Activities of Japanese Steel Industry to Combat Global Warming

March 2023

The Japan Iron and Steel Federation
Overview of JISF’s Carbon Neutrality Action Plan
Basic Policy

- JISF positioned global warming as the most important challenges in the steel industry and, in February 2021, stated that “The Japanese steel industry supports Japan’s ambitious policy of achieving carbon neutrality by 2050 and it will aggressively take on the challenge to realize carbon neutrality with the aim of contributing to the Japanese government policy.”

- In order to achieve carbon neutrality ahead of other countries, the *Commitment to a Low Carbon Society* was amended to the “*Carbon Neutrality Action Plan*” and the Phase II target (2030 target) was revised.

- In setting the new 2030 target for the Eco Process, JISF decided to increase the ambition level by taking into account not only the maximum introduction of BAT based on energy efficiency that is already among the highest in the world, but also new perspectives such as the expansion of scrap use.

- To achieve carbon neutrality throughout the world, it is critical to decarbonize the steel production process in the Asian regions, where steel production is expected to expand in the future. JISF will develop Eco Solution activities for technologies transfer and dissemination to these regions, which includes creating systems for appropriate technologies introduction.

- Regarding GHG emission reduction at the product use stage by Eco Product, in particular, high-performance steel plays a major role in the promotion of offshore wind power and electrification of automobiles, which are positioned as 14 fields in the government’s Green Growth Strategy. In addition to the conventional quantitative evaluation of the five major types of high-performance steel, it made such contributions visible. This will enable the Japanese initiative to accelerate practical global warming measures from a global perspective, without being restricted by national borders or industry sectors.

- In innovative technology development, JISF will take on the challenges of direct hydrogen reduction and high-performance steel production technology using electric arc furnaces under the Green Innovation Fund as well as COURSE 50 and Ferro coke.
Overview

Cut energy-related CO₂ emissions (total volume) in FY2030 by 30% vs. FY2013 by adopting BAT to promote energy conservation, utilizing waste plastics, adopting innovative technologies that are currently under development and scheduled to be into use around 2030, and utilizing raw fuel with less CO₂ emissions.

Supplied domestically and internationally, high-performance steel will contribute to CO₂ reduction when used in the final product. The reduction potential in 2030 is estimated to be approximately 42 million tons-CO₂ for the 5 steel products that are quantitatively evaluated for their contribution toward emissions reduction.

Contribution towards CO₂ emission reduction worldwide by transferring the Japanese steel industry’s advanced energy-saving technologies and facilities to the world’s steel industry. Estimated contribution on CO₂ emission reduction is 80 million tons in 2030.

JISF will contribute towards Carbon Neutrality by boldly embarking on the development of technologies in the following 4 areas:
- Hydrogen reduction technology using in-house hydrogen
- Low-carbon technology utilizing CO₂ contained in external hydrogen or blast furnace exhaust gas
- Direct hydrogen reduction technology
- Impurity removal technology for electric furnace using direct reduced iron
Certification of International standard ISO 50001

- On February 20, 2014, JISF became the first industry association in the world to receive ISO 50001 certification (energy management system) owing to its actions to combat global warming within the Voluntary Action Plan/Commitment to a Low Carbon Society activities for conserving energy. Commitment to a Low Carbon Society was amended to the Carbon Neutrality Action Plan, but JISF is steadily promoting Carbon Neutrality Action Plan while maintaining the certification in 2023.

ISO 50001 (Energy management system)
An international standard for visualizing an organization's energy performance and improving it to save energy/costs, adopting the PDCA (Plan-Do-Check-Act) cycle concept.

Initial registration: February 20, 2014
1st extension: February 2, 2017
2nd extension: January 23, 2020
Review(Transfer): May 20, 2021
3rd extension: February 20, 2023
Eco Process
## FY2020 Results of JISF’s Commitment (Total of the participated companies)

<table>
<thead>
<tr>
<th>Category</th>
<th>FY2030</th>
<th>FY2020</th>
<th>Comparison to FY2013</th>
<th>Comparison to FY2020</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FY2030 energy-related CO2 emissions (total volume)</strong></td>
<td>163.09Mt-CO$_2$</td>
<td>▲31.34Mt (▲16.1%)</td>
<td>+ 17.05Mt (+11.7%)</td>
<td></td>
</tr>
<tr>
<td>(Using electricity factor with relevant fiscal year credit)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>FY2030 target (30% reduction compared to FY2013) achievement rate</strong></td>
<td>53.7%</td>
<td>—</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td><strong>Energy consumption</strong></td>
<td>1,959PJ</td>
<td>▲338PJ (▲14.7%)</td>
<td>+ 200PJ (+11.4%)</td>
<td></td>
</tr>
<tr>
<td><strong>Crude steel production</strong></td>
<td>91.65Mt</td>
<td>▲1,681万t (▲15.5%)</td>
<td>+ 1,197万t (+15.0%)</td>
<td></td>
</tr>
</tbody>
</table>

### Reference: Japanese steel industry total (including companies not participating the Carbon Neutrality Action Plan)

- **Energy-related CO2 emissions in FY2021 (total)**: 167.20Mt-CO$_2$
  - Down 31.65Mt from FY2013 (▲15.9%), plus 16.96Mt from FY2020 (+11.3%) ※1
- **Energy consumption**
  - 2,045PJ (down ▲325PJ from FY2013 (▲13.7%), plus 200PJ from FY2022 (+10.9%))
- **Crude steel production**
  - 95.64Mt (down ▲1,589Mt from FY2013 (▲14.2%), plus 12.85Mt from FY2020 (+15.5%))

※1 Using electricity coefficient with said FY credit)
※2 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 CO₂ Emissions

Total Energy Consumption

Crude steel (million ton)

CO₂ Emissions from Fuel Combustion
(Incorporate improvement by emission credit)

Unit Energy Consumption
(FY1990 level=100)

Unit CO₂ Emissions
(FY1990 level=100)

*PJ is a petajoule (10¹⁵ joules). One joule is 0.23889 calories. 1PJ is equivalent to about 2.58 million kiloliters of crude oil.
Evaluation Indicator used from FY2021

• As the Phase I period of the Carbon Neutral Action Plan ended in FY2020 and shifted to the Phase II period (FY2021-FY2030), the reference year for the Phase II target was reviewed from FY2005 to FY2013, and the management indicator was revised from BAU-based emissions (evaluation method using the baseline emissions calculated at the technology level as of 2005 as an indicator) to CO2 emissions (total amount).

• Evaluation using BAU emissions as management indicator was effective within a certain range of crude steel production. However, the FY2020 performance indicated that BAU emissions cannot function adequately as the indicator in case of discontinuous operating conditions due to the COVID-19 pandemic or structural changes in production levels. Therefore, we have replaced CO2 emissions (total amount) as the management indicator.

• In accumulation of energy saving measures such as the maximum introduction of BATs as an indicator to grasp the amount of energy saving, efficiency improvement of coke ovens*1 and power demand facilities*2 were reviewed in line with actual conditions.

*1 In the past, the number of next-generation coke ovens installed was used as an indicator for improving coke oven efficiency. However, given that renewal to conventional ovens are prevalent, we decided to capture the efficiency of coke ovens as a whole by using changes in the heat consumption using dry distillation as an indicator.

*2 As it has become difficult to capture energy saving efforts due to factors such as increased energy consumption (worsening of power consumption rate) caused by strengthened environmental measures and other factors, we decided to identify facilities with large power consumption, such as oxygen plants and blowers, for which power consumption rate can be determined on a facility-by-facility basis, and to capture changes in the total power consumption rate of these facilities.

<table>
<thead>
<tr>
<th>Phase I period (FY2013-FY2020)</th>
<th>Phase II period (FY2021-FY2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reference year</strong></td>
<td></td>
</tr>
<tr>
<td>FY2005</td>
<td>FY2013</td>
</tr>
<tr>
<td><strong>Management Indicator</strong></td>
<td></td>
</tr>
<tr>
<td>CO₂ emissions performance vs BAU</td>
<td>CO₂ emissions (total amount)</td>
</tr>
<tr>
<td>Efficiency improvement of coke ovens:</td>
<td>Efficiency improvement of coke ovens:</td>
</tr>
<tr>
<td>Number of next-generation coke ovens installed</td>
<td>Heat consumption per ton of coke oven</td>
</tr>
<tr>
<td>Efficiency improvement of power demand facilities:</td>
<td>Efficiency improvement of major power demand facilities:</td>
</tr>
<tr>
<td>Electricity consumption intensity of crude steel</td>
<td>Electricity consumption intensity of oxygen plants, blowers, etc.</td>
</tr>
</tbody>
</table>
Components of Changes in FY2021 CO\textsubscript{2} Emissions

- CO\textsubscript{2} emissions in FY2021 were 163.09 million mt-CO\textsubscript{2}, a decrease of 31.34 million mt-CO\textsubscript{2} from FY2013.
- Factors contributing to this result include progress in energy and CO\textsubscript{2} saving (e.g., improved efficiency of coke ovens and power generation facilities, and increased energy-saving equipment such as CDQ systems), utilization of cold iron sources (scrap), improvement on factor of purchased electricity, and production fluctuations.

*1 CO\textsubscript{2} emissions from electricity purchased externally by the participating companies of the JISF Carbon Neutral Action Plan were evaluated using the CO\textsubscript{2} emission coefficient published by the Electric Power Council for a Low Carbon Society. CO\textsubscript{2} reductions were calculated from the difference in coefficients between the reference year (2013) and FY2021.

*2 The production fluctuations, etc. include energy-saving factors such as operation efforts and the effect of fixed energy due to production fluctuations (consumption rate fluctuations).
<table>
<thead>
<tr>
<th>Initiatives</th>
<th>FY2021 Performance (Mt-CO2)</th>
<th>Expected FY2030 Performance (Mt-CO2)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Promote energy conservation</td>
<td>▲100</td>
<td>▲270</td>
<td>• All member companies continued their efforts to promote energy saving by sequentially upgrading their coke ovens, which had increased CO₂ emissions due to age deterioration and the impact of the Great East Japan Earthquake.</td>
</tr>
<tr>
<td>Improving efficiency of coke ovens and power generating facilities; reinforcement of energy-saving facilities; improving efficiency of power-consuming facilities; making EAF process energy efficient</td>
<td>▲4</td>
<td>▲210</td>
<td>• The amount of waste plastic collected in FY2021 increased by 10,000 tons compared to FY2013.</td>
</tr>
<tr>
<td>2. Expand chemical recycling of waste plastics</td>
<td>0</td>
<td>▲260</td>
<td>▲210</td>
</tr>
<tr>
<td>3. Adopt innovative technologies</td>
<td></td>
<td>▲333</td>
<td>• Promotion of utilization of cold iron sources and heating furnace fuel conversion (from heavy oil, etc. to city gas).</td>
</tr>
<tr>
<td>COURSE50, Ferro coke</td>
<td></td>
<td>▲850</td>
<td>▲300</td>
</tr>
<tr>
<td>4. Other</td>
<td>▲300</td>
<td>▲800</td>
<td>• Calculated using the 2013 coefficient (0.567 kg-CO₂/kWh) and the 2021 coefficient (0.436 kg-CO₂/kWh).</td>
</tr>
<tr>
<td>Using raw material and fuel with less CO₂ emissions, etc.</td>
<td>▲333</td>
<td>▲850</td>
<td>▲300</td>
</tr>
<tr>
<td>5. Improve CO₂ emission factor of purchased electricity</td>
<td>▲2,398</td>
<td>▲3,400</td>
<td>• The production fluctuations includes energy-saving factors such as operation efforts and the effect of fixed energy due to production fluctuations (consumption rate fluctuations).</td>
</tr>
<tr>
<td>6. Production volume change, etc</td>
<td>▲2,398</td>
<td>▲3,400</td>
<td>▲5,790</td>
</tr>
<tr>
<td>Total</td>
<td>▲3,134 (16.1% reduction)</td>
<td>▲5,790 (30% reduction)</td>
<td>▲100</td>
</tr>
</tbody>
</table>
Evaluation of FY2021 Performance (General Remarks)

Evaluation

Based on the FY2021 performance and the analysis of the underlying factors, we confirmed that the steel industry is steadily and appropriately implementing the measures that it should take spontaneously to achieve the 2030 target.

Evaluation background

• Energy-related CO₂ emissions and energy consumption have been decreasing over the years, and the achievement rate of the FY2030 target (30% reduction from FY2013) has progressed to 53.7%. One reason for this is that the participating companies continued to promote energy saving as part of their self-help efforts. For example, heat consumption per ton of coke oven showed an improvement trend due to the upgrading of coke ovens (p.15).

• The result of estimation using the BAU indicator, adopted in the Phase I period (2013-2020), showed progress of 2% compared to the FY2020 performance in the amount of reduction through the voluntary action (promotion of energy saving, etc.): i.e., a 3.07 million mt-CO₂ reduction on the BAU basis in FY2021 compared to a 3.02 million mt-CO₂ reduction in FY2020. The target for FY2020, which was the target year of the Phase I period, was substantially exceeded, showing that further energy-saving efforts are being made continuously and ambitiously.

• While the energy efficiency of the Japanese steel industry is among the highest in the world, the participating companies are eagerly working to promote further energy saving. For example, a total of 11 energy saving projects (see next page) have been implemented in the last three years through subsidies to promote investment in energy saving.
### Energy Saving Projects Supported by Subsidies to Promote Investment in Energy Saving

Among the energy-saving projects adopted as eligible for energy-saving subsidies, the following 11 projects of blast furnace companies appear to have newly demonstrated energy-saving benefits in the most recent three-year period (FY2019-2021). These companies continue to aggressively pursue energy saving.

<table>
<thead>
<tr>
<th>FY</th>
<th>Steelworks</th>
<th>Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FY2019</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nippon Steel North Nippon Works Muroran Area</td>
<td>Project for energy saving by introducing electrically driven blast furnace blowers</td>
</tr>
<tr>
<td></td>
<td>Nippon Steel East Nippon Works Kimitsu Area</td>
<td>Project for energy saving by increasing the efficiency of hot-blast stoves in No.2 blast furnace (second blast furnace)</td>
</tr>
<tr>
<td></td>
<td>JFE East Japan Works Keihin</td>
<td>Project for energy saving by replacing in-house power generation equipment with GTCC equipment at steelworks</td>
</tr>
<tr>
<td></td>
<td>JFE West Japan Works Fukuyama</td>
<td>Project for energy saving in coal moisture control equipment</td>
</tr>
<tr>
<td></td>
<td>JFE West Japan Works Fukuyama</td>
<td>Project for air compressor renewal and energy saving of plant facilities within the area</td>
</tr>
<tr>
<td><strong>FY2020</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nippon Steel Setouchi Works Hanshin Area (Toyo)</td>
<td>Project for energy saving at the Toyo Manufacturing Plant</td>
</tr>
<tr>
<td></td>
<td>JFE West Japan Works Kurashiki</td>
<td>Project for energy saving by installing high-efficiency steam turbine generators at the Kurashiki Power Plant</td>
</tr>
<tr>
<td></td>
<td>JFE West Japan Works Fukuyama (Setouchi Joint Thermal Power)</td>
<td>Project for energy saving by introducing high-efficiency power generation equipment</td>
</tr>
<tr>
<td><strong>FY2021</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nippon Steel Kansai Works Wakayama Area (Wakayama Kyodo Power)</td>
<td>Project for energy saving by introducing electrically driven blast furnace blowers</td>
</tr>
<tr>
<td></td>
<td>JFE West Japan Works Fukuyama</td>
<td>Project for energy saving by improving byproduct gas utilization equipment</td>
</tr>
<tr>
<td></td>
<td>JFE East Japan Works Chiba</td>
<td>Project for energy saving by recovering waste heat and introducing high-efficiency equipment</td>
</tr>
</tbody>
</table>
Specific initiative - Coke Oven Updates

- JISF member companies have started replacing aging bricks in coke ovens, which is one cause of the increase in CO2 emissions. Improvements at 13 coke ovens were already completed after Phase I (FY 2013) of the Commitment to a Low Carbon Society.
- Although work has started, due to the limited availability of workers (coke oven construction specialists) and the high cost of updates (tens of billions of yen for each oven), it is still under development.

### Completed Updating Projects (13 ovens)

<table>
<thead>
<tr>
<th>Year</th>
<th>Steel works</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2013</td>
<td>JFE Steel, West Japan Works, Kurashiki</td>
<td>About ¥15 billion</td>
</tr>
<tr>
<td>FY2015</td>
<td>JFE Steel, West Japan Works, Kurashiki</td>
<td>About ¥20 billion</td>
</tr>
<tr>
<td>FY2016</td>
<td>Nippon Steel, East Nippon Works, Kashima Area</td>
<td>About ¥18 billion</td>
</tr>
<tr>
<td></td>
<td>JFE Steel, East Japan Works, Chiba</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Nippon Steel, East Nippon Works, Kimitsu Area</td>
<td>About ¥29 billion</td>
</tr>
<tr>
<td>FY2017</td>
<td>JFE Steel, West Japan Works, Kurashiki</td>
<td>About ¥18.4 billion</td>
</tr>
<tr>
<td>FY2018</td>
<td>Nippon Steel, East Nippon Works, Kashima Area</td>
<td>About ¥31 billion</td>
</tr>
<tr>
<td></td>
<td>JFE Steel, East Japan Works, Chiba</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Nippon Steel, East Nippon Works, Kimitsu Area</td>
<td>About ¥33 billion</td>
</tr>
<tr>
<td>FY2019</td>
<td>Nippon Steel, North Nippon Works, Muroran Area</td>
<td>About ¥13 billion</td>
</tr>
<tr>
<td></td>
<td>JFE Steel, West Japan, Fukuyama Works</td>
<td>About ¥13.5 billion</td>
</tr>
<tr>
<td>FY2021</td>
<td>JFE Steel, West Japan Works, Fukuyama</td>
<td>About ¥13.5 billion</td>
</tr>
<tr>
<td></td>
<td>Nippon Steel, Nagoya Works</td>
<td>About ¥57 billion</td>
</tr>
</tbody>
</table>

### Expected Updating Projects (3 ovens)

<table>
<thead>
<tr>
<th>Year</th>
<th>Steel works</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>FY2015</td>
<td>JFE Steel, West Japan Works, Fukuyama</td>
<td>About ¥45 billion</td>
</tr>
<tr>
<td></td>
<td>Nippon Steel, Kyushu Works, Oita Area</td>
<td>About ¥50 billion</td>
</tr>
<tr>
<td>FY2016</td>
<td>Nippon Steel, East Nippon Works, Kimitsu Area</td>
<td>About ¥29 billion</td>
</tr>
</tbody>
</table>

JISF Member Company Coke Oven Update Plans

(Company and newspaper announcements as of Dec 2022)
<table>
<thead>
<tr>
<th>Higher efficiency of power plants</th>
<th>Number of fuel intensity improvement measures (year)</th>
</tr>
</thead>
</table>
| Kobe Steel Kakogawa Station No. 1  
Gas turbine combined cycle unit (2011) | 2011                                               |
| Kimitsu Joint Thermal Station No. 6  
Advanced combined cycle unit (2012) | 2012                                               |
| Kashima Joint Thermal Station No. 5  
Advanced combined cycle unit (2013) | 2013                                               |
| Wakayama Joint Thermal Station No. 1  
Advanced combined cycle unit (2014) | 2014                                               |
| Oita Joint Thermal Station No. 3  
Advanced combined cycle unit (2015) | 2015                                               |
| Kobe Steel Kakogawa Station No. 2  
Gas turbine combined cycle unit (2015) | 2015                                               |
| JFE Steel Chiba Station West-No. 4  
Gas turbine combined cycle unit (2015) | 2015                                               |
| Nisshin Steel Kure Power Station No. 6  
Boiler, turbine and generator (planned for 2017) | 2016                                               |
| JFE Steel Ohgishima Thermal Station No. 1  
Gas turbine combined cycle (planned for 2019) | 2017                                               |
| Fukuyama Joint Thermal Station No. 2  
Gas turbine combined cycle (planned for 2020) | 2018                                               |
Specific initiative -by Electric Arc Furnace (EAF) Manufacturer (Chiyoda-Steel Co., Ltd.)

- In February 2021, with the rationalization of innovative steelmaking technologies, Chiyoda Steel reinforced its electric arc furnace and updated ancillary power supply equipment at its Ayase plant. The plant is making full use of STARQ (rotating electric arc furnace), which is equipped with even scrap melting technology, high-voltage operation, and appropriate electrification pattern and scrap mix. Chiyoda Steel will contribute toward energy conservation and a low-carbon society by cutting CO₂ emissions through optimal steelmaking operations.

- In the conventional three-phase AC EAF with three electrodes, uneven melting occurred due to the difference in distance between the electrodes and the furnace wall and it was standard practice to install an auxiliary burner in areas far away from the electrode (cold spot).

- However, although the melting capacity of the burner improved, there was still the issue of high maintenance cost due to increase in unit total energy consumption and damages to the body of the burner caused by rebounding flames. Rotating the furnace body of the EAF brings the cold spot closer to the electrode, thereby fundamentally solving the issue of uneven melting. Using this EAF also reduces energy consumption.

【Conventional Issues】
- The electrodes are arranged in a triangle position inside the round furnace body, creating differences in the distance between the electrode and the furnace wall.
- As a result, materials melt quickly in the hot spots (areas near the electrode) while there is residue in the cold spots. If electric currents continue to pass through in this situation, it will lead to a significant loss of energy in the hot spots.

【EAF with Rotating Body System】
- Installing STARQ and updating ancillary power supply equipment improved unit energy consumption of EAF

![Image of EAF with Rotating Body System](image_url)
One goal of the Carbon Neutral Action Plan is to raise the use of waste plastics and other recycled materials to 1 million tons, on the premise that the government establishes a necessary collection infrastructure. However, collections totaled 410,000 tons in FY2021 and the volume of cargo collection remains sluggish.

**Use of Waste Plastics and Waste Tires**

Source: The Japan Iron and Steel Federation

- Full enactment of Japan's Containers and Packaging Recycling Law
- Start of reuse of general waste plastics as products (April 1, 2000)
Current status of chemical recycling

As for the procurement of plastic packaging and containers, priority is given to material recycling. Therefore, the quantity of the plastic containers and packaging which was bid off for chemical recycling (using blast furnaces or coke ovens, shown in brown and red individually) is showing little growth.

The bidding system was revised in FY 2018, enabling companies that failed to successfully bid for and purchase plastic packaging and containers designated specifically for material recycling can now bid for plastic packaging and containers designated for general purposes (chemical recycling, etc.). In FY 2021, the composition ratio of chemical recycling increased slightly from FY 2018, but remained at a level similar to that in previous years.

Source: The Japan Containers and packaging recycling association
For expansion of chemical recycling

- Chemical recycling produces fewer residues than material recycling, and nearly all the materials are recycled. In addition, unit contract prices are low (which means that the recycling-related social cost is low). Chemical recycling is an excellent recycling method.
- Currently, steelmakers can process about 300,000 tons of plastic packaging and containers by using their steel production processes.
- Regarding the effective utilization of waste plastics, etc., we will closely monitor the trend to see whether it is operated as a system that contributes to the promotion of chemical recycling conducted by the steel industry under the law on recycling of plastics.

From the standpoint of efficiently and effectively using waste materials (recycling waste materials that are highly effective at cutting CO2 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 CO2 emissions.
Japan’s steel industry’s energy efficiency

- The Research Institute of Innovative Technology for the Earth (RITE) issued a report in 2022 on international comparison of energy efficiency level in steel industry (BF-BOF and EAF*). The report showed that Japan maintains the world’s highest energy efficiency in 2019, as in 2005, 2010 and 2015.

*This report is normally published every five years, but since the 2020 was based on discontinuous operations due to the COVID-19 pandemic, comparisons were made based on the actual results of 2019, which was the most recent year of regular operations.

Why is Japan’s steel industry the most efficient?

- The penetration rate of energy-saving technologies is extremely high in Japan’s steel industry.
- Steelmakers are working on achieving the goals of the Carbon Neutral Action plan to Low Carbon Society and sharing best-practice knowledge among themselves.

Estimate of Steel Industry (BF-BOF*) Energy Efficiency (2019, Japan=100)

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary energy intensity (BF-BOF) (G/t crude steel)</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>Japan</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>110</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td>UK</td>
<td>115</td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>116</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>119</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>128</td>
<td></td>
</tr>
<tr>
<td>US</td>
<td>129</td>
<td></td>
</tr>
</tbody>
</table>

Estimate of Steel Industry (EAF) Energy Efficiency (2019, Japan=100)

<table>
<thead>
<tr>
<th>Country</th>
<th>Primary energy intensity (EAF) (G/t crude steel)</th>
<th>2019</th>
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</thead>
<tbody>
<tr>
<td>Japan</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>104</td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>103</td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>104</td>
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<tr>
<td>US</td>
<td>104</td>
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<tr>
<td>Spain</td>
<td>106</td>
<td></td>
</tr>
<tr>
<td>Portugal</td>
<td>107</td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Italy</td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Turkey</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>113</td>
<td></td>
</tr>
</tbody>
</table>

How can further reduction of CO2 emission be achieved in the steel industry?

- Increasing the use of energy saving measures and technologies not only domestically, but also globally will be effective.
Eco Product
Japanese Industrial Products that Conserve Energy and Cut CO₂ 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 CO₂ emissions in Japan and worldwide.

- The Japanese steel industry has established a close relationship with these manufacturers by developing and supplying steel with various characteristics. This high-performance steel is vital to achieving the outstanding functions of advanced products, and has earned a reputation for reliability among manufacturers.

<table>
<thead>
<tr>
<th>Airplane components</th>
<th>Motors for hybrid/electric cars</th>
<th>Automotive and industrial machinery parts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strong and durable jet engine shafts further boost maximum thrust = Longer range, better fuel efficiency</td>
<td>High-efficiency non-oriented electrical sheets for higher fuel efficiency, more power, smaller size and lower weight</td>
<td>Strong gear steel increases gears and reduces size and weight – higher fuel efficiency</td>
</tr>
</tbody>
</table>

- 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
Quantitative Evaluations – Contributions of Major High-performance Steel

To establish a method to determine the quantitative contribution of high-performance steel, JISF set up a committee in FY2001 with the associations of steel-consuming industries, The Institute of Energy Economics, Japan (IEEJ) 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 (FY2021 production of 6.69 million tons, 7.3% of Japan’s total crude steel production). The use of finished products made of high-performance steel cut FY2021 CO₂ emissions by 10.56 million tons for steel used in Japan and 23.12 million tons for exported steel, a total of 33.69 million tons of CO₂.

CO₂ Emission Reductions by the five major types of high-performance steel (FY2021)

CO₂ Emission Reductions: 33.69 million tons CO₂ in total (6.69 million tons of high-performance steel)

Ref:
CO₂ Emission Reductions: 32.53 million tons CO₂ by the end of FY2020 (6.06 million tons of high-performance steel)

※The results for previous years were also revised following a close examination, such as the inclusion of IGCC in the scope of calculation from FY2021 (actual cross-sectional results for FY2020 before the revision: 32.26 million t-CO₂).

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 FY2021, use of the five categories of steel products in Japan was 2.75 million tons and exports were 3.94 million tons for a total of 6.69 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.
Approaches to Quantitative Assessment from New Perspective (Offshore Wind)

- Since high-performance steels will contribute to products essential to achieving carbon neutrality, JISF commissioned Akita University to promote quantitative evaluations of such materials.
- In FY2022, quantitative evaluation of bottom-fixed offshore wind power (bottom-mounted monopile and jacket types) was conducted. In FY2023 and beyond, assessments will be conducted for floating offshore wind power, CCS-related infrastructure, and hydrogen-utilizing infrastructure.
- For example, in offshore wind power, steel is used for the foundation (for both monopile and jacket types) and the nacelle. These steel products are required to have high rust resistance and strength according to the operating environment. By supplying high-performance steel products that meet various requirements, we will support the social implementation of offshore wind power toward carbon neutrality.
- Unlike the five conventional products listed on the previous page, products for offshore wind power are those that will be implemented in society in the future. The quantitative evaluation results on the next page show estimates of their potential contribution in the future.

Image of offshore wind power generation facility

(Courtesy of Nippon Steel Engineering Co., Ltd.)

(Courtesy of JFE Holdings, Inc.)
In FY2022, the annual contribution of steel to CO$_2$ reductions in a typical example of offshore wind power (installation of 77 monopile type units) was calculated to be a total of 104 kt-CO$_2$/year (*).

(*) This is only a representative example of calculation, and the amount of reduction contribution will vary depending on the combination of method and facility size.

Example of quantitative evaluation approach (monopile type)

\[
\text{US$181/kW} \div \text{US$2,400/kW} \times \text{CO}_2 \text{ reduction per offshore wind unit}^{*1} \times \text{No. of offshore wind units}^{*2} = \text{Reduction contribution}
\]

<table>
<thead>
<tr>
<th>Steel procurement cost</th>
<th>Capital cost (initial investment, total project cost)</th>
<th>CO$_2$ reduction per offshore wind unit$^{*1}$</th>
<th>No. of offshore wind units$^{*2}$</th>
<th>Reduction contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>US$181/kW</td>
<td>US$2,400/kW</td>
<td>About 18 kt-CO$_2$/yr</td>
<td>77 units</td>
<td>104 kt-CO$_2$/yr</td>
</tr>
</tbody>
</table>

\[
\text{Share of CO}_2 \text{ reduction contribution per offshore wind unit}^{*1} = 7.54\%
\]

\[
\text{Total CO}_2 \text{ reduction from offshore wind} = \text{About 1.381 Mt-CO}_2$/yr
\]

$^{*1}$ CO$_2$ emissions reduction per offshore wind unit is set by the difference between the FY2020 CO$_2$ emissions intensity of all power sources (0.48 kg-CO$_2$/kWh), which is used as a reference for comparison, and the CO$_2$ emissions intensity of offshore wind (0.03 kg-CO$_2$/kWh).

$^{*2}$ The number of offshore wind units is calculated as 77 units from <1> divided by <2> given below:

<1> Amount of offshore wind power expected by the national government to be introduced by FY2030: 1 million kW (source: Agency for Natural Resources and Energy)

<2> Capacity per offshore wind unit: 13 MW (source: press information on an offshore project off Akita Prefecture)
Future Potential of Steel Products

- Steel products have greatly improved their mechanical and electromagnetic properties. However, the characteristic level we put into practical use is only 1/10-1/3 (in the case of strength) with respect to the theoretical limit value.
- The Japanese steel industry will contribute to the reduction of CO2 in the entire life cycle, while supporting the foundation of the future society, through not only further strengthening steel products but also developing next-generation steel products for hydrogen infrastructure to be expected in the future.
Eco Solution
CO₂ Emission Reduction from Increasing Use of Technologies

- Japanese companies provided other countries major energy conservation technologies that the Japanese steel industry developed and installed. As a result, CDQ, TRT and other major types of equipment alone are already lowering annual aggregate CO₂ emissions in China, Korea, India, Brazil and other countries by 75.55 million tons.

### Emission Reductions in Other Countries from Japanese Energy-conserving Equipment (FY2021)

<table>
<thead>
<tr>
<th>Equipment Type</th>
<th>No. of units</th>
<th>Reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coke dry quenching (CDQ)</td>
<td>128</td>
<td>2,581</td>
</tr>
<tr>
<td>Top-pressure recovery turbines (TRT)</td>
<td>64</td>
<td>1,129</td>
</tr>
<tr>
<td>Byproduct gas combustion (GTCC)</td>
<td>58</td>
<td>2,545</td>
</tr>
<tr>
<td>Basic oxygen furnace OG gas recovery</td>
<td>22</td>
<td>821</td>
</tr>
<tr>
<td>Basic oxygen furnace sensible heat recovery</td>
<td>8</td>
<td>90</td>
</tr>
<tr>
<td>Sintering exhaust heat recovery</td>
<td>7</td>
<td>98</td>
</tr>
<tr>
<td><strong>Total emission reduction</strong></td>
<td><strong>7,555Mt</strong></td>
<td></td>
</tr>
</tbody>
</table>

Ref: Total emission reduction in FY2020 was 72.64Mt - CO₂/year
CO₂ Emission Reduction from Increasing Use of Technologies

- There is much potential in increasing the use of by-product gas and major energy conservation technologies globally, especially in China which accounts for about 50% of the world's crude steel production, and India where steel production is expected to continue to grow.

### Results of potential evaluation for the recovery and efficient use of by-product gases (2019)

<table>
<thead>
<tr>
<th>Region</th>
<th>COG</th>
<th>BFG</th>
<th>LDG</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>1.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>0.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EU(28)</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Korea</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>China</td>
<td>0.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>0.4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>0.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>World</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Energy conservation potential through the spread of major energy conservation technologies

<table>
<thead>
<tr>
<th>Region</th>
<th>CDQ</th>
<th>TRT</th>
<th>WHRS</th>
<th>PCI</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>1.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Germany</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EU</td>
<td>0.5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Japan</td>
<td>0.3</td>
<td></td>
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<tr>
<td>Korea</td>
<td>0.2</td>
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</tr>
<tr>
<td>China</td>
<td>0.5</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>India</td>
<td>0.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Russia</td>
<td>0.7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>World</td>
<td>2.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Source) PCI is set based on JISF's "Steel Statistics Handbook 2021" and the German Iron and Steel Federation (2013). The other four technologies are set based on 2015 penetration rates <based on Arens et al. (2017), Schulz et al. (2015), China Steel Industry Yearbook (2016), etc.> and actual subsequent adoption.

Add: This potential is not the maximum technically possible potential, but rather a potential that takes into account feasibility. Here, the vintage of existing facilities, energy-saving equipment installed in existing facilities (with somewhat inferior energy-saving performance), and even natural gas blowing technology into the blast furnace are considered in a simplified manner.
International Collaboration for the Support of Eco Solutions

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
- ENCO (~2009)
  Environment Committee
- EPCO (2010~2013)
  Environmental Policy Committee
- ECO (2014~)
  Environment Committee

Development of ISO14404* (2009~)
  Versions for integrated steel plants and EAF issued in 2013, version for DRI-EAF in 2017 and version for all types of process in 2020
  *International standard for the calculation of CO₂ emission from steel plants

CO₂ data collection (2007~)
Online Steel Plant Diagnosis

• Implemented energy-saving technologies and operational improvement initiatives via online.

Outline

<table>
<thead>
<tr>
<th>Target plants</th>
<th>Electric arc furnaces plants in Thailand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Online</td>
</tr>
<tr>
<td>Schedule</td>
<td>July, 2022~October, 2022</td>
</tr>
</tbody>
</table>

Step of the Diagnosis

STEP1 Selecting plants for diagnosis (screening/selection)
Since the project in the previous FY was highly evaluated by the target company, they requested to operate a diagnosis at other steel mills. Japanese experts examined and selected a steel plant from the viewpoint of feasibility.

STEP2 On-line steel plant diagnosis and data collection via e-mail

STEP3

① Compile collected data
② Study recommended energy saving and CO₂ reducing technologies
③ Provide advice on operational improvement

STEP4 Report the result of the steel plant diagnosis to the participating steel plants (online)

Overview of the result

1. Analyzed energy/CO₂ emission intensity, and energy consumption trend using ISO 14404**. Indicated each plant's standing in the industry and energy saving potential, then recommended further energy conservation efforts.
2. Presented anticipated power reduction and cost estimate along with the energy saving technologies selected from Technologies Customized List. To meet the needs of the participating plants, the focus was on small-scale technologies and low-cost operational improvements.

Evaluation by the counterpart

• With the growing need to reduce energy consumption due to issues on increasing productivity and price competitiveness and demands from stakeholders, it is critical to actively receive information from external experts. Hence it is meaningful to receive advice on energy-saving ideas from Japan.
• We would like to continue our ongoing energy-saving efforts while also utilizing ideas from Japan.

*Blast furnace, electric furnace, DRI electric furnace and guidance versions have been published.
Following a request from the Government of India, the first face-to-face meeting was held after almost 4 years (An online meeting was held in January 2022).

Meeting details

<table>
<thead>
<tr>
<th>Schedule</th>
<th>December 13, 2022 (4hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Online</td>
</tr>
<tr>
<td>Participants</td>
<td>Government officials and steel makers from India and Japan (Approximately 50)</td>
</tr>
</tbody>
</table>

Presentation of policies and initiatives toward carbon neutrality in both countries

- Presentation of policies toward carbon neutrality in India and Japan
- Case studies of Japanese and Indian steel companies' initiatives to achieve carbon neutrality
- Transition finance initiatives in Japan
- Importance of BAT (Best Available Technology) to achieve carbon neutrality and overview of the technology customized list (*1).
- International standards related to energy efficiency and decarbonisation for the steel industry and examples of the use of EPDs (*2) in the Japanese steel industry, etc.

Evaluation by Ministry of Steel and participants

- Ministry of Steel, Government of India emphasized that cooperation with the Japanese public and private steel industry is very important to meet the common challenge of decarbonizing including primary steel making route.
- The dissemination of BATs such as those listed in the technology customized list is important in the transition period.
- Several Indian steel companies introduced that they have been adopting technologies from the list, and one of the companies introduced a case study to reduce CO2 emissions by 19% by adopting several technologies on the list, such as blast furnace top pressure recovery turbine (TRT) and sinter cooler heat recovery system.

(*1) A technology list featuring superior Japanese energy-saving, environmental protection and recycling technologies that are suitable for steel mills in different countries and regions.

(*2) Environmental Product Declaration: Type III environmental label as defined in the ISO 14025 standard. Operated in Japan since 2002 as 'EcoLeaf'.
Even during the pandemic, JISF remained committed to the international community by committing through multilateral cooperation on long- and short-term energy-saving initiatives.

**Schedule**: February 14, 2023 (approx. 4 hours)
**Location**: Online
**Participants from ASEAN countries**: Ministries and agencies related to steel and energy conservation and steel industry organizations and their member companies*
**Participants from Japan**: Ministry of Economy, Trade and Industry, JISF and its member companies, Nippon Steel Research Institute etc.

**Presentation of policies and initiatives toward carbon neutrality**

=> While many countries, including Japan, have declared their future carbon neutrality, it is not easy to decarbonize the steel industry, which emits large amounts of CO\(_2\). The presentation shows how the steel industry aims to achieve carbon neutrality, and introduces policies in Japan and ASEAN countries as well as initiatives of steel companies.

**Introduction of several best available technologies (BATs) effective in combating global warming in the near term.**

=> The steel industry is aiming to develop innovative technologies to achieve carbon neutrality, but this will take a considerable amount of time. Until innovative technologies become available, implementation of BATs is effective to combat global warming. In response to requests from the ASEAN steel industry, which has a large potential for CO\(_2\) reduction through BAT introduction, a number of BATs, including energy-saving-type carbon dioxide capture equipment and hydrogen/ammonia combustion technology, are scheduled to be presented by Japanese engineering companies.

**Themes that meet ASEAN’s needs**

=> we share information related to technology as well as EPD and environment-related international standards, and prepared presentations on a wide range of initiatives, including steelworks diagnosis for energy saving. An active discussion is expected by introducing a panel discussion.

<table>
<thead>
<tr>
<th>Session 1</th>
<th>Session 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Policies and initiatives toward carbon neutrality in the steel industry</td>
<td>Best available technologies (BATs) - First steps to carbon neutrality</td>
</tr>
<tr>
<td>• Japan and ASEAN’s efforts toward carbon neutrality</td>
<td>• Introduction of energy saving technologies for blast/electric furnaces by engineering companies</td>
</tr>
<tr>
<td>• International standards related to steel and energy saving</td>
<td>• Introduction of technologies for environmental protection and hydrogen production and utilization in the steel industry</td>
</tr>
<tr>
<td>• Outline of exploration of bilateral credit scheme projects in ASEAN</td>
<td>• Overview and results of online steel plant diagnosis</td>
</tr>
</tbody>
</table>

*South East Asia Iron and Steel Institute*
Promoting Eco Solution

- To encourage developing countries to select Japanese technologies when introducing energy saving technologies, the ISO14404-4 series and BATs (Best Available Technologies) such as TCL were used to visualize the comprehensive evaluation of energy-saving steelmaking technologies, including environmental and social considerations and life cycle costs and to implement PDCA to steadily promote energy conservation. In November 2021, This aim was systemized and proposed as “Guidelines for Promoting Comprehensive Energy Efficiency and Conservation Measures in Steel Plants” in ISO/TC17 (steel).
- In March 2022, a Study Group (SG) was set up within TC17 with the aim to make a new proposal. After discussions with the experts participating in the SG, a new proposal was made and voting started at the end of November 2022.

Energy-saving process under the new standard

1. Plan
   - Identify the energy usage status of steel plants using ISO 14404, etc.
   - Set energy saving targets

2. Do
   - Implement operational improvements if possible.
   - Select an energy saving technology based on the results of 1 and the BAT list.
   - Select and install an energy saving equipment based on the “comprehensive evaluation criteria.”

3. Check
   - Evaluate and analyze the energy conservation effects of installed equipment using ISO 14404, etc.

4. Action
   - Investigating ways for further improvement on energy efficiency

Comprehensive evaluation (Example)

<table>
<thead>
<tr>
<th>Equipment by A</th>
<th>Equipment by B</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Criteria</strong></td>
<td><strong>Criteria</strong></td>
</tr>
<tr>
<td>Safety</td>
<td>Safety</td>
</tr>
<tr>
<td>Environmental/Social considerations</td>
<td>Environmental/Social considerations</td>
</tr>
<tr>
<td>Life cycle cost</td>
<td>Life cycle cost</td>
</tr>
<tr>
<td>Reduction potential of energy</td>
<td>Reduction potential of energy</td>
</tr>
<tr>
<td>Operational Availability</td>
<td>Operational Availability</td>
</tr>
<tr>
<td>Durability</td>
<td>Durability</td>
</tr>
<tr>
<td>etc.</td>
<td>etc.</td>
</tr>
</tbody>
</table>

**Overall Evaluation**

△: Applicable
△: Not applicable
Example of Japan’s Energy-Saving Technology

• A press release in December 2021 reported that Nippon Steel Engineering received an order for its CDQ system from Korea’s Hyundai Steel after the company highly evaluated the system for its top global level steam generation rates and abundant delivery record, high operating rate, and stable operation results.

• The announcement of a steelmaker in Korea, Japan’s competitor, placing an order for Japan’s energy-saving technology, is expected to stimulate JISF’s eco solution activities.

• According to Hyundai Steel’s press release, the company is currently planning large-scale investments and technology development toward reducing greenhouse gas emissions, and as part of this plan will install CDQ systems by issuing Green Bonds.

*Schematic drawing of a CDQ system (Nippon Steel Engineering)*

*CDQ (Coke Dry Quenching)*
Innovative technology development
Innovative Technology Development
Challenged by Japanese Steel Industry

References:
Research Evaluation Committee, “(1) Hydrogen Reduction Process Technology Development” in “Environmentally Harmonious Process Technology Development” (Step 1 of Phase II) (Post-evaluation), Subcommittee Meeting Document, December 23, 2022, NEDO.

The results of technology development to achieve the Zero-Carbon Steel (FY2021-2022 NEDO project) will also be utilized.

Kobe Steel, JFE Steel, Nippon Steel, and Nippon Steel Engineering were commissioned by NEDO to conduct the “Environmentally Harmonized Steelmaking Process Technology Development (COURSE50).”

The Green Innovation Fund project “Project/Hydrogen utilization project in the steelmaking process” was commissioned by NEDO and implemented by the Consortium for Hydrogen-Based Steelmaking.
Achievement in COURSE50 ahead of the other countries

The Japanese steel industry started technology development of hydrogen reduction steelmaking in 2008, ahead of the world (NEDO project commissioned).

Since then, we have continued to develop our technology and, since 2016, have been conducting tests using a 12 m³ test blast furnace.

Achievement 1: Demonstrated for the first time in the world that CO₂ emissions can be reduced by 10% or more by blowing hydrogen-based gas into the blast furnace.

Achievement 2: Established chemical absorption and physical adsorption methods necessary for CO₂ separation and capturing.*

We will continue to pursue practical application in the Green Innovation Fund project, with the aim of operating the first commercial unit by 2030.

*C Costs were estimated using the developed absorbing solution and heat exchanger (for waste heat recovery), confirming that the CO₂ separation and capturing cost target of 2,000 yen/t-CO₂ could be achieved.

Acknowledgement: This presentation is based on results obtained from “CO2 Ultimate Reduction System for Cool Earth 50 (COURSE50) Project” commissioned by New Energy and Industrial Technology Development Organization (NEDO).
Ref: COURSE50 Experimental Facilities

COURSE50 project Experimental Blast Furnace

- Experimental Blast Furnace
- Hot Stove
- PCI
- Ore Storage Bin

*CPC*: Pulverized Coal Injection

COURSE50 CO2 Absorption Facility

- Stripper
- Absorber
- Reboiler

NEDO・JISF・COURSE50
Innovative Technology Development

Japanese steel industry promotes the development of innovative technologies to achieve carbon neutrality, as a large amount of CO$_2$ is emitted when iron ore, the raw material for iron, is reduced to iron using coal and other materials. Currently, the following projects are being implemented as Green Innovation Fund projects.

- Development of hydrogen reduction technology using blast furnaces
  1. Development of hydrogen reduction technology using on-site hydrogen
  2. Development of low-carbon technology using external hydrogen and CO$_2$ contained in blast furnace exhaust gas

- Development of direct hydrogen reduction technology using only hydrogen to reduce low-grade iron ore
  1. Development of direct hydrogen reduction technology
  2. Development of technology to remove impurities in electric furnaces using direct reduced iron

The following members of JISF: Nippon Steel, JFE Steel, and Kobe Steel along with the Japan Research and Development Center for Metals (JRCM) applied for New Energy and Industrial Technology Development Organization (NEDO)'s “Green Innovation Fund Project/Hydrogen utilization project in the steelmaking process” and were entrusted with the project on December 24, 2021.

"Development Items of the Project"

1. Development of hydrogen reduction technology using in-house hydrogen
   - By 2030, cut CO₂ emissions from steelmaking by 30% or more through the adoption of technologies such as hydrogen reduction technology utilizing in-house hydrogen and CO₂ separation and collection technology in blast furnaces.

2. Development of low-carbon technology utilizing external hydrogen or CO₂ contained in blast furnace exhaust gas
   - By 2030, demonstrate technologies that can cut CO₂ emissions from steelmaking by 50% or more in a medium-scale test blast furnace.

3. Development of direct hydrogen reduction technology
   - By 2030, demonstrate that direct hydrogen reduction technologies that use low-grade iron ore can cut CO₂ emissions by 50% or more versus existing blast furnace method used in medium-scale reduction furnaces.

   *2-① is a joint initiative by Nippon Steel, JFE Steel, and JRCM

4. Development of impurity removal technology for electric furnace using direct reduced iron
   - By 2030, demonstrate technologies to be used in the comprehensive direct hydrogen reduction to electric arc furnace process that can control the concentration of impurities (components that affect the product) in a large-scale test electric arc furnace to a level similar to that of a blast furnace method in order to produce high-performance steel that can be used for the outer panel of automobiles.
1-① Hydrogen reduction technology using in-house hydrogen (COURSE50)

Development of Hydrogen injection into BF (Reducing CO₂ emissions by 10%)

CO₂ capture (Reducing CO₂ emissions by 20%)

Iron ore
Sintered ore (Fe₂O₃, etc)
Coke (C)
Coal
Coke oven gas
Hydrogen-based gas
Blast furnace gas

Chemical absorption method
Absorption
Capture

Physical absorption method
1. Pressure
2. Reduced pressure

Reforming facilities of coke oven gas

Technologies for Heat recovery from low-temperature off-gas

Ref: Green Innovation Fund/ Utilizing Hydrogen in Steelmaking Process Project
1-② Low-carbon technology utilizing external hydrogen or CO₂ contained in blast furnace exhaust gas

(Ref) conventional blast furnace

Hydrogen direct injection (Super COURSE50)

Hydrogen indirect injection (Carbon recycling blast furnace)

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Ref: Green Innovation Fund/ Utilizing Hydrogen in Steelmaking Process Project

2-① Direct hydrogen reduction technology
2-② Impurity removal technology for electric furnace using direct reduced iron
Other activities
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 20,000 households participating in this program in FY2021.

The Japanese Steel industry is taking actions to reduce energy consumption and CO₂ emission from offices. Unit energy consumption in offices in 2021 was down 31% compared to FY 2008-2012.

**Household CO₂ Emissions**

<table>
<thead>
<tr>
<th></th>
<th>Japan Total (FY2020)</th>
<th>Steel Industry (FY2020)</th>
<th>Steel Industry (FY2021)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kg-CO₂/capital</td>
<td>877</td>
<td>795</td>
<td>662</td>
</tr>
<tr>
<td>Households</td>
<td>397</td>
<td>674</td>
<td>581</td>
</tr>
</tbody>
</table>

**Unit energy consumption in offices**

Data for 300 business sites of 68 companies in FY2021

<table>
<thead>
<tr>
<th></th>
<th>Avg. FY08-FY12</th>
<th>FY21</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit energy consumption per floor area [MJ/m²]</td>
<td>1429</td>
<td>982</td>
</tr>
</tbody>
</table>

▲31%
CO2 emissions per unit of cargo transport decreased to 36.1kg of CO2/k ton-km in FY21 from 44.0kg of CO2/k ton-km in FY06. In FY21, the steel industry modal shift (ships + rail) was 75% for primary transportation and 96% 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.

### CO₂ Emissions per Unit of Cargo Transport

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ Emissions (kg of CO₂/k tons-km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>44.0</td>
</tr>
<tr>
<td>2021</td>
<td>36.1</td>
</tr>
</tbody>
</table>

*Total CO2 emissions from the use of gasoline and diesel oil, heavy oil, etc. of the 42 companies cooperating in the survey, divided by the number of tons/km transported.

### Fuel saving by using electricity from shore-based sources

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

<table>
<thead>
<tr>
<th>No. of units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel mills</td>
</tr>
<tr>
<td>Junction port</td>
</tr>
</tbody>
</table>
Reference
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 a 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**

**ISO50001 Certificate**

- JISF establishes the highest possible goals based on available technologies.
- Member companies take actions for conserving energy and cutting CO2 emissions based on JISF targets.
- 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.
- Performance is evaluated every year by the government advisory council (steel working group) and Keidanren third-party evaluation committee.

- Suitability of the plan is confirmed by providing explanations during the target setting process to the government advisory council and the Keidanren third-party evaluation committee.
- JISF checks the progress by reporting to each companies president at its Executive Board Meeting.
Target in 2030 and initiatives

On the premise that the macro assumptions in the government’s Strategic Energy Plan and the prerequisites for implementing the various measures are met, cut FY2030 energy-related CO2 emissions (total volume) by 30% versus FY2013 by adopting BAT to promote energy conservation, utilizing waste plastics, adopting innovative technologies currently under development and scheduled to be put into use around 2030, and utilizing raw fuel with less CO2 emissions.

<table>
<thead>
<tr>
<th>Initiatives</th>
<th>Expected Reduction (kilotons-CO2)</th>
<th>Calculation Basis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Promote energy conservation (Improving efficiency of coke ovens and power generating facilities; reinforcement of energy-saving facilities; improving efficiency of power-consuming facilities; making EAF process energy efficient)</td>
<td>Approx. 2,700</td>
<td>Potential indicated by the government in the Strategic Energy Plan/Plan for Global Warming Countermeasures *Energy conservation during the EAF process is based on each company's reporting</td>
</tr>
<tr>
<td>2. Expand chemical recycling of waste plastics</td>
<td>Approx. 2,100</td>
<td>Potential indicated by the government in the Strategic Energy Plan/Plan for Global Warming Countermeasures <em>(Expand use of waste plastics to 1 million tons)</em></td>
</tr>
<tr>
<td>3. Adopt innovative technologies (COURSE50, Ferro cokes)</td>
<td>Approx. 2,600</td>
<td>Potential indicated by the government in the Strategic Energy Plan/Plan for Global Warming Countermeasures</td>
</tr>
<tr>
<td>4. Other (Using raw material and fuel with less CO2 emissions, etc.)</td>
<td>Approx. 8,500</td>
<td>Reduction achieved when all the exported scrap (7.5 million tons) is utilized in Japan.</td>
</tr>
<tr>
<td>5. Production volume change</td>
<td>Approx. 3,400</td>
<td>CO2 emission reduction achieved when national crude steel production reaches 90 million tons* as indicated in the Strategic Energy Plan/Plan for Global Warming Countermeasures *This is not the total of each company’s production capacity reduction announced in its management plan</td>
</tr>
<tr>
<td>6. Improve CO2 emission factor of purchased electricity</td>
<td>Approx. 8,000</td>
<td>CO2 emission reduction achieved when emission factor of purchased electricity improves to (0.25kg-CO2/kWh)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>Approx. 57,900 (30% reduction)</td>
<td></td>
</tr>
</tbody>
</table>

*FY2030 target before the reexamination was a “9 million-ton reduction in CO2 emissions versus BAU”.
Prerequisites for Eco Process Target

Promote Energy Conservation

- The goal of the JISF’s Action Plan is to incorporate the total amount of CO2 emissions reductions calculated from the maximum energy conservation potential without physical/economic constraints. It does not promise the amount of reduction or the number of countermeasure to be implemented for each specific measure.

Expand Chemical Recycling of Waste Plastics

- The quality and collection volume of waste plastics suitable for steel chemical recycling must be ensured and the bidding system for plastic packaging and containers must be drastically improved under the new law on waste plastics.

Introduce Innovative Technology

- Innovative technologies must be developed through industry-wide technological development under government support such as the Green Innovation Fund, and economic rationality must be ensured in their introduction.
- Regarding COURSE50, international equal footing must be ensured. It should also be ensured that the social infrastructure, including selection and securing of storage space, is in place when conducting CCS as a national initiative.

Use of raw material and fuel suitable for CO2 reduction, etc.

- With regard to the use of cold iron sources such as scrap and reduced iron, technology for manufacturing high-grade steel products using cold iron sources as raw materials should be established by the industry’s effort in R&D, with government support through the Green Innovation Fund.
- Economic rationality must be ensured in the domestic collection of scrap that can withstand the production of high-grade steel and in the utilization of cold iron sources. Furthermore, when expanding the use of scraps to electric arc furnaces, the industrial electricity price must be at the same level as neighboring steel trading countries, such as China and Korea.
External Factors and review of 2030 Target

External Factors

- Increase in CO₂ emissions in FY2030 resulted by increased production (domestic crude steel production exceeding 90 million tons) and/or failure to improve the CO₂ emission factor of purchased electricity to 0.25 kg-CO₂/kWh will not fall under target management.

Review of Target

- Targets will at least be reviewed at the following timing until the target year.
  - When policy changes are made due to revisions to the Strategic Energy Plan and/or Plan for Global Warming Countermeasures
  - When it is clear that the prerequisites for each measure indispensable to achieving the target will not be met
  - When there is considerable impact on production activities due to natural disasters and/or a significant change in the social environment
Comparison with the Government and overseas steel makers

**Target**

- JISF has set an ambitious target which includes not only the steel industry’s energy conservation and CO₂ reduction potential (maximum adoption of BAT) outlined in the 6th Strategic Energy Plan/Plan for Global Warming Countermeasures, but also the amount of reduction to be achieved through the utilization of scraps.

- If this target is achieved, the unit CO₂ emission per ton of crude steel in FY2030 will improve approximately 13% versus FY2013 (approx. 15% improvement versus FY2020).

- This is consistent with the assumed base unit improvement (about a 10% improvement versus FY2020 as of FY 2030) necessary to achieve 2050 Carbon Neutrality as indicated in the government’s Technology Roadmap Formulated for Transition Finance Toward Decarbonization in the Iron and Steel Sector.


- The international comparison based on the 2019 actual results also shows that Japan has the world’s most energy-efficient steel industry.

- The new Phase II target is sufficiently ambitious even when compared to the current energy efficiency as well as the targets of major foreign steelmakers.
Investments for Environmental Protection and Energy Conservation

- The 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 ¥2.1 trillion between FY2005 and FY2021.

*Consolidation of production facilities, renewal of energy saving equipment, etc.

Source: Development Bank of Japan Inc.
Energy Conservation Initiatives of the Steel Industry

**SCOPE-21**

1) Process innovations
   - Continuous casting, continuous annealing, etc.
   - Blast furnace coal powder input, coal moisture control, etc.
   - Artificial intelligence, supply chain network, etc.
   - Constant improvements

2) Recovery and efficient use of byproduct gases
   - Gas holder, high-efficiency gas turbine combined cycle generation, etc.
   - Hydrogen amplification, CO₂ recovery

3) Exhaust heat recovery
   - TRT, (CDQ), etc.
   - Regenerative burners, etc.
   - Recovery of mid/low-temp. exhaust heat

4) Use of waste materials
   - Waste plastics and tires, biomass
   - Gasification, etc.

**COURSE-50**

- Ferro-coke
- Process innovations
- Process improvements
- Byproduct gas use
- Exhaust heat recovery
- Waste material use
According to the IEA, Japan has the world’s smallest potential for energy conservation per ton of crude steel. According to RITE, Japan has the world’s most energy efficient 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 (2019, Japan=100)

Source: RITE “Estimated Energy Unit Consumption in 2019”

Japan has the world’s highest energy efficiency.
Crude Steel Production and Total/Unit CO₂ Emissions

**Crude Steel Production and CO₂ Emissions**
(Electricity emission factor after arrangement)

![Graph showing crude steel production and CO₂ emissions over time](image)

**Crude Steel Production and CO₂ Emissions factor**
(Electricity emission factor after arrangement)

![Graph showing crude steel production and CO₂ emissions factor over time](image)
Introduction of AI, IoT, and other Digital Technologies

- Steelmakers are increasingly introducing AI, IoT, and other advanced digital technologies. This is expected to contribute to preventing operational troubles and stabilizing operations (energy saving).

**Examples of technologies introduced by JISF member companies**
(excerpted from data released by JISF member companies)

<table>
<thead>
<tr>
<th>Company</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nippon Steel Corporation</td>
<td>At the No.2 blast furnace of Muroran Works, Nippon Steel introduced a system to predict conditions inside a blast furnace by using a mathematical model. AI helps automatically adjust and achieve optimal operational conditions.</td>
</tr>
<tr>
<td>JFE Steel Corporation</td>
<td>JFE Steel introduced a data science technology at its domestic blast furnaces for the purpose of developing a cyber-physical system (CPS). This enables to detect signs of abnormality and predict conditions inside a blast furnace to achieve stable operations.</td>
</tr>
<tr>
<td>Kobe Steel, Ltd.</td>
<td>At the No. 2 blast furnace of Kakogawa Works, Kobe Steel introduced a system to predict blast furnace heat levels by using AI. This enables to predict hot metal temperature automatically and highly accurately.</td>
</tr>
</tbody>
</table>
Quantitative Evaluation of Contribution of High Strength Sheets for Automobiles

Summary

Emissions can be efficiently reduced in the in-use stage by using high-strength steels in components of final products. High-strength steel sheets for automobiles are steel sheets that can be thinned out while maintaining high strength (and thus reducing material and product weight). Automobiles using this material are lighter than those using conventional steel sheets without such features, thus leading to fuel efficiency improvement that enables CO₂ emission reduction during operation.

Assessment of reductions achieved in use phase

Quantification results of avoided emissions

Avoided emissions at the in-use stage of high-strength steel sheets for automobiles in FY2017 were as followed below:

- Domestic use: 4.5 million t CO₂
- Export: 0.5 million t CO₂
- Total: 5.0 million t CO₂

Avoided emissions were calculated using the formula provided below. A cross-sectional assessment was conducted for total steel in a given year to estimate annual avoided emissions.

Avoided emissions = Number of new cars manufactured x Average travel distance x Fuel efficiency improvement rate / Average fuel efficiency of new cars x Average years in use

Baseline

High strength sheet for automobiles

(1) Baseline scenario and assumptions

-Assumptions

High-strength steel sheets can be made thinner than baseline normal steel while maintaining high strength; and therefore, automobiles using this material are lighter than those using conventional steel sheets without such features, thus leading to fuel efficiency improvements that enable CO₂ emission reductions during operation.

(2) Scope of quantification

-Target sheets:

Steel sheets used domestically and exported steel (steel ex-ports from JIS).

-Assumptions:

Japan steel manufacturers do not pass on environmental costs to consumers.

(3) Assumptions

The case study assessed CO₂ emission reductions due to fuel efficiency improvements at the in-use stage of automobiles.

(4) Assumptions

As new car travelled and transport account for a significant percentage of the entire life cycle of iron and steel, and also because the assessment involves replacing steel products, little changes is made at the manufacturing stage.

(5) Assumptions

When comparing the fuel efficiency of new cars manufactured in a given year, the case study performed a cross-sectional assessment of steel.

References

- Research on the contribution of steel products to society-wide energy conservation: Overview (Japanese)
  https://www.mext.go.jp/a_menu/sousa/kihon/0103/010302006.html
- Research on the contribution of steel products to society-wide energy conservation: Study 1: Automotive high-strength steel sheets (Japanese)
  https://www.mext.go.jp/a_menu/sousa/kihon/0103/010302006.html
- Research on the contribution of steel products to society-wide energy conservation: Study 2: Automotive high-strength steel sheets (English)
  https://www.mext.go.jp/a_menu/sousa/kihon/0103/010302006.html
- Research on the contribution of steel products to society-wide energy conservation: Study 3: Automotive high-strength steel sheets (Japanese)
  https://www.mext.go.jp/a_menu/sousa/kihon/0103/010302006.html
- Research on the contribution of steel products to society-wide energy conservation: Study 3: Automotive high-strength steel sheets (English)
  https://www.mext.go.jp/a_menu/sousa/kihon/0103/010302006.html
Quantitative Evaluation of Contribution of High Tensile Strength Plates for Vessels

Summary
Emissions can be effectively reduced at the in-use stage by using high-tensile steel in components of final products. High-tensile plates for vessels are made from plates that can be thinned out while maintaining high strength (and thus reducing steel product weight). Vessels using this material are lighter than those using conventional steel sheets without such features, thus leading to fuel efficiency improvements that reduce CO2 emissions during operation.

Quantification results of avoided emissions
Avoided emissions at the in-use stage of high-tensile plates for vessels in FY2017 were as provided below:
- Domestic use: 1.64 million t CO2
- Exports: 0.63 million t CO2
- Total: 2.27 million t CO2

Avoided emissions were calculated using the formula provided below. A cross-sectional assessment was conducted for each type of vessel to estimate avoided emissions.

Avoided emissions = Fuel consumed by vessel × (Weight reduction rate of operating vessel × Contribution ratio to fuel savings) × (Weight reduction rate of operating vessel × Contribution ratio to fuel savings) × (Calculation value of CO2)

(1) Baseline scenario and assumptions
- Baseline scenario
  This is a study assuming CO2 emission reductions from improving fuel efficiency at the in-use stage of vessels by replacing steel plates with high-tensile steel plates without special functions internal seals, which serve as a baseline, with high-tensile steel plates up to the current year.

- Assumptions
  High-tensile plates can be made thinner than baseline material steel while maintaining high strength, and therefore, vessels using this material are lighter than those using conventional steel sheets without such properties, thus leading to fuel efficiency improvements that reduce CO2 emissions during operation. (Quantifications are estimates based on actual data.)

(2) Scope of quantification
- Target steel plates
  Steel plates used domestically and exported (Steel experts from 2019)
  The steel used was in-house manufactured in Japan, and excludes overseas manufacture.
  (Japanese steel manufacturers do not possess integrated steel works overseas.)

- Target stages
  The steel study assumed CO2 emission reductions due to fuel efficiency improvements at the in-use stage of vessels.
  Avoided material mining and transport account for a significant portion of the entire life cycle of steel and steel.
  and also because the assessment is based on replacing steel plates, little change is seen in the manufacturing stage.
  When assessing the effect of reducing the weight of steel, CO2 emissions from steel material mining and transport become less than the baseline in accordance with the weight of steel used. But the calculation indicates only the in-use stage in its quantification.

(3) Assessment period
  From the viewpoint of comparing CO2 emissions from a manufacturing process during one fiscal year, the study performed a cross-sectional assessment of steel.

(4) References
  Papers on the method of analysis have been published in the Institute of Energy Economics, Japan reports:
  Research on Contributions of Steel Productivity Improvement in the Global Value Chain (2018)
  Research on Contributions of Steel Productivity Improvement in the Global Value Chain (2018)
  Research on Contributions of Steel Productivity Improvement in the Global Value Chain (2018)
  Research on Contributions of Steel Productivity Improvement in the Global Value Chain (2018)

Source: Japan Business Federation, "Contributing to Avoided Emissions through the Global Value Chain"
Quantitative Evaluation of Contribution of High Strength, Heat-resistant Tubes for Boilers

Summary

Emissions can be effectively reduced at the in-use stage by using high-function steels in components of final products. High-strength heat-resisting tubes for generating boilers can sustain higher temperatures compared to conventional heat-resistant steel tubes, and can thus improve the power generation efficiency of steam power plants. This leads to CO₂ emission reductions from fuel consumption savings.

Quantitative results of avoided emissions

Avoided emissions at the in-use stage of heat resistant tubes for generating boilers in FY2017 were as provided below:
- Domestic use: 0.456 million tCO₂
- Exports: 0.429 million tCO₂
- Total: 0.885 million tCO₂

Avoided emissions were calculated using the formula provided below. A cross-sectional assessment was conducted for total avoided emissions, with the efficiency improvements at 50°C – 400°C class steam power plants and emission reductions due to improved fuel consumption at the in-use stage of boilers.

(1) Baseline scenario and assumptions

- Baseline scenario
  - The case study analyzed CO₂ emission reductions attributable to savings in fuel input due to replacing baseline heat-resistant tubes for supercritical (SC) 560°C-class steam power plants with high-alloy steel tubes for ultra-supercritical (USC) 550°C – 600°C-class steam power plants.

- Assumptions
  - High-alloy steel tubes can resist higher temperatures compared to the baseline steel tubes for supercritical (SC) 560°C-class steam power plants. Therefore, steam power plants equipped with high-alloy steel tubes can operate at higher ranges of steam temperature compared to those using steel boiler tubes for supercritical (SC) 560°C-class steam power plants, thus improving power generation efficiency which results in energy savings. (Quantifications are estimates based on actual data.)

(2) Scope of quantification

- Target steel tubes: Steel tubes used domestically and exported steel (steel exports from 2009)
- Target steam power plants: Steam power plants that utilize high-performance heat-resistant tubes, or 25% of power plants that are in use

(3) Assessment period

Assessment period is the difference of CO₂ emissions from a manufacturing process during a fiscal year, the case study performed a cross-sectional assessment of steel.

(4) References

- "The role of the Industrial Steel Federation in the global value chain, Japan Business Federation, "Contributing to Avoided Emissions through the Global Value Chain""
Quantitative Evaluation of Contribution of Grain-oriented Sheets for Transformers

**Summary**

Emissions can be effectively reduced at the in-use stage by using high-function steel in components of final products. Current grain-oriented silicon steel sheets for transformers can reduce iron loss (energy loss) by up to 50% compared to conventional silicon steel sheets. Transformers from thirty years ago, and can thus contribute to efficient electric power transmission, and thus CO₂, emission reduction.

**Quantification results of avoided emissions**

Avoided emissions at the in-use stage of grain-oriented silicon steel sheets for transformers in 2021 were as follows:

- Domestic use: 2.15 million CO₂ units
- Export: 1.05 million CO₂ units
- Total: 3.20 million CO₂ units

Avoided emissions were calculated using the formula provided below. A mass emissions assessment was conducted for total steel ingot prior to manufacture of steel sheets.

\[
\text{Avoided emissions (tonnes CO₂)} = \left( \text{Transformed steel in kg} \times \text{heat capacity of steel} \times \text{CO₂ emission factor} \right) / 1000
\]

**Sources and Assumptions**

- **Assumptions**
  - Current silicon steel sheets for transformers can reduce iron loss (energy loss) by up to 50% compared to conventional silicon steel sheets.
  - Transformers from thirty years ago.
  - CO₂ emissions in factories, transformers, and in-use stage
  - CO₂ emissions in transportation
  - CO₂ emissions in manufacturing

**Scope of quantification**

- **Target steel sheets**: Steel sheets used domestically and exported steel
- **Target period**: 2021
- **Target emissions**: CO₂ emissions

**References**

- Japan Business Federation, "Contributing to Avoided Emissions through the Global Value Chain"

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Source: Japan Business Federation, "Contributing to Avoided Emissions through the Global Value Chain"
Quantitative Evaluation of Contribution of Stainless Steel Sheets for Railway Cars

Summary

Emissions can be effectively reduced at the in-use stage by using high-function steels in components of final products. Stainless steel sheets from railway cars are an ideal case that can be found not only in maintaining high strength and high reducing greenhouse gas emissions. Railways are using this material as lighter than those using conventional steal sheets without such features, thus leading to fuel efficiency improvements while reducing CO2 emissions during production.

Quantification results of avoided emissions

Avoided emissions at the in-use stage of stainless steel sheets for railway cars in FY2017 were as follows:
- Domestic use: 0.27 million t CO2
- Export: 0.40 million t CO2
Total: 0.67 million t CO2

Avoided emissions were calculated using the formulas provided below. A cross-sectional assessment was conducted for total steel use, given the importance of avoided emissions.

Avoided emissions = Energy saved during operation per unit railway car weight reduced per unit distance driven per car × Weight reduced per car × Annual distance travelled per car × Number of standard steel railway cars produced annually

(1) Baseline scenario and assumptions

Baseline scenario
The case study assessed CO2 emission reductions from improving fuel efficiency at the in-use stage of railway cars by using steel sheets with specific functions (inert steel), which serve as the base case, with stainless steel sheets on the second stage.

Assumptions
High strength steels can be made thinner than normal steel while maintaining high strength and ductility. Railway cars using this material are lighter than those using conventional steel sheets without such properties, thus leading to fuel efficiency improvements that reduce CO2 emissions during operation. (Quantifications are estimated based on actual data.)

(2) Scope of quantification

Target steel sheets
- Used in railcars and exported steel (not reported since 2009)
- The case study covered only steel manufactured in Japan and excludes overseas manufacturing.

Assessment period
From the viewpoint of comparing CO2 emissions from a manufacturing process during the fiscal year, the case study performed a cross-sectional assessment of stock.

References
- Japan Business Federation, “Contributing to Avoided Emissions through the Global Value Chain”
The global competitive edge of the Japanese steel industry, mainly for high-performance steel

- Steel from other countries is incomparable with 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. Japan is the only net exporter of steel to China now.
Mixed cement (mainly slag cement) is one way to lower CO₂ 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 CO₂ emissions.

Replacing conventional cement (Portland cement), which generates CO₂ during the firing of raw materials, with slag cement, which does not generate CO₂ during production, reduced annual CO₂ emissions by 10.69 million tons/year (FY21).

Domestic: Annual reduction of 3.24 mn tons of CO₂
Exports: Annual reduction of 7.45 mn tons of CO₂

Assumptions for emission reduction contribution:
Conversion to volume of cement: 450kg of slag/ Ton of cement
CO₂ emission reduction: 312kg of CO₂/Ton of cement

Source: Japan Cement Association, Nippon Slag Association
Growth of Global Crude Steel Production

- As of the 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 production will increase for many more years
India’s steel industry plans to approximately triple crude steel output to 300 million tons by 2030.

Source: worldsteel
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>• This conference has been held periodically since July 2005, when an MoU was signed by the leaders of steel industry in both countries. Providing a forum for exchanges of information about steel technologies, this conference plays a key role in international steel industry cooperation.</td>
</tr>
<tr>
<td>• The 12th conference was held in March 2022 online. Although it was the first time in two years due to COVID-19, approximately 150 people participated. The importance of continuing technical exchanges between Japan and China in the environmental field was reaffirmed.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. India: Public and Private Collaborative Meeting between the Indian and Japanese Steel industries (2011~)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Launched in 2011, this meeting has been held 11 times, bringing together Public and Private sector energy conservation experts from the Indian and Japanese Steel industries.</td>
</tr>
<tr>
<td>• 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. Most recently held in December 2022.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. ASEAN: ASEAN-Japan Steel Initiative (2014~)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Since its start in February 2014, this initiative brings together steel industry energy conservation professionals from Japan and 6 ASEAN countries (now 7 countries with Myanmar as a member). Workshops for specific themes have been held for the ASEAN region and individual countries to support energy conservation measures in the ASEAN steel industry.</td>
</tr>
<tr>
<td>• 16 ASEAN steel mills has undergone steel plant diagnoses (2 conducted online) and was provided advice for improving operations and using new technologies.</td>
</tr>
</tbody>
</table>
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. (revised Jan. 2022).

The Technologies Customized List for India

76 recommended technologies (42 techs for BF-BOF and 34 techs for EAF)
Energy conservation benefits, technology suppliers and other information

Technology Explanation Sheets
Thorough explanations of individual technologies

Contribution to the introduction of energy-saving technologies in the Indian steel industry

- At 9 steelworks where steel plant diagnoses were implemented between 2007 and 2018, Japanese experts recommended the introduction of energy conservation technologies in **42 cases** on the basis of the Technologies Customized List.
- **About 70%** of the recommended technologies have been introduced or planned to be introduced (as of January 2021).

### India Technologies Customized List (for blast furnaces)

<table>
<thead>
<tr>
<th>Technologies recommended for steelworks where energy conservation diagnoses have been implemented and technologies that have been introduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
</tr>
<tr>
<td>Number of technologies recommended</td>
</tr>
<tr>
<td>Number of technologies introduced*</td>
</tr>
<tr>
<td>Number of technologies planned to be introduced</td>
</tr>
</tbody>
</table>

*Many of them are large-scale, cost-effective technologies, including coke dry quenching (CDQ) and top-pressure recovery turbines (TRT).*
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 CO2 emissions from a steel plant.

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 steel plant diagnoses have been performed at 30* locations.
- 14 plants in India
- 16 plants in the ASEAN region in 6 countries**

*Including the on-line Steel Plant Diagnosis
**Indonesia, Singapore, Thailand, Philippines, Vietnam, Malaysia
Example of use of unused energy in nearby locations

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

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

<table>
<thead>
<tr>
<th>Steam generators</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam generation:</td>
<td>40 tons/hour</td>
</tr>
<tr>
<td>Heating capacity:</td>
<td>29.5GJ</td>
</tr>
<tr>
<td>Thermal transmission area:</td>
<td>382m²</td>
</tr>
<tr>
<td>Primary steam pressure:</td>
<td>1.01MPa (saturation temperature)</td>
</tr>
<tr>
<td>Secondary steam pressure:</td>
<td>0.837MPa (saturation temperature)</td>
</tr>
</tbody>
</table>

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)

Other activities
Examples of Efforts for Mixed-Firing Power Generation Using Forestry Residue

Characteristics
- Reducing greenhouse gas emissions by increasing the use of woody biomass
- Increasing the use of renewable energy that can generate power stably (biomass) under the feed-in tariff system
- Contributing to promoting the local forest industry and revitalizing the rural economy

Kamaishi Steelworks
Power generation facilities: Pulverized coal thermal power generation (149MW)
Quantity used: About 7,000 tons per year (current level) → 48,000 tons per year (final target)
Type: Chips → Fine-grained chips
Commencing time: October 2010 → June 2015: The quantity used was increased.

In 2017, this steelworks received the New Energy Award (the prize of the Minister of Economy, Trade and Industry) from the New Energy Foundation for its efforts to increase the use of biomass-coal co-firing power generation, together with IHI Corporation.

Oita Steelworks
Power generation facilities: Pulverized coal power generation (330MW)
Quantity used: 12,000 tons per year
Type: Chips
Commencing time: December 2014 (The planned quantity has been used since February 2015.)
Efforts to Achieve Zero-Carbon Steel Production

- In June 2020, Nippon Steel, JFE Steel, and Kobe Steel, which are members of the JISF, and the Japan Research and Development Center for Metals (JRCM) were entrusted with a technology development project for realizing zero-carbon steel. The New Energy and Industrial Technology Development Organization (NEDO) had publicly invited applications for the project.
- This project aims to extract several prospective innovative technologies that focus mainly on decarbonization in steel production and to prepare a technology development roadmap for the steel industry of Japan. The JISF has determined to lead the world in undertaking technology development for the purpose of realizing zero-carbon steel by bringing forward initial plans under the above-mentioned long-term vision.
Steel Production Processes and Development and Use of Energy Conservation Technologies