Activities of Japanese steel industry to Combat Global Warming

Report of “Commitment to a Low Carbon Society”

February 2017

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.

REGISTERED ORGANIZATION

No. N001-ISO 50001

0. Reexamination of FY2020 Targets in Commitment to a Low Carbon Society

JISF's Commitment to a Low Carbon Society – before reexamination

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

2020←2013

Eco Process

Aiming 5 million-tons CO_2 reduction vs BAU emission in FY2020 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. (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.

Interim- Review of the Keidanren's Commitment to a Low Carbon Society

- When the Keidanren's Commitment to a Low Carbon Society was established in January 2013, a interim-review was to be conducted in FY2016, the midway point of this plan, to evaluate progress.
- Based on this policy, each sector participating in Keidanren's Commitment to a Low Carbon Society is invited to conduct a target review if necessary, considering the performance in 2013-15, 2030 Energy Mix and INDC (Intended Nationally Determined Contributions) established by the government in 2015, revisions in business plan etc.
- Results of this interim-review by each sector will be reflected as elements of Keidanren's Commitment to a Low Carbon Society after FY2017.

Excerpt from the Keidanren's Overview of Results of the Commitment to a Low Carbon Society FY2016 Follow-up

*Keidanren: Japan Business Federation

Government Commission Remarks Concerning JISF Targets in the past

- For calculating BAU, incorporating the product mix, such as by incorporating changes in the product mix in the regression equation, would probably result in more precise figures.
- In the interim-examination processes, JISF's target should incorporate CO2 emission increase derived from the shift to high-performance steel.
- How JISF consider the relationship between BAU and old coke ovens (more than 35 years) and effects of major earthquakes for coke ovens?

Interim- Review of JISF Commitment to a Low Carbon Society

JISF’s interim-review is based on Keidanren’s guidance and feedback at governmental committees.

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**

1. Properly determine BAU by reflecting changes in steel production composition

- CO_2 emissions are increasing because the share of pig iron production is rising due to a shift in the product mix compared with steel production in FY2005.
- This change cannot be reflected by using the current calculation method. As a result, the product mix indexes of RITE* will be used in order to properly determine BAU based on changes in the composition of steel production.

Share of Pig Iron in FY2005 and FY2015 (Upstream processes)

	2005	2015	15-05	15/05 (%)
Crude steel (Mt)	112.7	104.2	-8.5	▲ 7.5
BF-BOF (Mt)	83.6	80.6	-3.0	▲ 3.6
EAF(Mt)	28.6	23.3	-5.3	▲ 18.6
Pig Iron (Mt)	82.9	80.5	-2.4	▲ 2.9
BF-BOF (%)	74.2	77.4	3.2	-
EAF (%)	25.4	22.3	-3.1	-
Pig Iron (%)	73.6	77.3	3.7	-

- ◆ 3.7% increase in pig iron's share from FY2005 to FY2015

Share of Long and Flat Products in FY2005 and FY2015 (Downstream processes)

		2005 ratio (%)	2015 ratio (%)	15-05
Long	Shape	7.5	6.8	-0.7
	Bar	12.3	9.9	-2.4
	total	**23.5**	**20.0**	**-3.5**
Flat	Plate	11.3	10.4	-1.0
	HRS	11.3	19.7	8.3
	Cold-rolled flat products	8.6	7.8	-0.9
	Galvanized sheet	14.6	12.3	-2.3
	total	**46.3**	**50.7**	**4.3**

- ◆ Between FY2005 and FY2015 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.

Determination of FY2015 Emissions Using RITE Product Mix Indexes

Upstream: 5.292mmtCO2

Downstream: -2.226mmt-CO2

Total: 3.065mmt-CO2

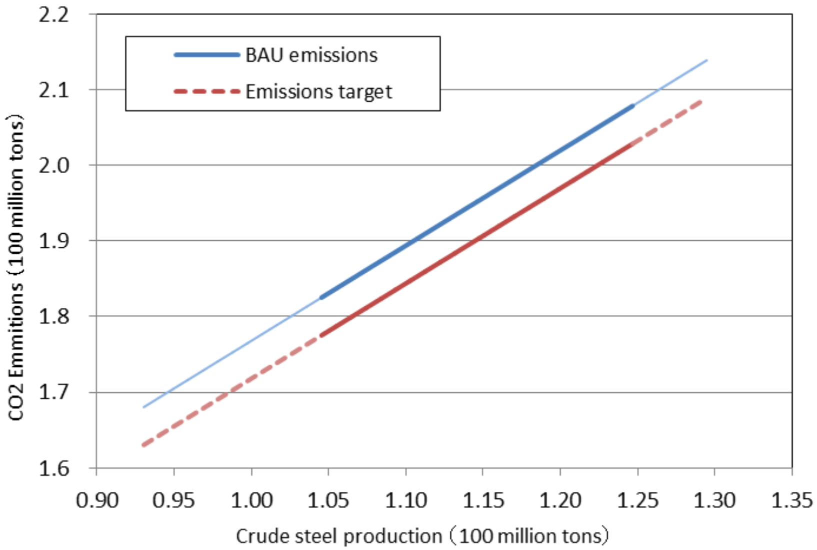
*RITE: Research Institute of Innovative Technology for the Earth

Using RITE Indexes for the Proper Determination of BAU

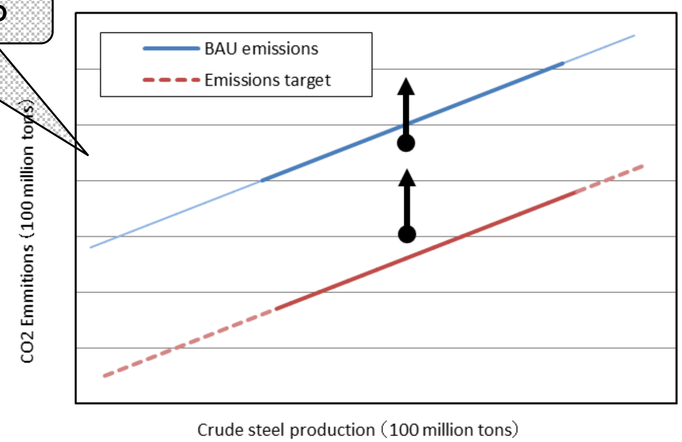
- JISF's Commitment to a Low Carbon Society has a BAU line using the premise of no change in the FY2005 product mix (graph on left).
- At the interim-review in FY2016, the previous method was used while also using the production composition indexes created by RITE. Using differences in the composition of production each year in relation to FY2005 output, which could not be incorporated with the previous method, yields more accurate figures for emissions (graph on right).

Used for FY2015

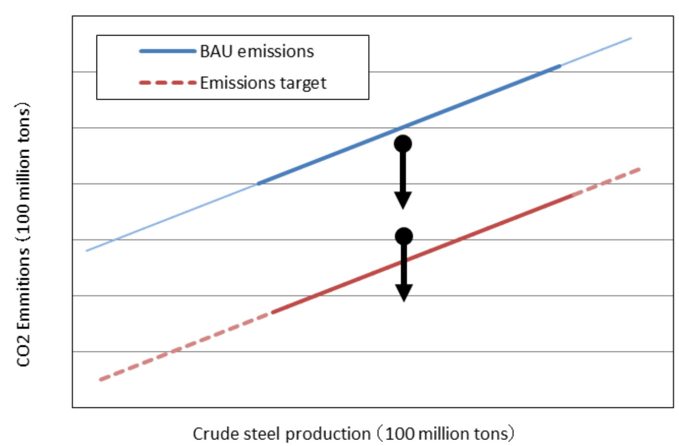
BAU and Target Line with Previous Method



Positive RITE Index



Negative RITE Index

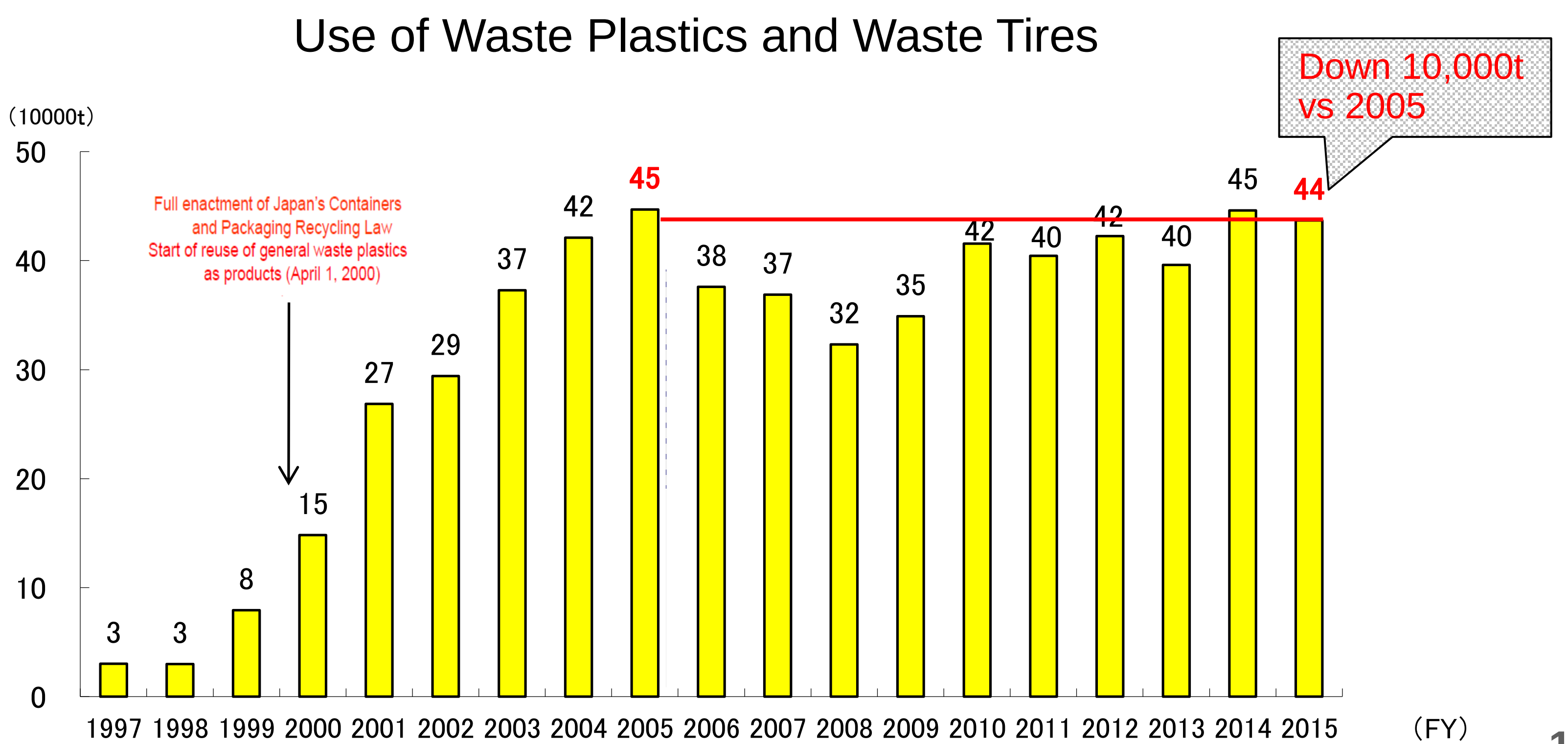


* This target assumes that Japan's crude steel output will be 120 million tons, with a variance of no more than 10 million tons.

* 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.

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.



JISF's Commitment to a Low Carbon Society – after reexamination

Japanese steel industry is supporting the Commitment to a Low Carbon Society by fighting global warming with the "three eco's" 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)

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

1. Eco Process

FY2015 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: 101.13 million tons (down 6.4% from FY05)
- BAU emissions for FY15 crude steel production: 182.66 million tons of CO_2 (1)
- CO_2 emissions (using FY05 electricity coefficient): 180.42 million tons (down 4.3% from FY05) (2)
- Reduction vs. BAU ((2) – (1)): 2.24 million tons of CO_2 (760,000 tons above the target)

FY2015 Energy Consumption and CO_2 Emissions

- Energy consumption: 2,178PJ (down 4.8% from FY05)
- CO_2 emissions (using electricity coefficient with FY15 credit): 183.82 million tons (down 2.5% from FY05)

Reference: Japanese steel industry total

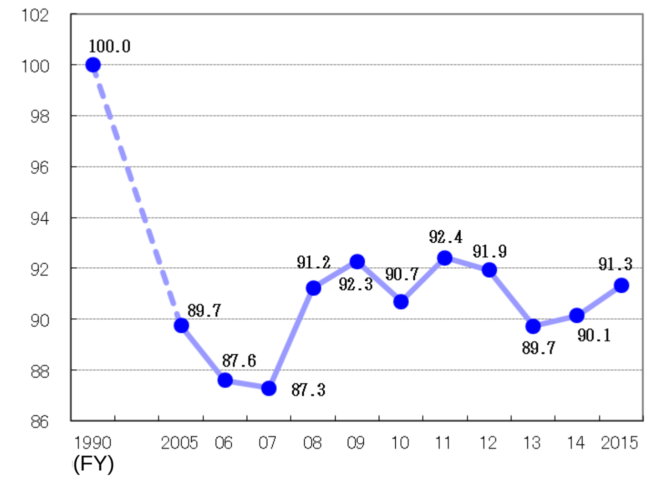
- Crude steel production: 104.23 million tons (down 7.5% from FY05)
- Energy consumption: 2,250PJ (down 4.7% from FY05)
- CO_2 emissions (using electricity coefficient with FY15 credit): 188.23 million tons (down 2.3% from FY05)

* 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

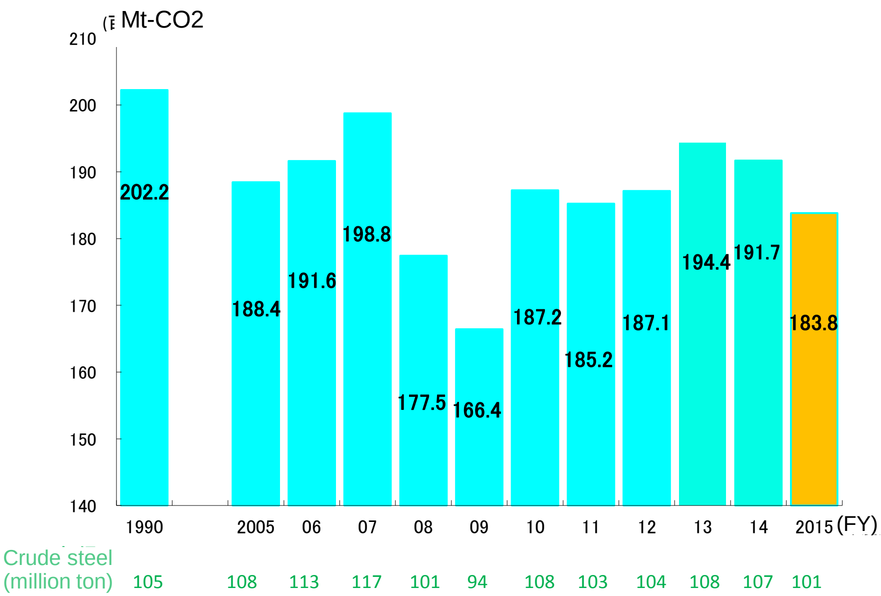
Total Energy Consumption

Unit Energy Consumption (Based on FY1990)



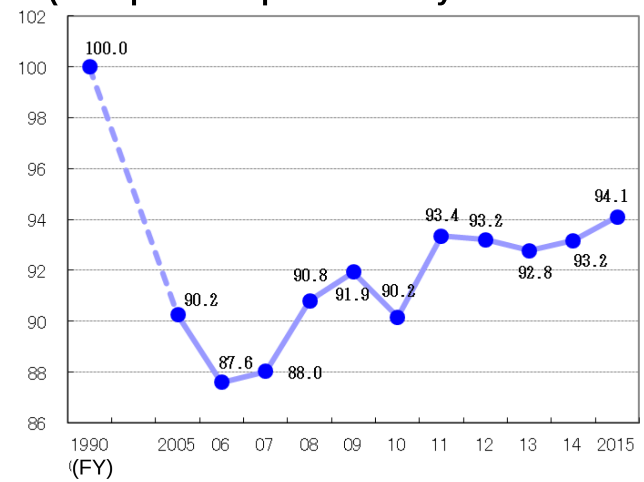
CO_2 Emissions from Fuel Combustion

(Incorporate improvement by emission credit)



Unit CO_2 Emissions (Based on FY1990)

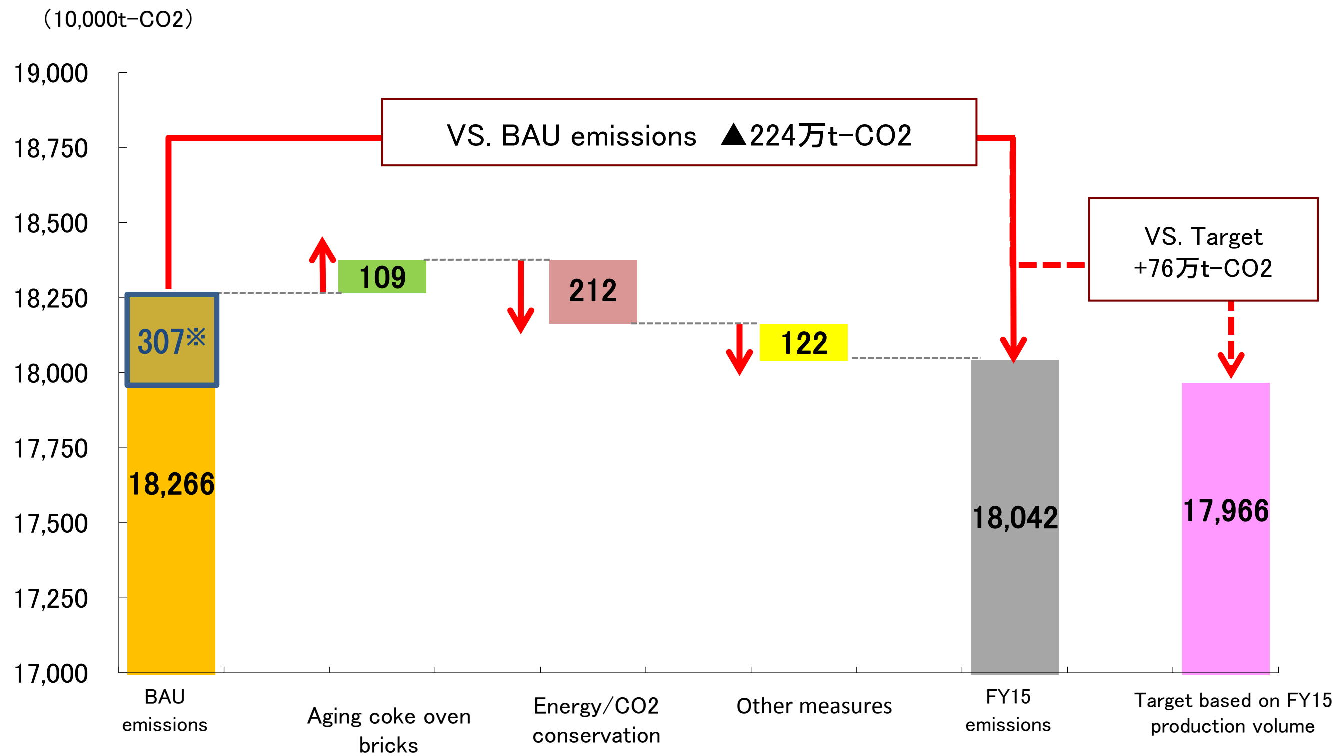
(Incorporate improvement by emission credit)



*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 FY2015 CO2 Emissions

- In FY2015, CO_2 emissions were 2.24 million tons below the BAU level, after adjustments using the RITE index. Aging bricks in coke ovens raised emissions by 1.09 million tons, energy and CO_2 conservation measures cut emissions by 2.12 million tons, and other measures cut emissions by 1.22 million tons.
- Regarding the target, the emission reduction was 0.76 million tons below the target of 3 million tons from the voluntary actions of steelmakers.
- More reductions are possible if the use of waste plastics and other recycled materials grows.



*FY2015 CO_2 emissions use the FY2005 electricity coefficient.
*RITE production composition difference index

Evaluation of FY2015 Performance

In FY2015, there was progress with using voluntary actions to cut emissions. However, emissions were higher than the target because of factors that could not be anticipated when the target was established.

1. Anticipated progress when target was established

	Expected target	FY2015	
Reductions from voluntary actions ● Higher coke oven efficiency ● More efficient power generation ● More energy conservation	-3Mt	-2.15Mt	• Progress of more than 70% toward the target between FY05-FY15 (10 years) • Aiming for 0.85 Mt reduction over the next five years
Increase use of waste plastics and other recycled materials	-2Mt	+0.04Mt	• 2 million ton reduction assumes that the required collection system will be established • 40,000 ton emission increase because recycled materials collected declined a marginal 10,000 tons between FY05-FY15 due to system problems and other issues
Total (1)	-5Mt	-2.12Mt	

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

	Expected target	FY2015	
Aging coke oven bricks	—	+1.09Mt	• 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	—	-12.2Mt	• Difficult to analyze causes, but one probably cause is efforts by operational improvement in steel mills.
Total (2)	Not included	-0.13Mt	

(1) + (2) = 2.24 Mt (0.76Mt 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 five 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 January 2017)

Year	Plan	Cost
FY2013	**Coke oven update (completed)**	
	JFE Steel, West Japan Works, Kurashiki	About ¥15 billion
FY2015	**Coke oven update (completed)**	
	JFE Steel, West Japan Works, Kurashiki	About ¥20 billion
	Coke oven update (started)	
	Nippon Steel & Sumitomo Metal, Kashima Works	About ¥31 billion
FY2016	**Coke oven update (completed)**	
	Nippon Steel & Sumitomo Metal, Kashima Works	About ¥18 billion
	JFE Steel, East Japan Works, Chiba	
	Nippon Steel & Sumitomo Metal, Kimitsu Works	About ¥29 billion
	Coke oven update (planned)	
	JFE Steel, East Japan Works, Chiba	
FY2017~	**Coke oven update (planned)**	
	Nippon Steel & Sumitomo Metal, Kimitsu Works	About ¥33 billion

Major Initiatives since FY2005

1. Next-generation coke oven (SCOPE21)

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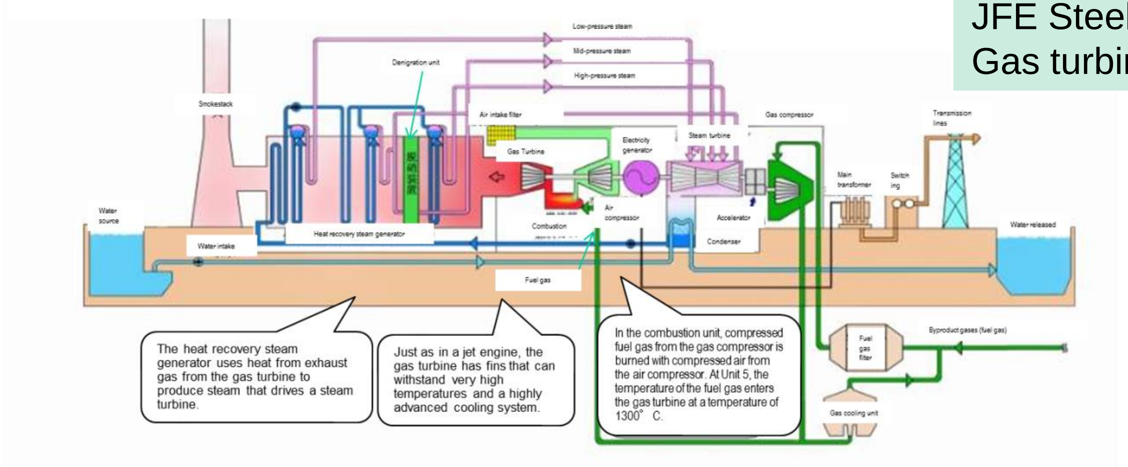
Nippon Steel & Sumitomo Metal Oita Works (2008)
Nippon Steel & Sumitomo Metal Nagoya Works (2013)

2. More efficient power

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)

Advanced Combined Cycle Power Generation



Source: Kimitsu Cooperative Thermal Power Company, Inc.

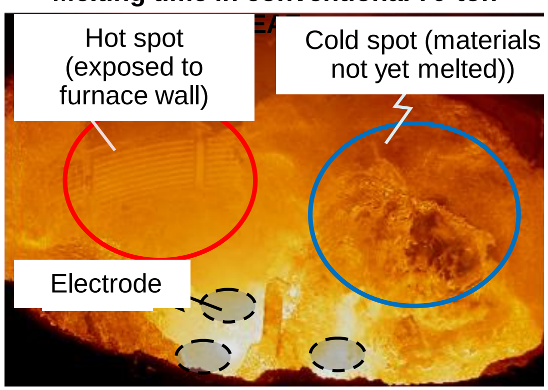
Energy Conservation in Electric Arc Furnace (EAF)

- 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 EAF

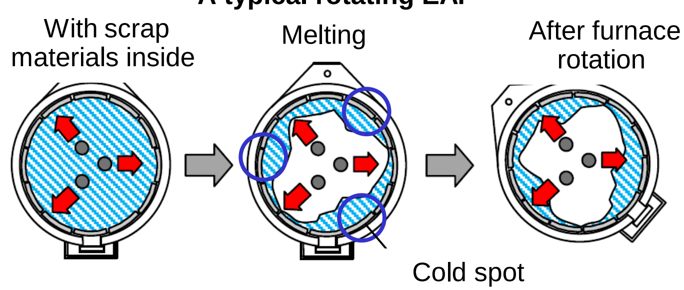


Source: Daido Steel

Rotating Furnace Technology

- Maximum furnace rotating angle is 50°

A typical rotating EAF

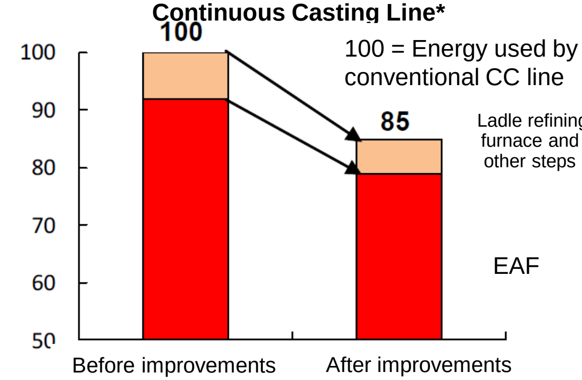


A rotating electric arc furnace

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%.

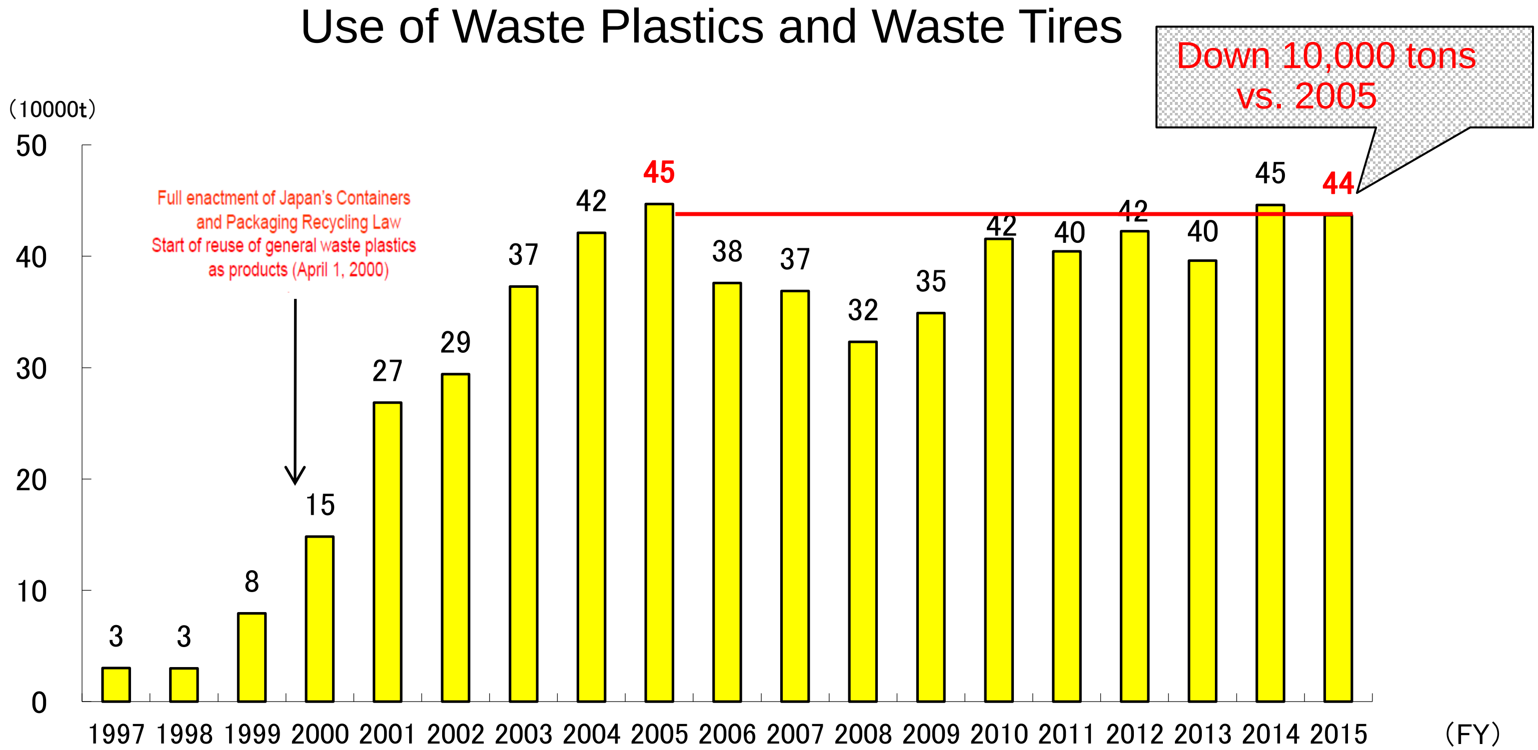
Energy Saving Due to Streamlined Continuous Casting Line*



* 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 440,000 tons in FY2015, a small decline of 10,000 tons compared with FY2005 collections of recycled materials.
- A big 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.



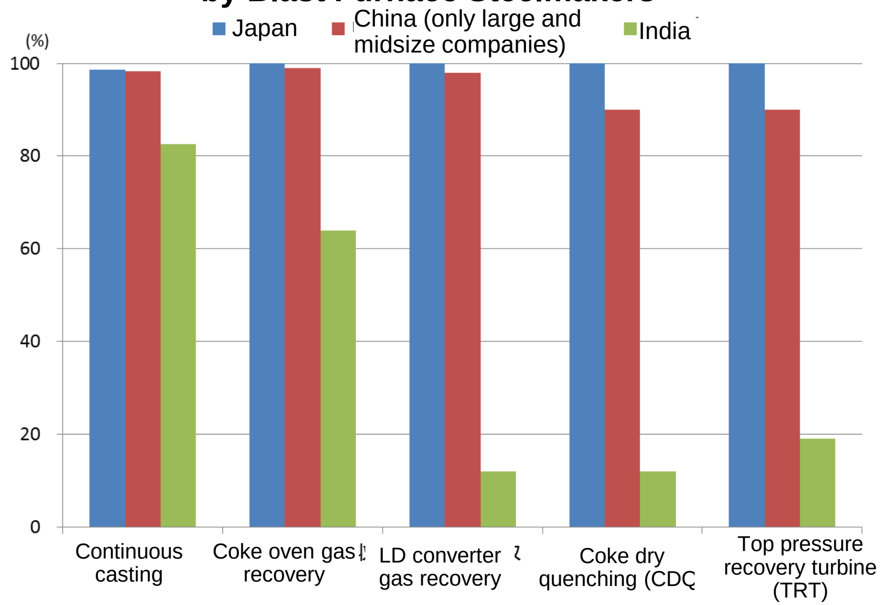
Source: The Japan Iron and Steel Federation

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 5.5 million tons.

Utilization Rates of Major Energy Conservation Equipment by Blast Furnace Steelmakers



Emission Reductions in Other Countries from Japanese Energy-conserving Equipment

(Mt/year)

	No. of units	Reduction
Coke dry quenching (CDQ)	95	17.80
Top-pressure recovery turbines (TRT)	60	10.79
Byproduct gas combustion (GTCC)	47	16.34
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	54.58Mt

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

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

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(2010~2016)
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* (2009～2013)
International standard for the calculation of CO_2 emission from steel plants, issued in March 2013 for integrated steel plants and EAF. Currently preparing new version for DRI-EAF.

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

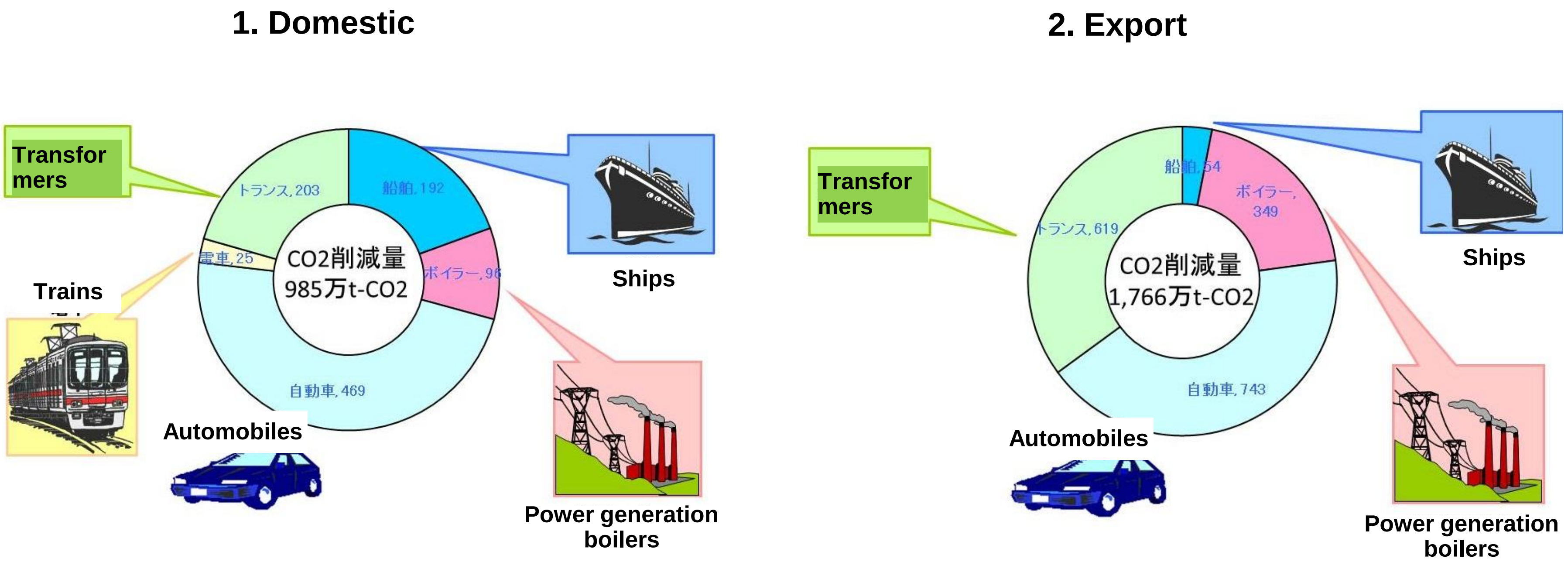
➢Generator parts

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 (FY2015 production of 7.24 million tons, 7.2% of Japan's total crude steel output). The use of finished products made of high-performance steel cut FY2015 CO_2 emissions by 9.85 million tons for steel used in Japan and 17.66 million tons for exported steel, a total of 27.51 million tons of CO_2.

CO_2 Emission Reductions by the five major types of high-performance steel (FY2015)



CO_2 Emission Reductions: 27.51 million tons CO_2 in total (7.24 million tons of high-performance steel)

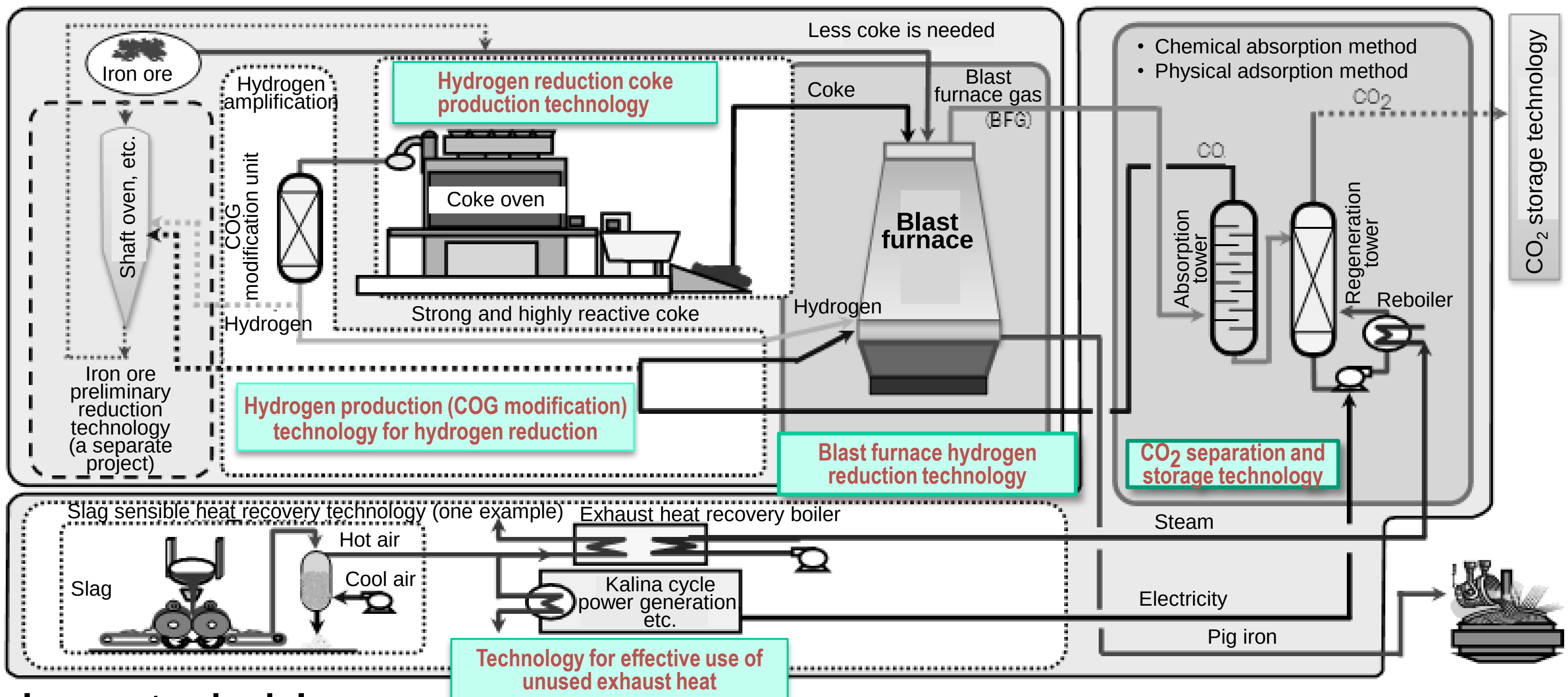
Source: The Institute of Energy Economics, Japan
*The five categories are automotive sheets, oriented electrical sheets, heavy plates for shipbuilding, boiler tubes and stainless steel sheets. In FY2015, use of the five categories of steel products in Japan was 3.696 million tons and exports were 3.544million tons for a total of 7.240 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)

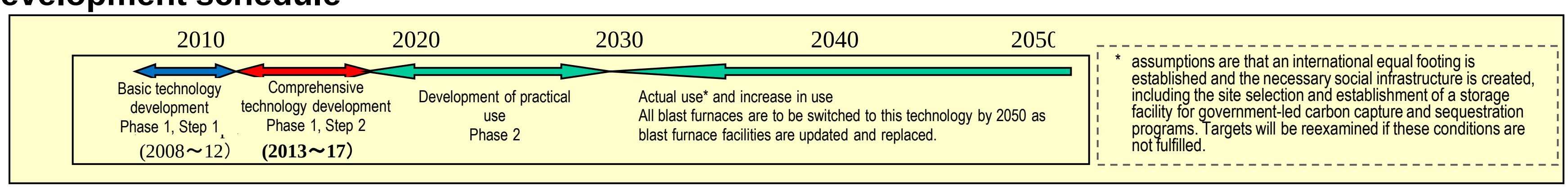
Development of Environmentally Responsible Steelmaking Processes (COURSE50)

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

Effective Use of Waste Plastics (Containers and Packaging Recycling)

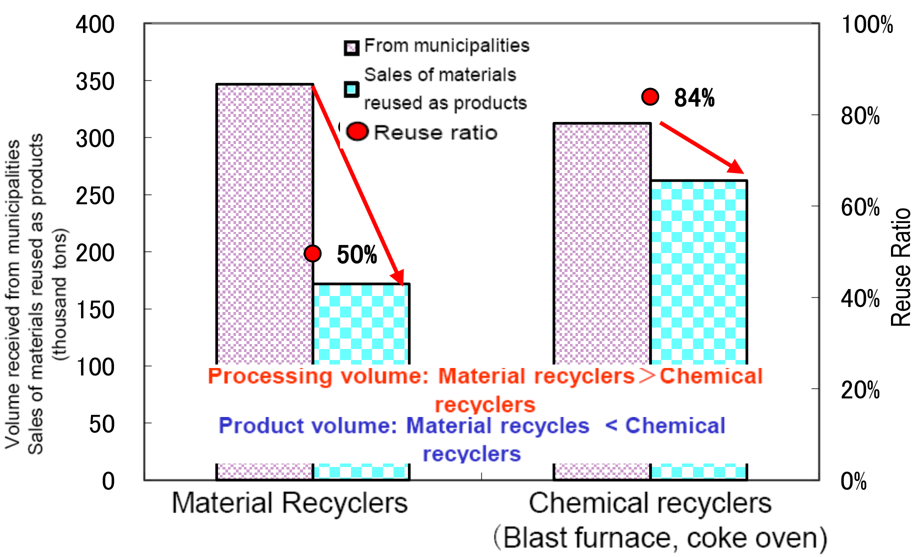
- Due to priority on recycling materials, purchased 250,000 tons of waste plastics in FY2015 under the container and packaging recycling system; current waste plastic processing capacity in the steel industry is about 400,000 tons, leaving significant unused capacity (utilization rate is slightly over 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.

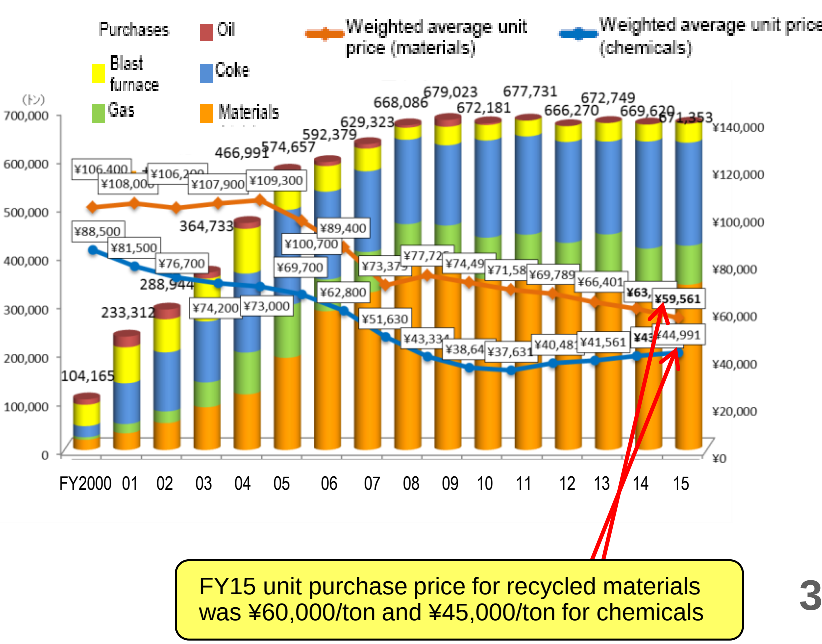
(2) A payment system should be considered to provide incentives to local governments that cut costs below a certain level or make big improvements; this would lower the social cost of recycling by encouraging local governments to improve efficiency of collecting and storing waste materials in separate 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 (2015)



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

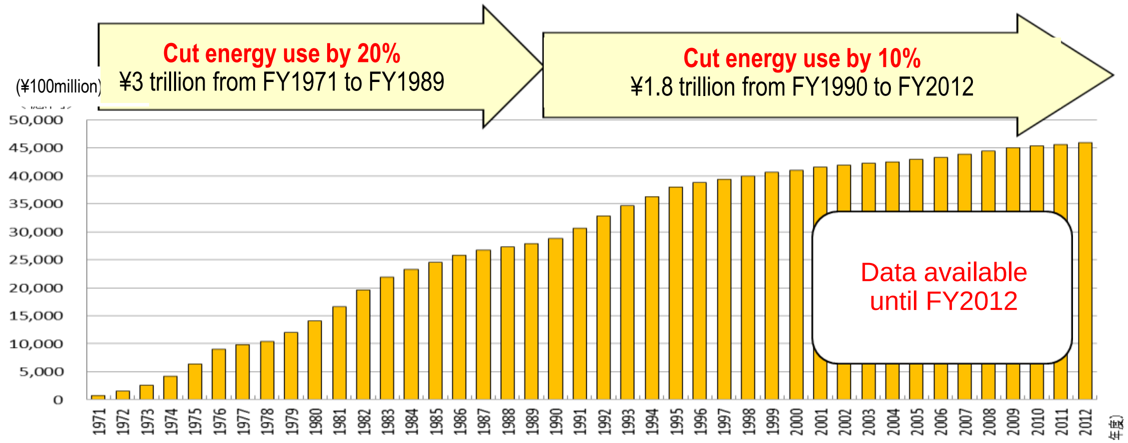


Source: The Japan Containers and Packaging Recycling Association

Investments for Environmental Protection and Energy Conservation

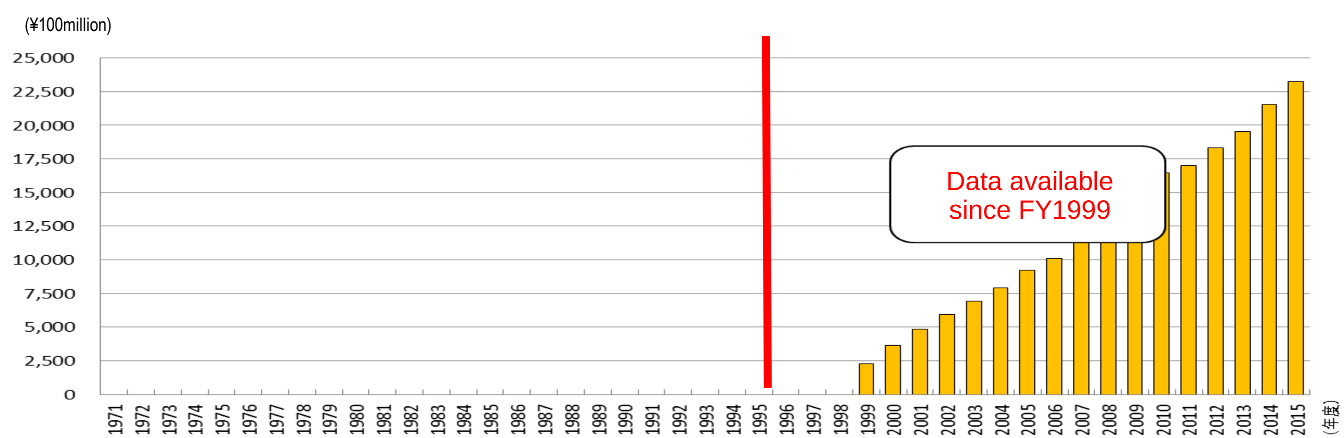
- Japanese steel industry made investments of about ¥3 trillion between FY1971 and FY1989 for environmental protection and energy conservation. These investments totaled about ¥1.8 trillion between FY1990 and FY2012.
- Investments for rationalization and labor-saving totaled about ¥1.4 trillion between FY2005 and FY2015.

Fig. Accumulative investment for environmental facilities since FY1971



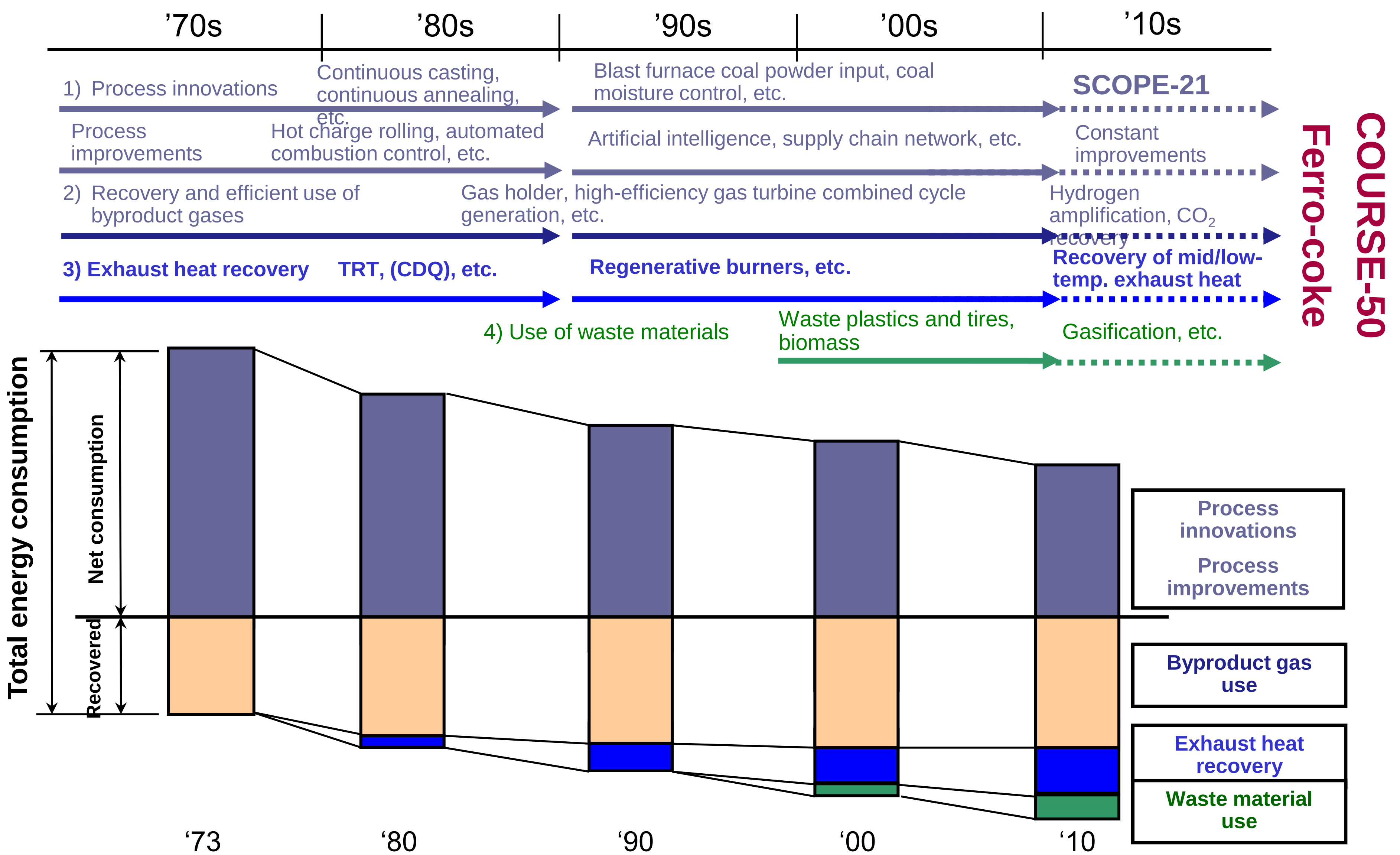
Source: ~FY2011: METI Survey on Capital Investments of Major Industries, FY2002~: METI Survey on Corporate Finance (former Survey on Capital Investments)

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



Source: Development Bank of Japan Inc

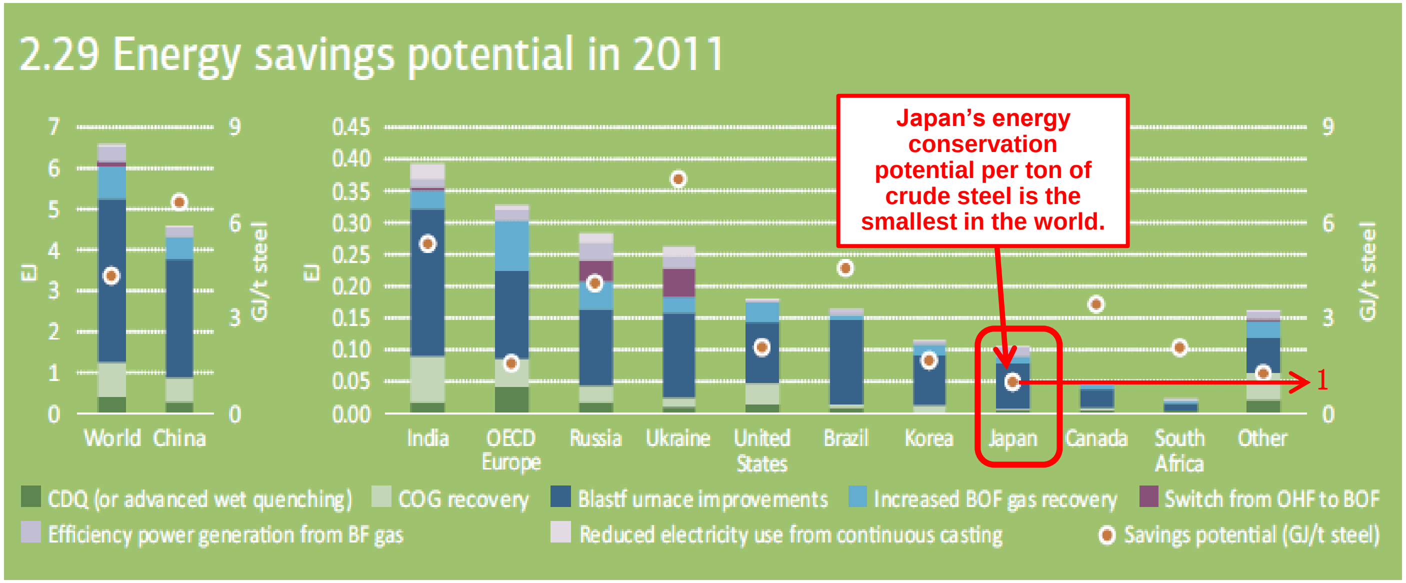
Energy Conservation Initiatives of the Steel Industry



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"

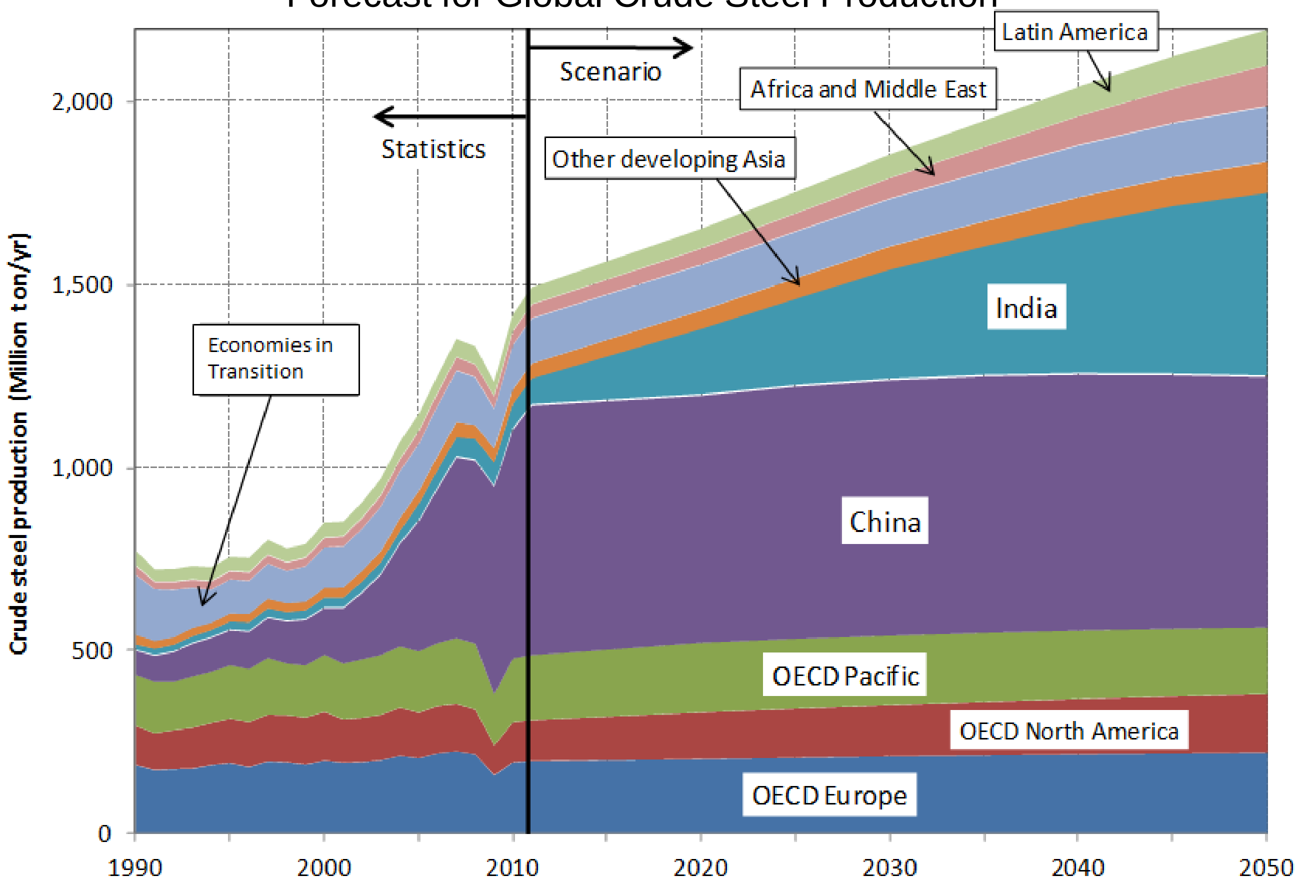
Comparison of Steel Industry Energy Efficiency (2010)

Source: RITE "Estimated Energy Unit Consumption in 2010"
(converted to an index by JISF)

Importance of Increasing Eco Solution

- Global steel demand is expected to increase, mainly in emerging countries, and steel production will climb with this demand. The RITE forecast for 2050 global crude steel production is 2.2 billion tons. This is about 30% higher than the 1.67 billion tons in 2014.
- Technologies are the only way to minimize CO_2 emissions as demand for steel increases. Japan's steel industry is the most energy-efficient in the world. Sharing energy conservation technologies and increasing their use will become even more important as an effective means of fighting global warming.

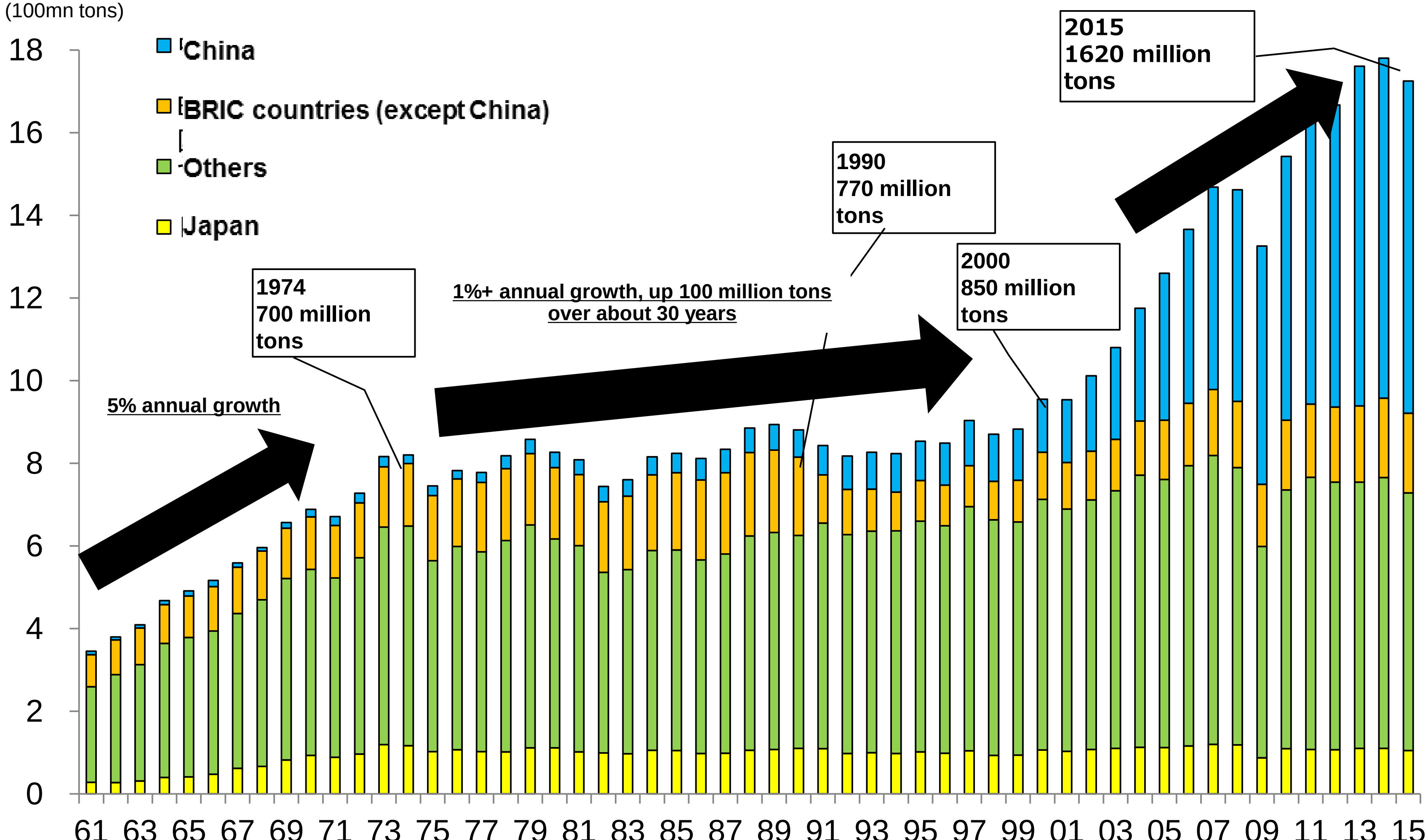
Forecast for Global Crude Steel Production



Source: Excerpt from "Research for Strategy to End Global Warming and Achieve a Sustainable Economic Society – ALPS Project" (April 2011) by RITE

Eco Solution: Global Crude Steel Production (Countries and regions)

- Global crude steel production in 2015 was 1.62 billion tons. During the 25 years since 1990, production has approximately doubled.
- China is the world's largest producer of greenhouse gases. China's steel production has grown more than tenfold since 1990 and the country accounts for almost half of global steel production volume.



Source: worldsteel

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 CO2 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

Eco Solution: Three pillars of the energy management in the steel plant

ISO14404 (issued in March 2013)

- This standard, which incorporates the proposal of the Japanese steel industry, permits comparisons and evaluations using more effective data by establishing uniform global indicators for individual steel mills for energy efficiency (unit CO_2 emissions)

Technologies Customized List (List of facilities and technologies)

- Includes the most suitable energy conservation equipment based on the characteristics of each country using items selected from the steel industry list of this equipment (India: 19 items, including CDQ and TRT)

Energy Management System (ISO50001 certified in Feb. 2014)

- An energy management system ideally suited for conducting energy conservation activities

Accurate measurements and evaluations by using a uniform standard (ISO14404)

Your blood pressure is higher…..

Best energy conservation technologies based on evaluations (Technologies Customized List)

I will give you medication to lower your blood pressure.

You need to exercise regularly.

Energy conservation PDCA (ISO50001)

Take medicine every day and jog on weekends

Measure blood pressure daily to confirm progress and work even harder if there are no benefits!

Higher energy efficiency (Goal achieved)

Meet targets and return to good health!

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 eighth conference took place in Tokyo in October 2016. On its tenth anniversary, this gathering covered the significant progress at Chinese steel mills involving environmental protection and energy conservation.

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

- Started in 2011, this meeting has been held six 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 (2013~)

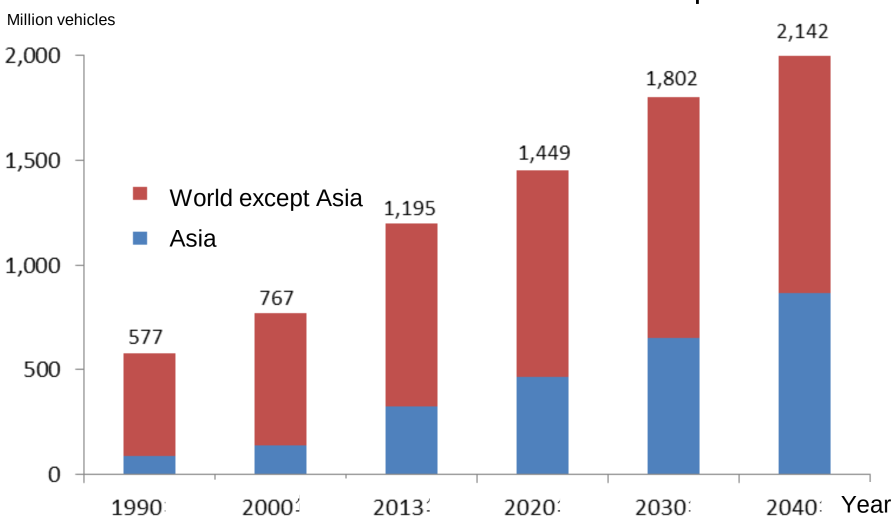
- Started in February 2014, this initiative brings together steel industry energy conservation professionals from Japan and six ASEAN countries. There have been three public/private-sector conferences for the entire ASEAN region and one workshop for each ASEAN country participating in this initiative. The initiative is a valuable opportunity for sharing thoughts about how the ASEAN steel industry can conserve energy.
- There have been steel plant diagnosis at 12 ASEAN steel mills in order to provide advice for improving operations and using new technologies.

The Importance of Increasing the Use of Eco Product

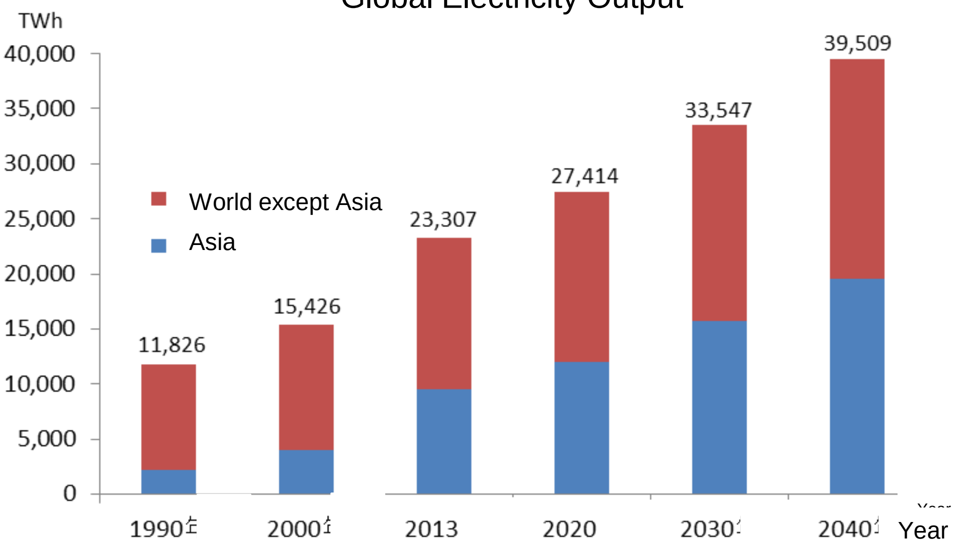
- High-performance steel generally has higher CO_2 emissions than ordinary steel does during the manufacturing stage. But high-performance steel is an eco product because it greatly lowers CO_2 emissions when used by making finished products more energy efficient.
- By supplying high-performance steel, 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

Global Automobile Ownership



Global Electricity Output

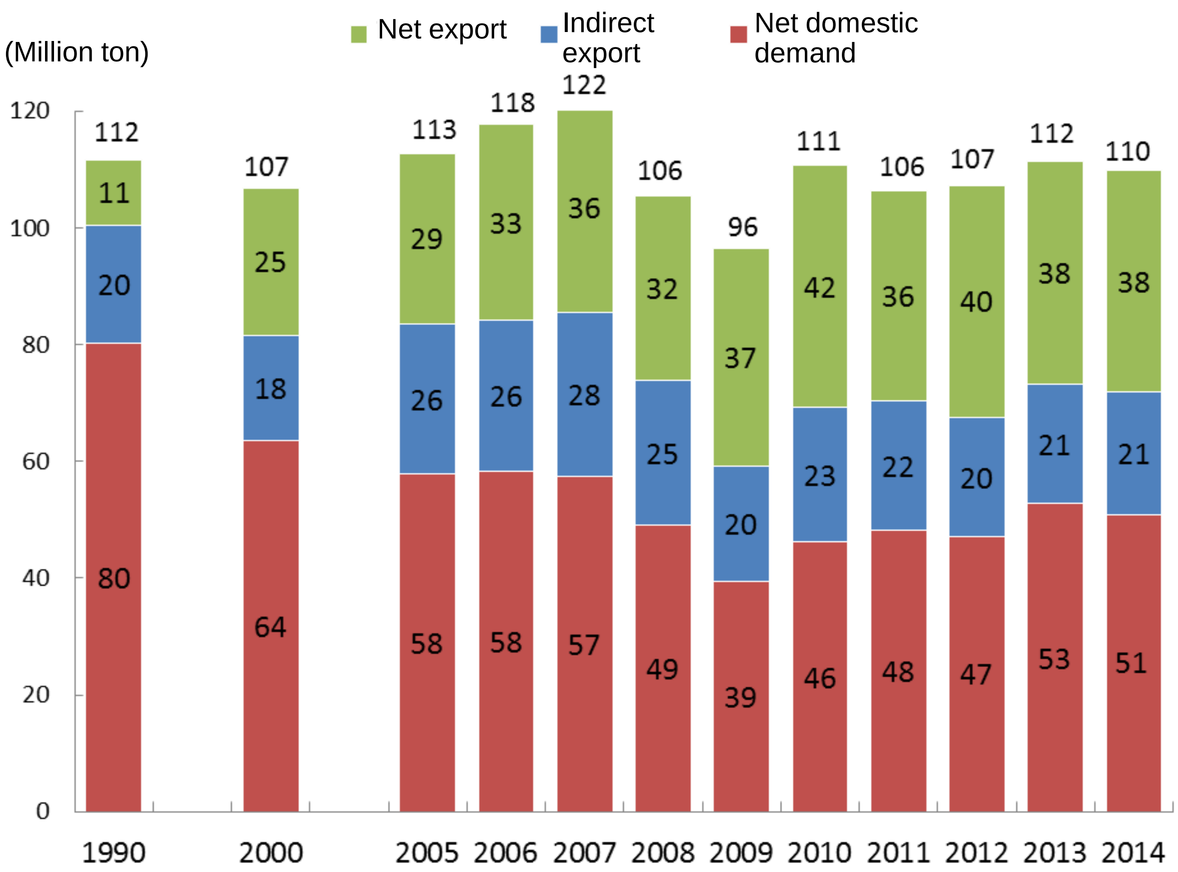


Source: The Institute of Energy Economics, Japan

Crude steel production trend per demand in Japan

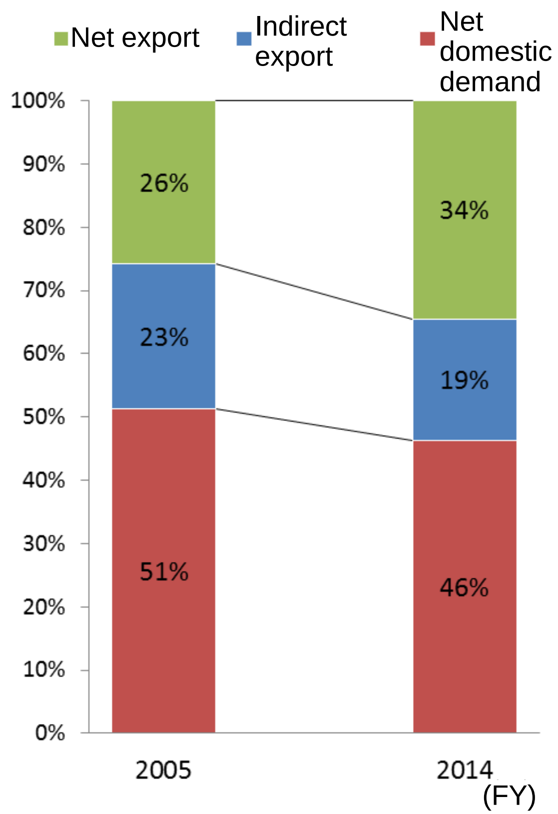
- Steel exports from Japan have been increasing. The main reason is strong demand overseas for high-performance steel backed by global economic growth, primarily in Asia.
- In recent years, external demand (direct and indirect exports) has accounted for more than half of Japan's crude steel production.

Crude steel production trend per demand in Japan



Source: JISF

Composition ratio (%)

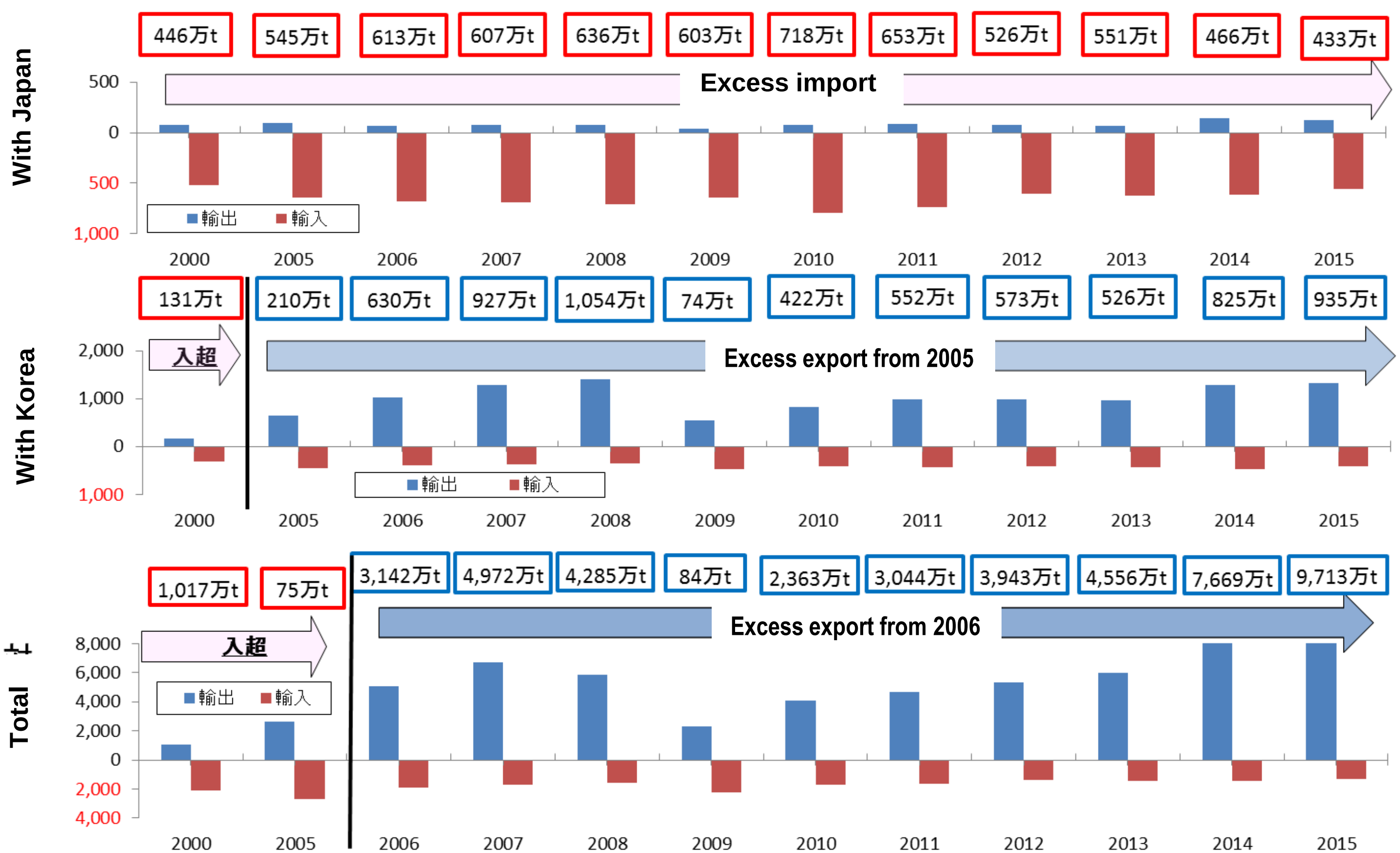


Eco Product: The global competitive edge of the Japanese steel industry, mainly for high-performance steel

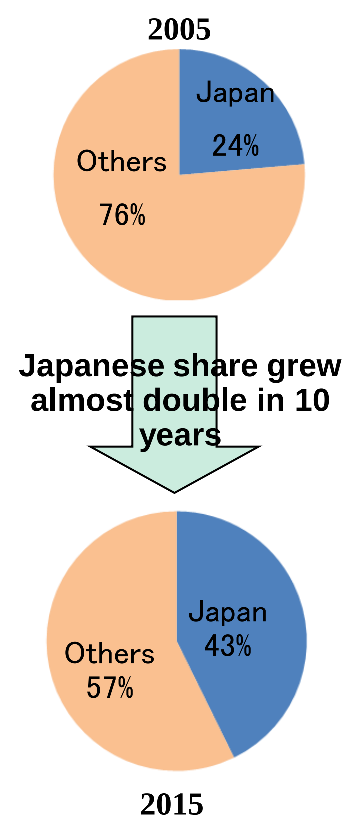
- Steel from other countries cannot match Japan's high-performance steel in terms of performance, quality, supply and other attributes. High-performance steel is the core element of the international competitive edge of the Japanese steel industry.
- China, the world's largest steel producer, became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



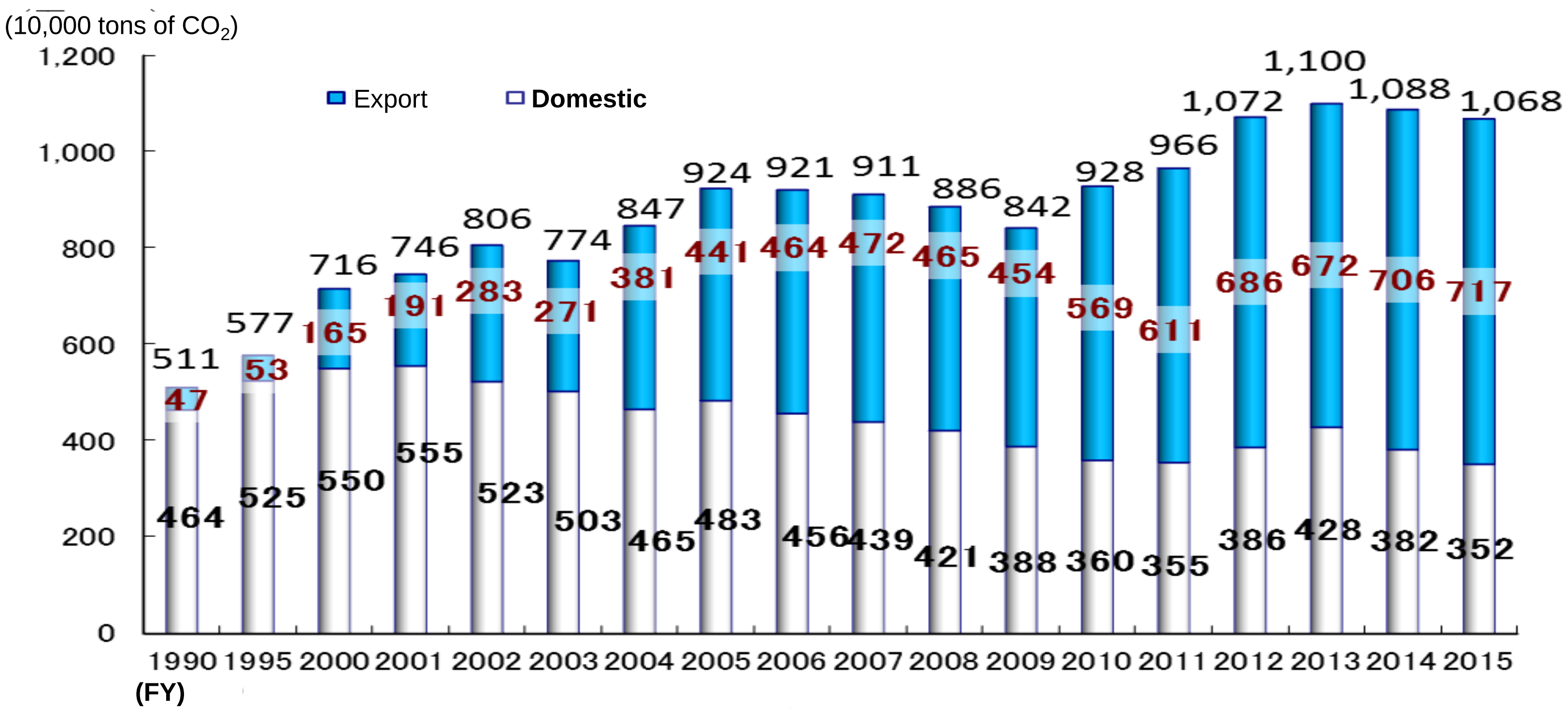
Source: Customs statistics China

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 10.88 million tons/year (FY15).

- **Japan: Annual reduction of 3.52 mn tons of CO_2**
- **Exports: Annual reduction of 7.17 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

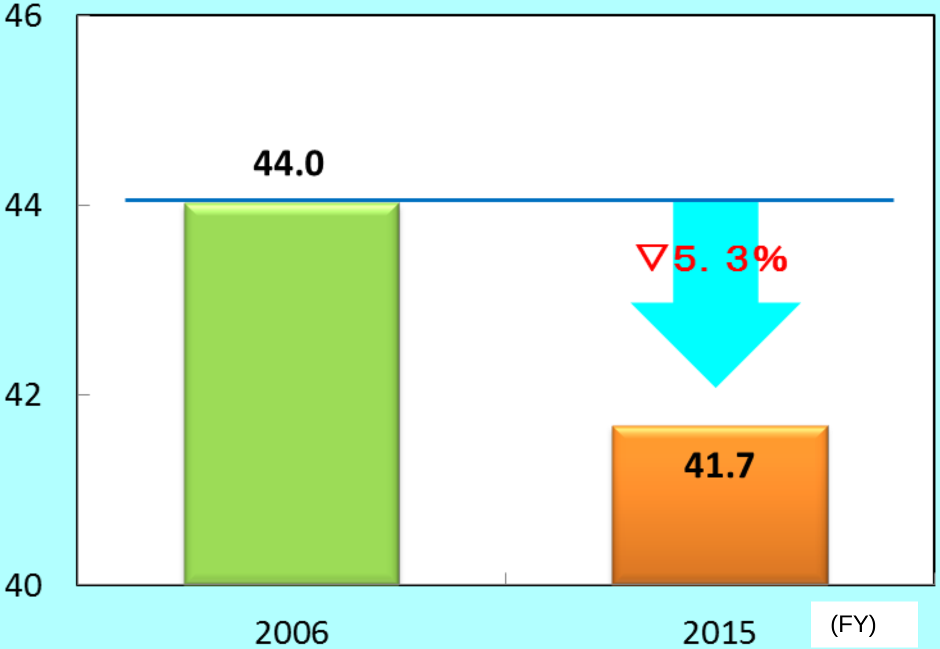
Source: Japan Cement Association, Nippon Slag Association

Initiatives in the cargo transport sector

- CO_2 emissions per unit of cargo transport decreased to 41.7kg of CO_2/k ton-km in FY16 from 44.0kg of CO_2/k ton-km in FY06.
- In FY15, the steel industry modal shift (ships + rail) was 76% 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

(kg of CO_2/k tons-km)



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

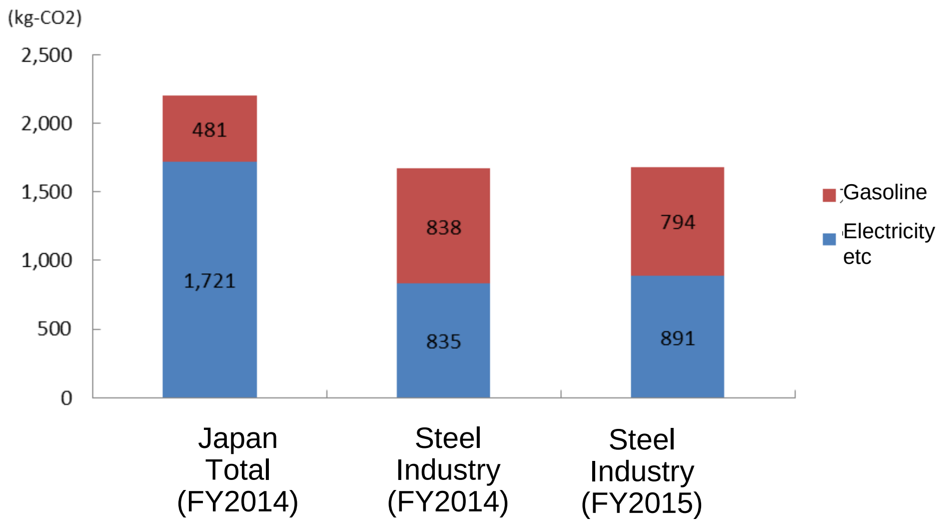
	No. of units
Steel mills	**218**
Junction port	**41**

(Totals for 4 blast furnace and 2 EAF steelmakers as of the end of FY15)

Initiatives in commercial/residential sector

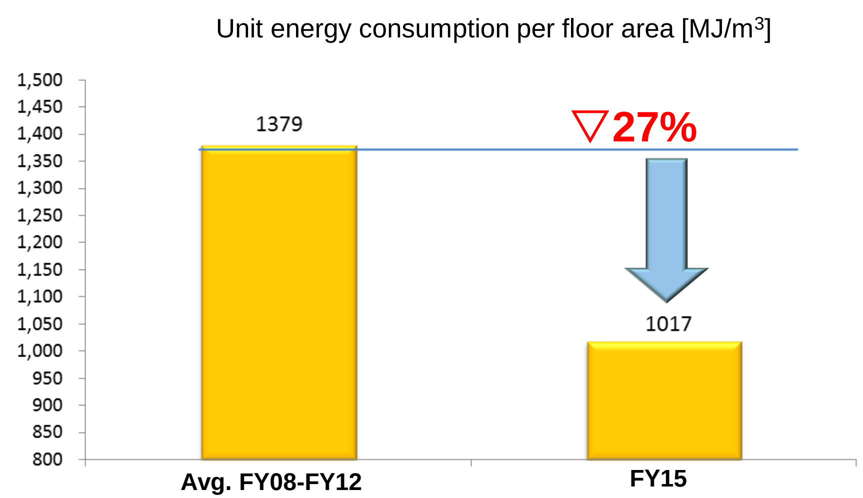
- In FY2005, Japan's steelmakers started energy conservation programs using environmental ledgers for residential sector. Steelmakers started education programs that included all employees, including at group companies, promotion of use of household environmental ledgers, and other actions. There are around 16,000 households participating in this program in FY2015.
- Steel industry is taking actions to reduce energy consumption and CO_2 emission from offices. Unit energy consumption in offices in 2015 were down 27% compared to FY 2008-2012.

Household CO_2 Emissions
(CO_2 emissions per individual: kg of CO_2/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 330 business sites of 74 companies in FY2014

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: 40 tons/hour Heating capacity: 29.5GJ Thermal transmission area: 382m2 Primary steam pressure: 1.01MPa (saturation temperature) Secondary steam pressure: 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

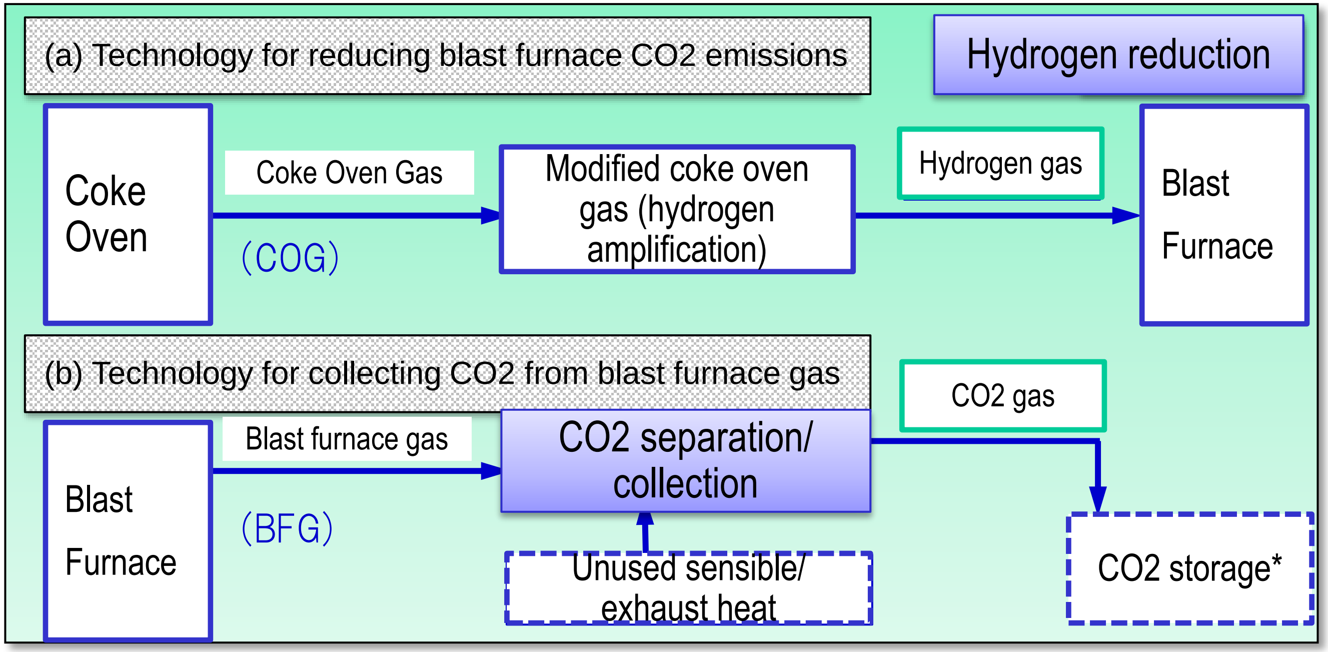
Phase 1, Step 2 (FY13-17) Initiatives

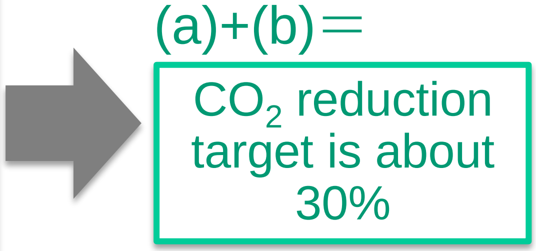
Development item (a): Technology for reducing blast furnace CO_2 emissions

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.



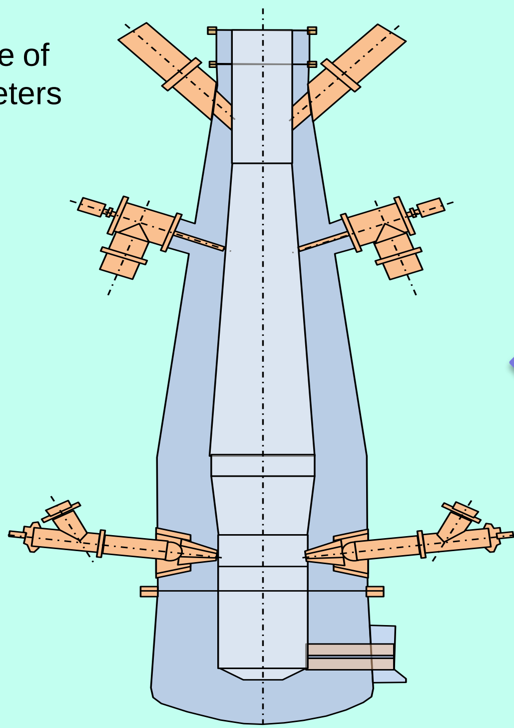


* assumptions are that an international equal footing is established and the necessary social infrastructure is created, including the site selection and establishment of a storage facility for government-led carbon capture and sequestration programs. Targets will be reexamined if these conditions are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

Construction of Trial Blast Furnace

- In Phase 1, Step 2, a 10^3 blast furnace for testing will be 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.
- Construction of testing furnace is completed in September 2015 and test operation is ongoing towards the experiment in 2016.

Volume of 10^3 meters



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 a 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)

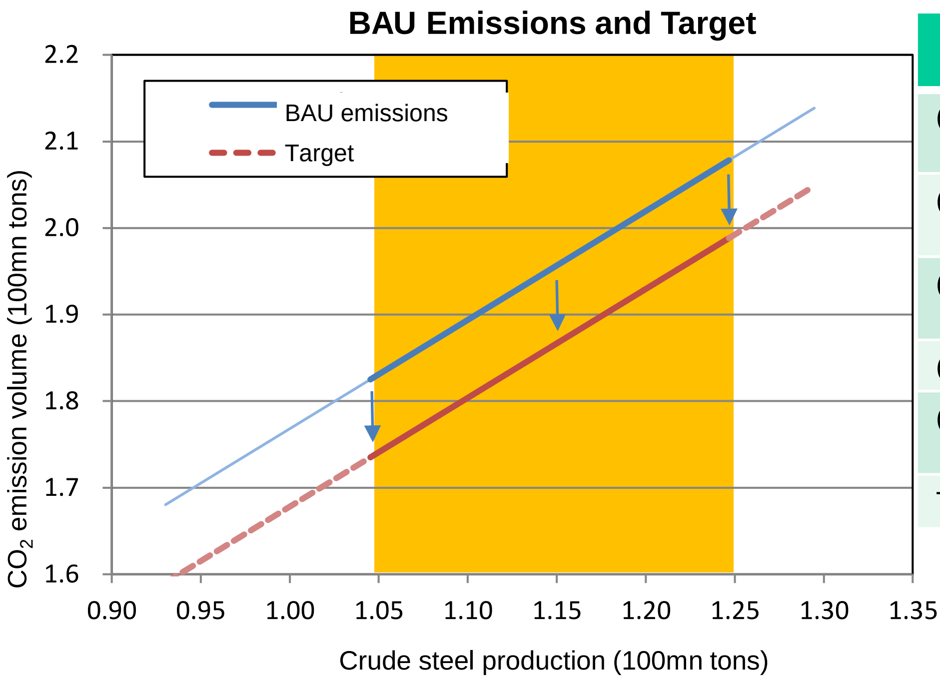
Cut CO_2 emissions from production processes about 30% by using hydrogen for iron ore reduction and collecting CO_2 from blast furnace gas. The first production unit is to begin operations by about 2030*. Goal is widespread use of these processes by about 2050 in line with timing of updates of existing 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	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	5mn tons of CO_2

* 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	19,675	18,775

*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.

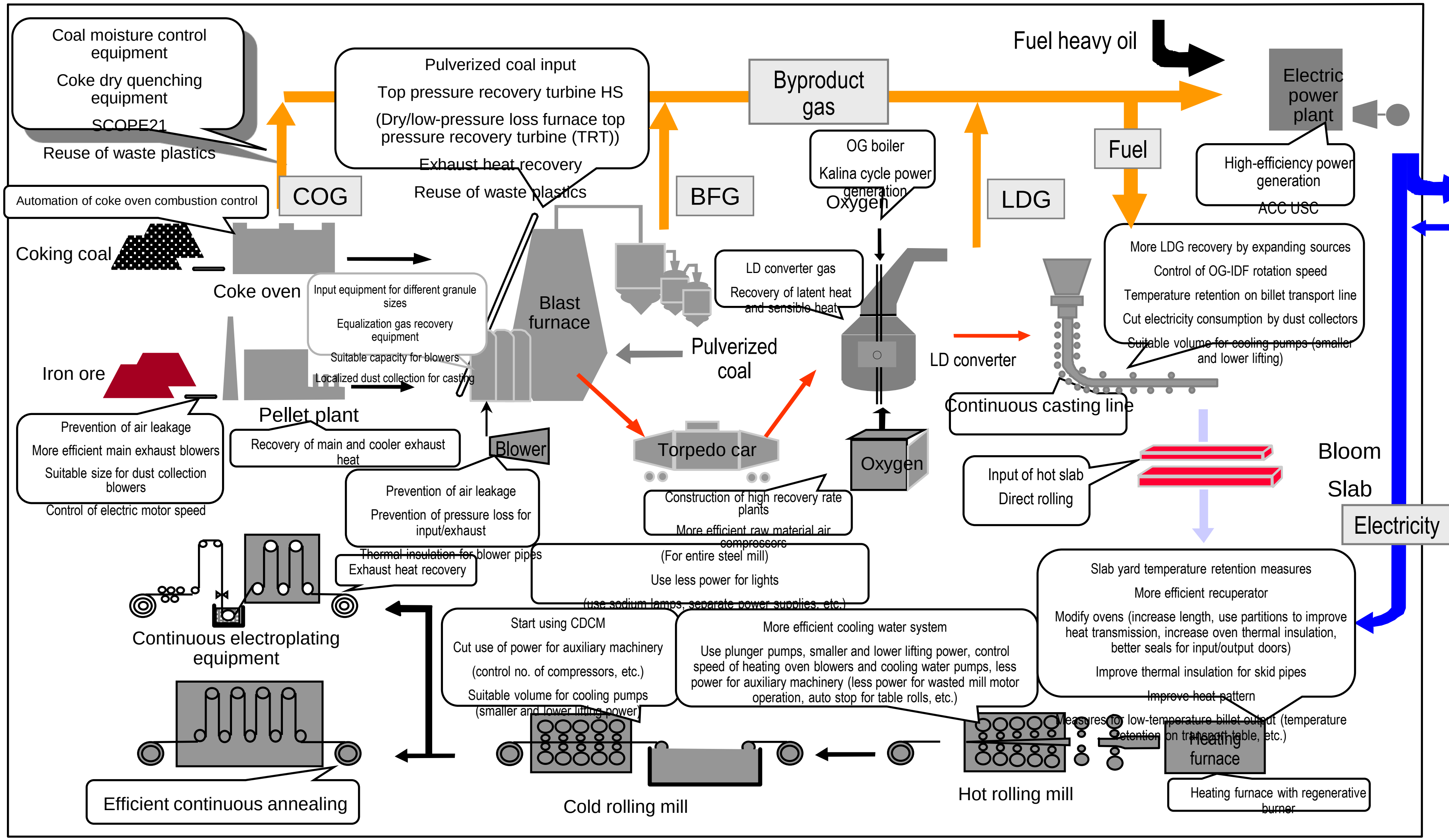
*2 Points concerning increasing the use of waste plastics and other waste materials

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.

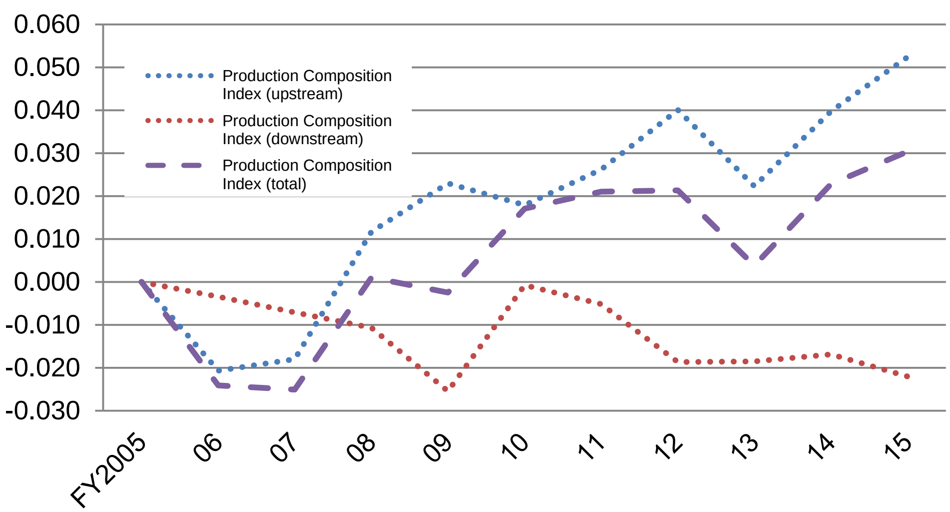
Steel Production Processes and Development and Use of Energy Conservation Technologies



Summary of JISF/RITE Production Composition Indexes

- JISF, with the cooperation of RITE has created production composition indexes. The purpose is to show how shifts in the product mix of steel mills in response to changing market needs that were unforeseen when plans are initially established can influence CO2 emissions from steelmaking processes.
- These indexes consist of indexes that have a big impact on CO2 emissions in upstream (iron resources) and downstream (rolling) processes.
- The ratio of pig iron to total crude steel production is a widely used indicator for upstream steelmaking processes. Using FY2005 as the reference year, the upstream index shows how changes in the pig iron ratio and other items affect unit CO2 emissions.
- For downstream processes, there are separate indexes for 35 production processes. Using FY2005 as the product mix reference year, these indexes show how changes in the product mix affect unit CO2 emissions.
- Calculations using these indexes indicate that shifts in the product mix (production of more advanced types of steel), which include measures to optimize upstream processes, have raised BAU emissions by approximately 3.07 million tons.

Production Composition Indexes Since FY2005



FY2015 Assessment

		CO2 emission intensity (t/tcs)	CO2 emission amount (Mt)
①Actual performance		1.784	180,416
②BAU		1.776	179,590
①-②		0.008	825
Product-mix index		0.030	3,065
Index	*upstream*	*0.052*	*5,292*
	downstream	*-0.022*	*-2,226*
Crude steel production		101.126Mt	-