://eneken.ieej.or.jp/data/pdf/465.pdf

4. Ships (High tensile strength sheets)

http://eneken.ieej.or.jp/data/pdf/466.pdf

5. Transformers (Oriented electrical sheets)

http://eneken.ieej.or.jp/data/pdf/467.pdf

6. Railway cars (Stainless steel sheets)

http://eneken.ieej.or.jp/data/pdf/468.pdf

(Reference) Major Applications for High-performance Steel

High-strength sheets for automobiles

High tensile strength sheets for ships

Stainless steel sheets for railway cars

Strong and heat-resistant boiler pipes

International Cooperation (1)

Examples of international cooperation for improving products

worldsteel posts case studies of member companies on its website.

Case studies

worldsteel uses a life cycle thinking approach to measure the potential greenhouse gas impacts from all stages of manufacture, product use and end-of-life. The case studies hereunder demonstrate that steel typically offers better environmental performance compared to other materials when a life cycle assessment is carried out. The case studies also show the reduction of CO2 emissions through the increased use of high-strength steels in many applications.

The life cycle of steel

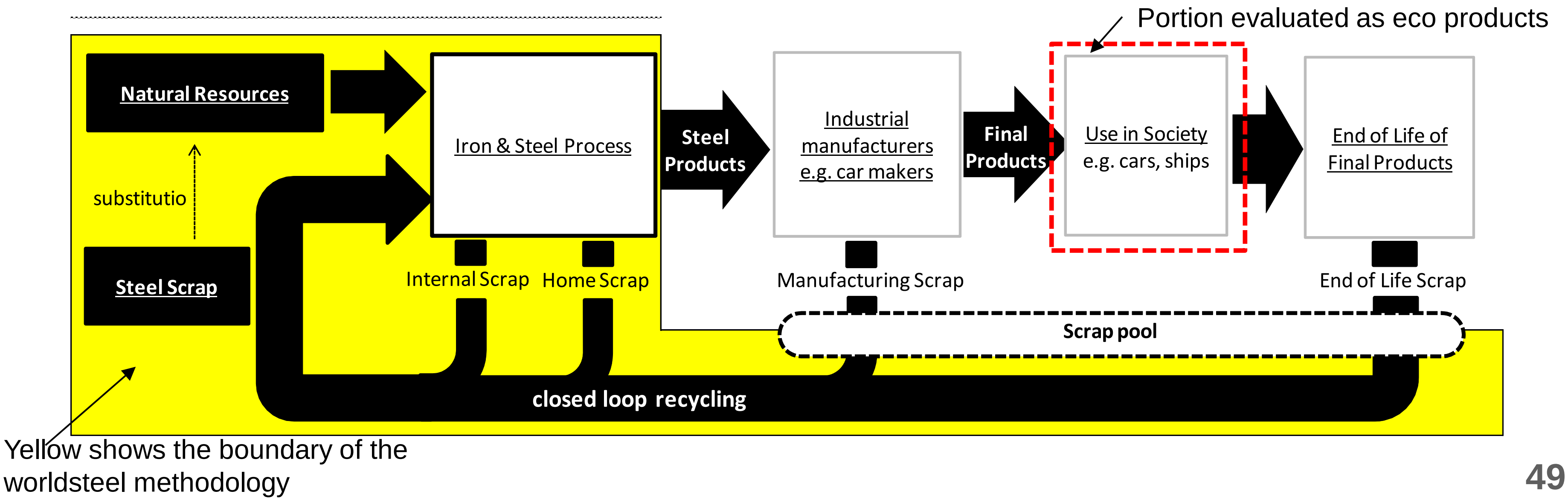
- American Iron and Steel Institute > Utility poles
- ArcelorMittal > Office buildings
- Baosteel › Packaging
- BlueScope > Special Steels
- China Steel Corporation > Motors
- Jernkontoret > Transport
- Tata Steel in Europe › Bridges
- Tata Steel in Europe > Buildings
- Vestas › Wind energy
- WorldAutoSteel › Automotive

https://www.worldsteel.org/steel-by-topic/life-cycle-thinking/case-studies/

International Cooperation (2)

Establishment of steel LCI calculation method and ISO standard (worldsteel-LCA method)

- A method to calculate the environmental value of steel products (for example, the environmental impact per kilogram of hot-rolled sheets)
- This can be used as the environmental impact of the steel portion of a product when a company using steel performs a life cycle assessment of its own products.
- The worldsteel-LCA method has five key points:
  - The blast furnace method and EAF method are both evaluated as a single steel cycle system.
  - Scrap is given an environmental value to reflect the reduction in the use of natural resources, the lower environmental impact and other benefits resulting from the use of scrap.
  - When scrap is used to manufacture steel products, the scrap environmental value and volume of scrap used are multiplied. The resulting number is reflected in the steel product's LCI as the environmental impact associated with the use of scrap.
  - The value of the ability to recycle steel when a finished product reaches the end of its life must be evaluated. To do this, the steel product's LCI incorporates a number obtained by multiplying the scrap environmental value and the recycling ratio.
  - This method conforms with ISO14040 and ISO14044, which are the basic international standards for LCA.
- Activities are under way to establish an international standard (ISO) based on Japan's proposal. The goal is to issue this standard during FY2018. (ISO20915: LCI calculation methodology for steel products)

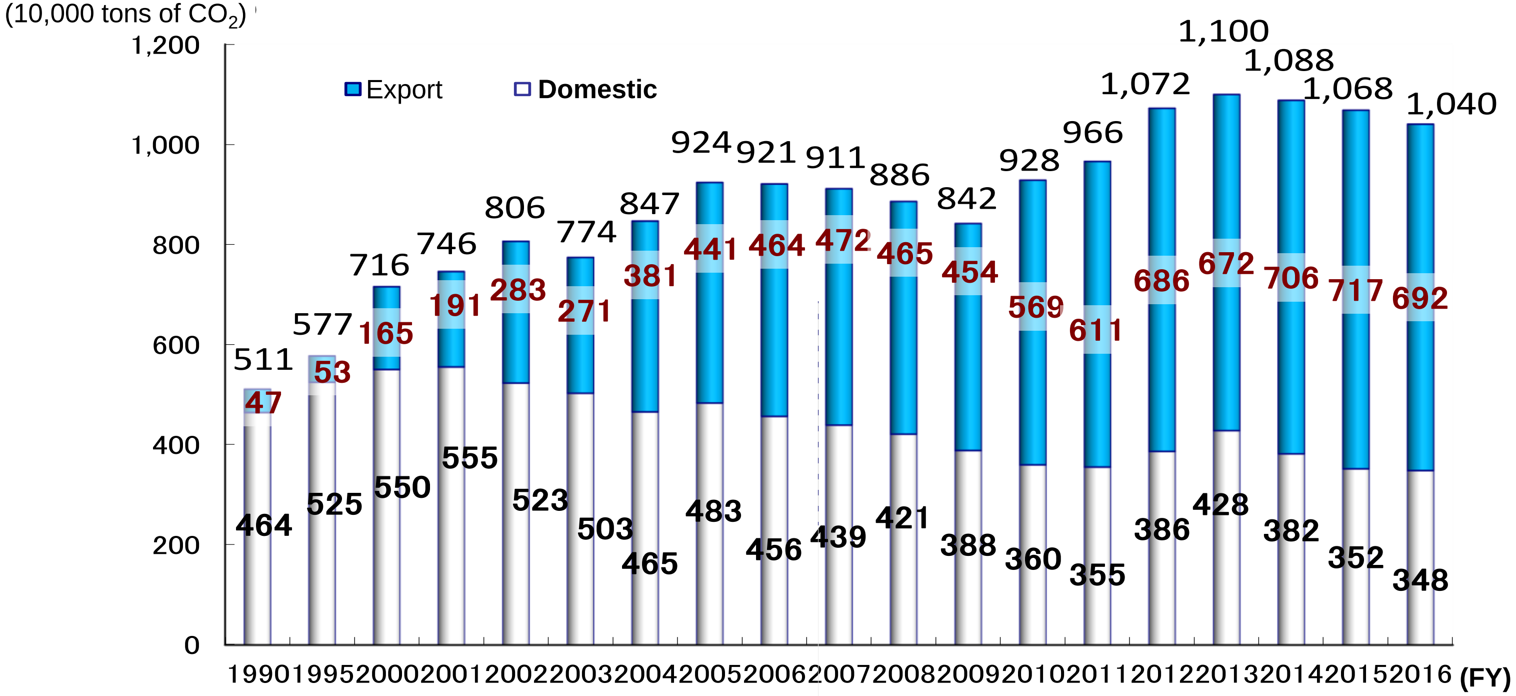


CO_2 Emission Reduction from Blast Furnace Slag Used in Cement

Mixed cement (mainly slag cement) is one way to lower CO_2 emissions related to energy consumption. The use of this cement is growing and a further increase in the production ratio of mixed cement could significantly lower CO_2 emissions.

Replacing conventional cement (Portland cement), which generates CO_2 during the firing of raw materials, with slag cement, which does not generate CO_2 during production, reduced annual CO_2 emissions by 10.40 million tons/year (FY16).

- **Japan: Annual reduction of 3.48 mn tons of CO_2**
- **Exports: Annual reduction of 6.92 mn tons of CO_2**



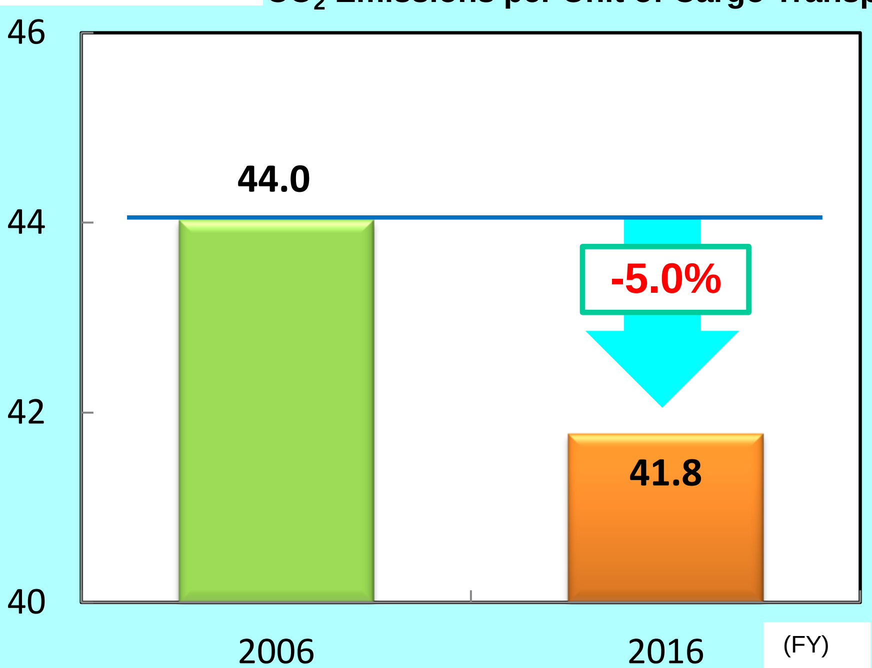
Assumptions for emission reduction contribution Conversion to volume of cement: 450kg of slag/ Ton of cement CO_2 emission reduction: 312kg of CO_2/Ton of cement

Source: Japan Cement Association, Nippon Slag Association

Initiatives in the cargo transport sector

- CO_2 emissions per unit of cargo transport decreased to 41.8kg of CO_2/k ton-km in FY16 from 44.0kg of CO_2/k ton-km in FY06.
- In FY16, the steel industry modal shift (ships + rail) was 77% for primary transportation and 97% for cargo transported more than 500km. This is far higher than the average modal shift rate of 38.1% for all industries in Japan (Ministry of Land, Infrastructure and Transport FY05 data for more than 500km).
- Steelmakers are taking other actions too, such as improving cargo transport efficiency by using a higher pct. of cargo space on ships, utilizing shore-based electric power supplies for ships and using eco-tires on trucks and using eco-friendly driving methods.

CO_2 Emissions per Unit of Cargo Transport



Note: Total CO_2 emissions from use of gasoline, light oil and heavy oil at 49 companies surveyed divided by total ton-kilometers of cargo transported

Fuel saving by using electricity from shore-based sources

Cuts fuel oil use by 70% to 90% while ships are docked

	No. of units
Steel mills	**218**
Junction port	**41**

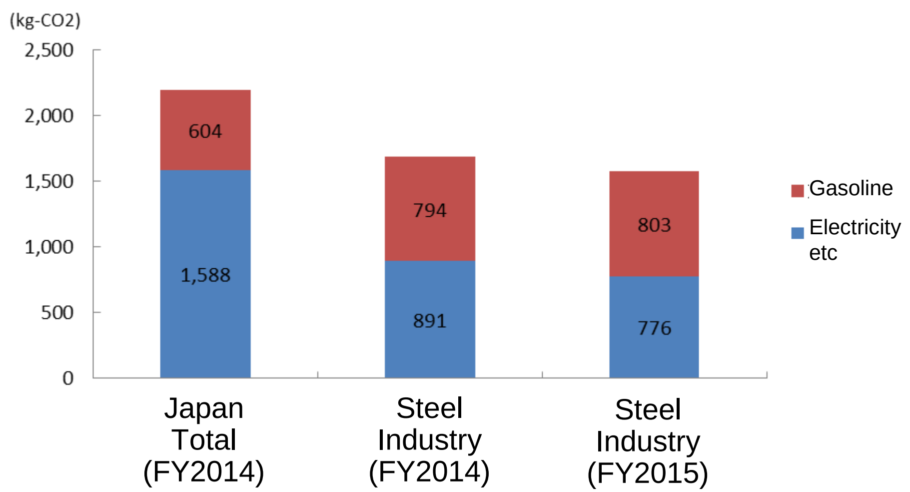
(Totals for 4 blast furnace and 2 EAF steelmakers as of the end of FY16)

Initiatives in commercial/residential sector

- In FY2005, Japan's steelmakers started energy conservation programs using environmental ledgers for residential sector. Steelmakers started education programs that included all employees, including at group companies, promotion of use of household environmental ledgers, and other actions. There are around 18,000 households participating in this program in FY2016.
- Steel industry is taking actions to reduce energy consumption and CO_2 emission from offices. Unit energy consumption in offices in 2016 were down 23% compared to FY 2008-2012.

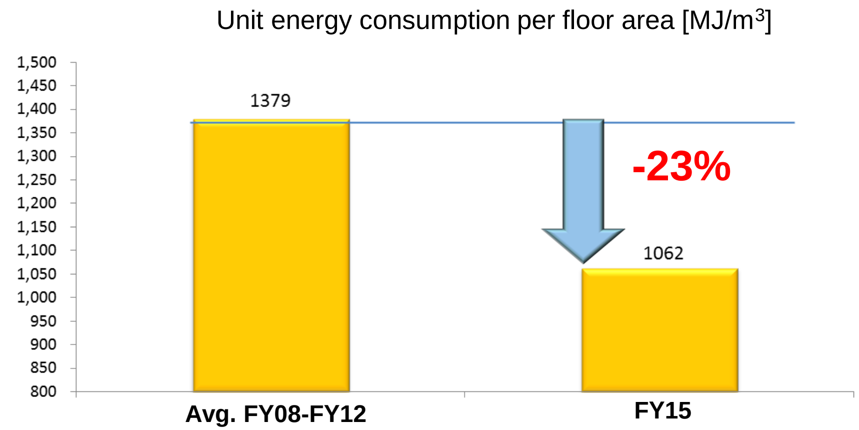
Household CO_2 Emissions

(CO2 emissions per individual: kg of CO2/person-year)



Source: Estimates based on Greenhouse Gas Inventory Office materials
Notes:
1.Total for Japanese households includes households and household use of automobiles.
2. Total for steel industry households is an estimate by JISF based on the inventory in Japan

Unit energy consumption in offices



Data for 339 business sites of 68 companies in FY2016

Example of use of unused energy in nearby locations

Supply of heat to sake companies by a steelmaker in the Kobe area

Equipment to supply heat to sake companies

Features of the heat source system

1. Supply of heat source
   Steam from a power plant is used as the heat source.
2. Energy conservation
   Energy use is down 30% from when each company had its own boiler. Part of steam used for power generation is drawn off from between turbines and supplied in order to reduce energy lost to cooling water.

Equipment

Steam generators	**3**	Steam generation: Heating capacity: Thermal transmission area: Primary steam pressure: Secondary steam pressure:	40 tons/hour 29.5GJ 382m2 1.01MPa (saturation temperature) 0.837MPa (saturation temperature)
Water softener: 1 set			
Water supply method: Two-pipe system with direct-buried steam (300-150A) and recirculated water (50A) (24-hour supply all year)			

Steam generators

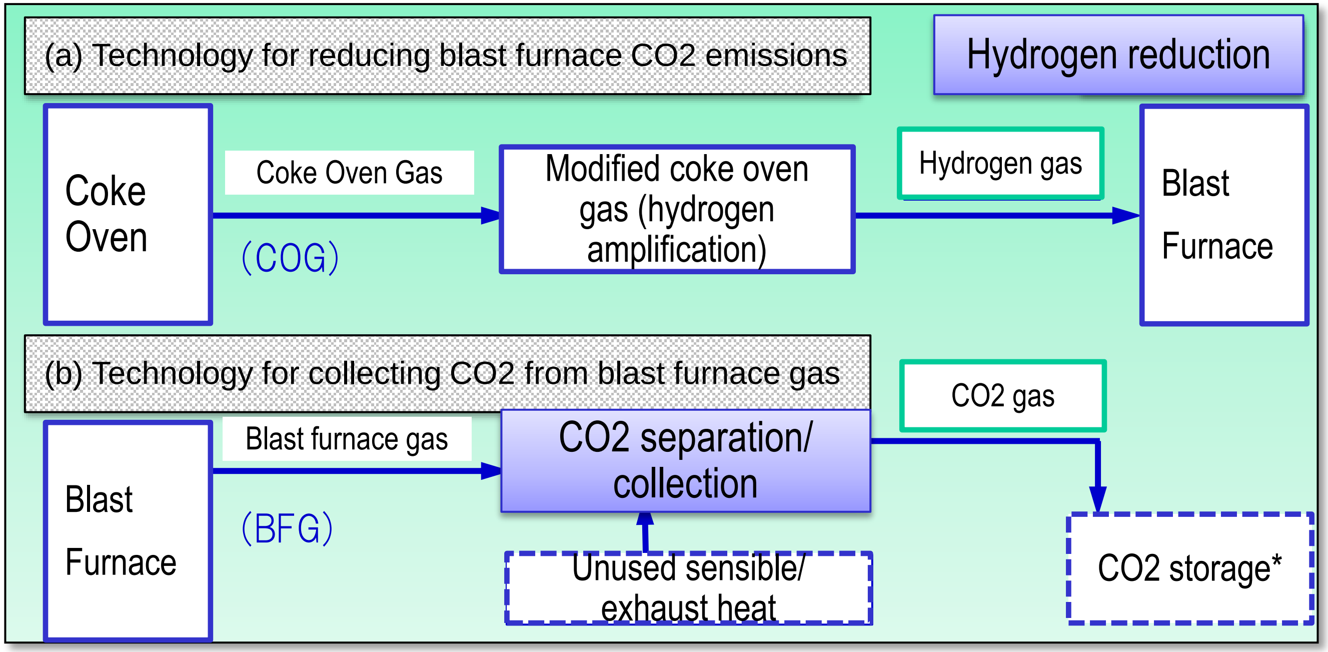
Phase 1, Step 2 (FY13-17) Initiatives

Development item (a): Technology for reducing blast furnace CO_2 emissions

To develop this technology, a 10m3 blast furnace was constructed for testing. Comprehensive trials were performed to verify the results of laboratory research conducted during Phase 1, Step 1. One goal is to create a reaction control technology that maximizes the effectiveness of hydrogen reduction. Another is to obtain data for increasing the scale for phase 2 tests using the demonstration test blast furnace.

Development item (b): Collection of CO_2 from blast furnace gas

The goal is to develop a technology that makes it possible to collect CO_2 at a cost of ¥2,000 per ton of CO_2, which is the cost that matches the requirements of the demonstration test blast furnace. This will require developing a high-performance chemical absorption liquid and other substances, creating a more efficient physical adsorption method, performing applied research for technologies for utilizing exhaust heat, and creating technologies for more cost reductions.



(a)+(b)＝

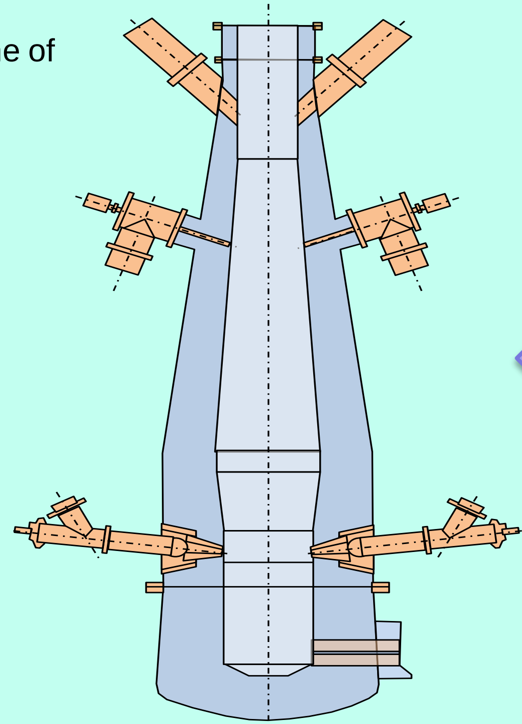
CO_2 reduction target is about 30%

* assumptions are that an international equal footing is established and the necessary social infrastructure is created, including the site selection and establishment of a storage facility for government-led carbon capture and sequestration programs. Targets will be reexamined if these conditions are not fulfilled.

Construction of Trial Blast Furnace

- In Phase 1, Step 2, a $10m^3$ blast furnace for testing was constructed at the Kimitsu Works, which has a trial CO_2 separation and collection system (CAT1, CAT30) that can be used for tests with this blast furnace.
- Trial operations were performed four times during FY2016 and FY2017.

Volume of $10m^3$



Construction and operation of trial blast furnace

CAT1
（1t-CO_2/d）

CAT30
（30t-CO_2/d）

Kimitsu Works CO_2 separation and collection system

Commitment to JISF's Low Carbon Society Phase II

2030←2020

Eco Process

Aiming 9 million-tons CO_2 reduction vs BAU emission in FY2030 by fully implementing state-of-the-art energy technologies

Eco Solution

Contribute worldwide by transferring the world's most advanced energy-saving technologies to other countries (especially to developing countries)and increasing the use of these technologies. (Ca. 50 million ton of CO_2 reduction contribution in FY2013. Ca. 80 million tons of estimated CO_2 emission reduction contribution in FY2030)

Eco Product

By supplying the high-performance steel that is essential to create a low-carbon society, contribute to lowering emissions when finished products using this steel are used.
(Ca. 26 million tons of CO_2 emission reduction contribution in FY2013. Ca. 42 million tons of estimated CO_2 emission reduction contribution in FY2030.)

Development of revolutionary steelmaking processes (COURSE50)

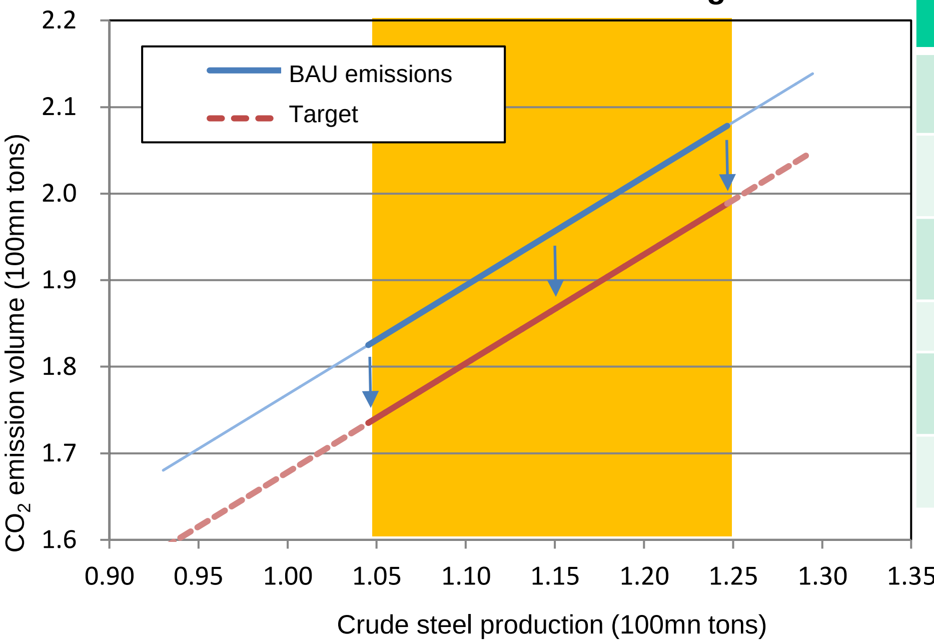
Cut CO_2 emissions from production processes about 30% by using hydrogen for iron ore reduction and collecting CO_2 from blast furnace gas. The first production unit is to begin operations by about 2030*. Goal is widespread use of these processes by about 2050 in line with timing of updates of existing blast furnace facilities.

Development of innovative ironmaking process (Ferro Coke)

Develop ferro-coke that can speed up and lower the temperature of the reduction reaction inside a blast furnace and create the associated operating process. Develop revolutionary technologies that can reduce energy consumption for pig iron production and permit the greater use of low-grade raw materials.

Eco Process (Reduction targets in Japan for production processes)

The 2030 goal for steel production processes is to use advanced technologies as much as possible to lower CO_2 emissions by 9 million tons compared with the volume of these emissions (BAU emission volume) expected from each production volume figure*1 (but excluding the improvement in the electricity coefficient).



Actions	Phase II 2030	Phase I 2020
(1) Improve coke oven efficiency	About 1.3mn tons of CO_2	About 0.9mn tons of CO_2
(2) More efficient electricity generation	About 1.6mn tons of CO_2	About 1.1mn tons of CO_2
(3) More energy conservation	About 1.5mn tons of CO_2	About 1.0mn tons of CO_2
(4) Waste plastics*2	2.0mn tons of CO_2	–
(5) Develop and use revolutionary technologies*3	About 2.6mn tons of CO_2	–
Total	9mn tons of CO_2	3mn tons of CO_2 + Waste plastics*4

These reductions do not include the effect of changes in the electric power emissions coefficient.

Fiscal 2030 Assumption

Crude steel output in Japan (10,000 tons)	Participants' Crude steel output (10,000 tons)	BAU emissions (tons of CO2)	Emissions after target is reached (tons of CO2)
12,000	11,508	19,733	18,833

*1 These targets are based on total crude steel production of 120 million tons in Japan, plus or minus 10 million tons. Emission reductions may be more or less than the anticipated range if there is a significant change in production volume. If there is a significant change, the suitability of the BAU figure and emission reduction will be reexamined in accordance with the actual production level.

*2 Points concerning increasing the use of waste plastics and other waste materials

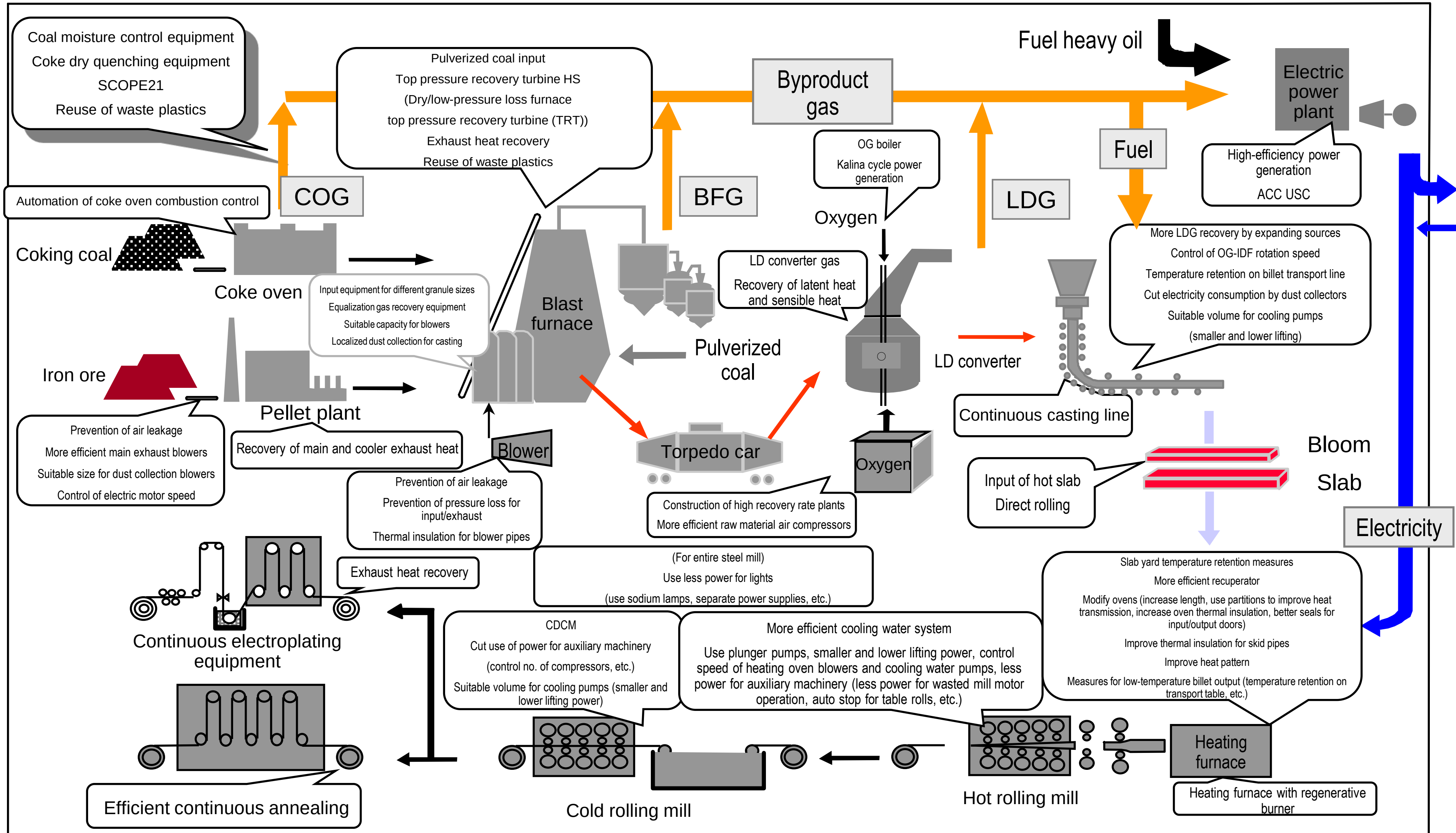
a. Awaiting results of studies concerning a Japanese government review of the container, packaging and plastic recycling system and other related items; may be reviewed (target reduced) if there is no outlook for growth in the waste materials handling capacity of the steel industry by FY2030 in relation to the actual FY2005 capacity.

b. In addition, for the reduction target incorporated in the FY2020 target, awaiting results of a Japanese government study of the recycling system; may be reviewed (target reduced) if there is no outlook for growth in waste materials handling capacity by FY2020 in proportion to the above target.

*3 For the development and use of revolutionary technologies, assumptions are that (a) technologies will be in use in FY2030 and (b) the use of these technologies is economically feasible. In addition, for COURSE50, assumptions are that an international equal footing is established and the necessary social infrastructure is created, including the site selection and establishment of a storage facility for government-led carbon capture and sequestration programs. Targets will be reexamined if these conditions are not fulfilled.

*4 Within the target for the 5 million ton reduction in CO2 emissions in FY2020, the primary focus is on a 3 million ton reduction in CO2 emissions by steelmakers' own initiatives for efficient use of energy and other ways. Concerning collection of waste plastics and other ways, only an increase in the collected volume compared to FY2005 is counted as the amount of reduction in emissions

Steel Production Processes and Development and Use of Energy Conservation Technologies



(Reference) Change in Product Mix for Downstream Evaluations