

JFE Steel's Environmental Conservation and Effective Utilization of Energy

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Abstract:

The JFE Group aims to create a prosperous society by promoting business activities that are in harmony with the environment. As part of its environmental policy, the JFE Group is working to reduce the environmental impact of all its business activities, conserve resources, and contribute to energy conservation. This paper introduces the effective utilization of energy in steel works and environmental technologies related to environmental conservation and effective utilization of resources.

1. Introduction

The JFE Group aims to create a prosperous society by promoting business activities that are in harmony with the environment¹⁾.

As part of those efforts, based on the recognition of the problem of climate change as a top-priority management issue, the JFE Group is promoting CO₂ emission reduction in its steel business and expansion of its contribution to CO₂ reduction in society as a whole.

The Japanese steel industry has drawn up a roadmap toward realization of carbon neutrality in 2050, and is promoting initiatives for CO₂ reduction based on short-term, medium-term and long-term goals set by the industry.

As part of its environmental policy, the JFE Group is committed to reducing environmental impacts, conserving resources and contributing to the environment through energy-saving businesses in all Group business activities, and is grappling with environmental conservation, resource conservation and effective utilization of energy as continuing activities.

This Special Issue presents examples of the development and introduction of equipment which contributes to effective utilization of energy through improvement of the efficiency of energy equipment, waste heat

recovery, etc. in the steel works, the construction of an environmental management system in the JFE Group as a whole, environmental conservation efforts being carried out in the Group, and environmental technologies for effective utilization of resources. In addition, examples and technologies for improvement of the level of environmental and energy management by utilizing state-of-the-art IT and DS technologies are also introduced.

2. Initiatives for Prevention of Global Warming in the Steel Industry

JFE Steel is a member of the Japan Iron and Steel Federation (JISF), which has positioned the problem of global warming as a top-priority issue for the steel industry, and has endorsed Japan's "2050 Carbon Neutral" policy. To contribute to achieving that goal by realizing carbon neutrality in the Japanese iron and steel industry, the JISF amended its "Commitment to a Low Carbon Society," which had been its voluntary plan until that time, to "Carbon Neutrality Action Plan," and revised its Phase II target (FY 2030 target) in February of 2021. The main points consist of the following four pillars²⁾.

① Eco Process

Cut energy-related CO₂ emissions (total volume) in FY 2030 by 30% vs. FY 2013 by adopting BAT (best available technology) to promote energy conservation, utilizing waste plastics, adopting innovative technologies that are currently under development and scheduled to be in use around 2030, and utilizing raw fuels that contribute to CO₂ reduction.

② Eco Product

Contribute to CO₂ reduction in the stage of use in final products in society by supplying high performance steel domestically and internationally. The reduction

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potential in 2030 is estimated to be approximately 42 million t-CO₂ for the following 5 products that have been evaluated for their quantitative contributions to reduction of CO₂ emission: Automotive steel sheets, grain-oriented electrical sheets, heavy plates for ship-building, boiler tubes, stainless steel sheets.

③ Eco Solution

Contribute to CO₂ emission reduction worldwide by transferring and spreading the Japanese steel industry's advanced energy-saving technologies and equipment to the world's steel industry. The estimated contribution to CO₂ emission reduction in 2030 is approximately 80 million t-CO₂.

④ Innovative technology development

Since 2008, the Japanese steel industry has carried out the development of hydrogen reduction steel making and CO₂ separation and capture technologies under the COURSE50 Project. Japan's steel makers participated in carrying out these projects under commission from Japan's New Energy and Industrial Technology Agency (NEDO). However, as innovative technology development for realizing carbon neutrality in 2050, the following four technology development efforts have been proposed as main initiatives to be realized through transfer to Green Innovation Fund projects and continuing implementation.

- a) Development of hydrogen reduction technology, etc. using in-house hydrogen
- b) Development of low-carbon technologies utilizing external hydrogen and CO₂ contained in blast furnace exhaust gas

c) Development of direct hydrogen reduction technology

d) Development of an impurity removal technology for electric arc furnaces using direct reduced iron

In February 2023, the JISF announced the CO₂ reduction effects expected in the Japanese iron and steel industry, mainly through these efforts, as a report of the Iron and Steel Working Group of the Industrial Structure Council. **Table 1** shows an outline.

3. Energy-Saving and CO₂ Reduction Activities

3.1 Energy Efficiency of the Japanese Iron and Steel Industry

In 2022, the Research Institute of Innovative Technology for the Earth (RITE) published a report on the international comparison of energy efficiency in the steel industry, which covered periods of 5 years each from 2005. Although the results were reported as data for fiscal year 2019 and did not include FY 2020, which was heavily influenced by COVID-19, it became clear that the Japanese steel industry is firmly maintaining the world's highest level of energy efficiency. **Figure 1** shows the comparison of primary energy intensity for converter steel. The factors in this result are considered to be a high diffusion rate of energy-saving technologies, implementation of measures to achieve the above-mentioned JISF "Carbon Neutrality Action Plan" by each company, and information sharing and friendly rivalry in the steel industry.

Table 1 Performance evaluation by CO₂ reduction countermeasures³⁾

Initiatives	Expected FY2030 performance (Mt-CO ₂)	Remarks
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	Approx. ▲ 270	• All member companies continued their efforts to promote energy saving by sequentially upgrading their coke ovens, which had increased CO ₂ emissions due to age deterioration and the impact of the Great East Japan Earthquake.
2. Expand chemical recycling of waste plastics	Approx. ▲ 210	• The amount of waste plastic collected in FY2021 increased by 10 000 tons compared to FY2013.
3. Adopt innovative technologies COURSE50, Ferro coke	Approx. ▲ 260	
4. Other Using raw material and fuel with less CO ₂ emissions, etc.	Approx. ▲ 850	• Promotion of utilization of cold iron sources and heating furnace fuel conversion (from heavy oil, etc. to city gas).
5. Improve CO ₂ emission factor of purchased electricity	Approx. ▲ 800	• Calculated using the 2013 coefficient (0.567 kg-CO ₂ /kWh) and the 2021 coefficient (0.436 kg-CO ₂ /kWh).
6. Production volume change, etc.	Approx. ▲ 3 400	• The production fluctuations includes energy-saving factors such as operation efforts and the effect of fixed energy due to production fluctuations (consumption rate fluctuations).
Total	Approx. ▲ 5 790 (30%reduction)	

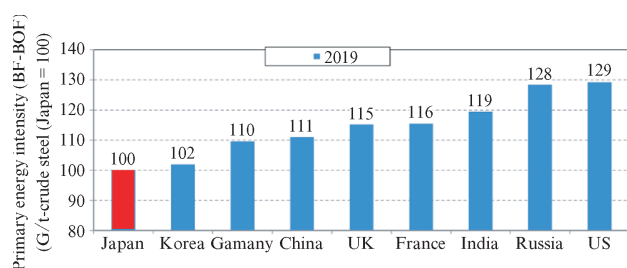


Fig. 1 Estimate of steel industry (BF-BOF*) energy efficiency⁴⁾ (2019, Japan = 100)

*Blast Furnace-Basic Oxygen Furnace

3.2 Energy-Saving and CO₂ Reduction Activities

To realize carbon neutrality, the steel industry is carrying out technology development which will revolutionize the steel manufacturing process as such. On the other hand, although the industry has grappled with energy-saving activities for many years, the importance of those activities and the technology development that supports them is also increasing.

Blast furnace steel manufacturers devise ways to minimize the total energy consumption in the steel works by achieving a balance of energy supply and demand between processes which are sources of byproduct energy, centering on the ironmaking and steelmaking processes, and processes that consume byproduct energy when rolling sheets and plates and performing surface treatment, as well as thermal power plants and oxygen-producing plants. “Development of Steelworks Operation Strategy Model,” which is reported in this Special Issue, is effective in the stage of preparing plans for this purpose. In addition, “Transition to Digital Smart Maintenance in Steel Plant Power Equipment” is intended to avoid large-scale trouble in the steel works, but because stable operation while maintaining the optimum balance between processes mentioned above also has the effect of suppressing total energy consumption, advanced maintenance technology can also be seen as an item that contributes to energy saving.

Improvement of fuel combustion technology is also effective for increasing energy use efficiency. This Special Issue includes three papers on combustion technology, and takes up a technology aimed at improvement of heat transfer efficiency, and a technology that combines more advanced waste heat recovery with a technology that suppresses environmentally hazardous substances in exhaust gas. This issue also includes a technology for byproduct gas that must unavoidably be flared off by combustion dissipation when a power outage or other abnormality occurs, which was developed to reduce environmental loads such as soot gener-

ation (black smoke).

From the viewpoint of strengthening waste heat recovery, technologies utilizing thermoelectric conversion devices are also discussed. A technology that effectively utilizes the radiant heat during slab casting in the steelmaking process, and a technology that provides a power supply for measuring instruments by using the radiant heat of the coke oven furnace body are introduced.

3.3 Use of IT and DS Technologies

The JFE Group is promoting a substantial improvement in productivity, cost reduction and strengthening of equipment inspection and maintenance based on a fusion of the data, know-how and technologies accumulated over many years and DX (digital transformation).

The applications of technologies utilizing information technology (IT) and data science (DS) are extremely diverse, but in the energy field, in addition to the aforementioned “Development of Steelworks Operation Strategy Model” and “Transition to Digital Smart Maintenance in Steel Plant Power Equipment,” the development⁵⁾ and practical operation of “Fuel, Electric Power and Steam Supply and Demand Guidance System in Steel Works” may also be mentioned. By using this guidance function, as shown in Fig. 2, even young employees can perform optimum steel works energy operation, which had depended largely on the experience and instincts of veterans until now.

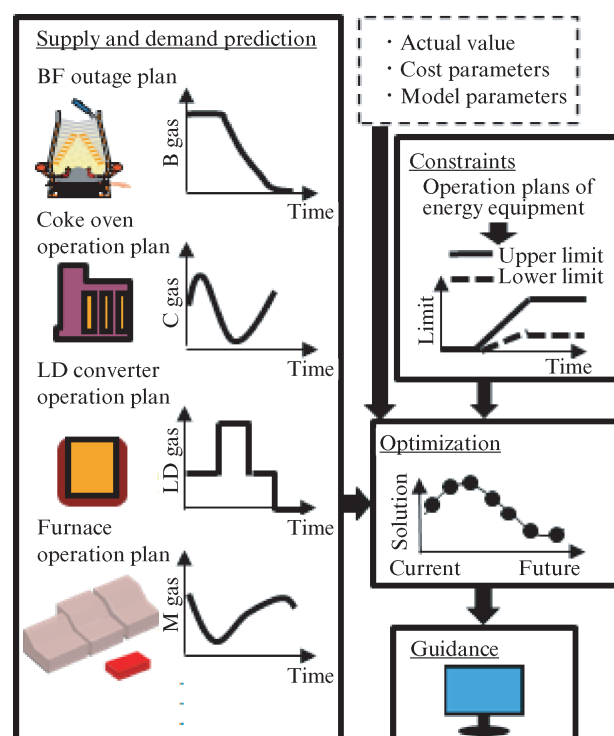


Fig. 2 Overall configuration of guidance system

For details, please refer to JFE Technical Report No. 30 (English edition), “Special Issue on IT Reform.” In the environmental field, the current Special Issue also introduces automatic dust detection, monitoring of the condition of dust collectors and technology utilizing drones, among other topics.

4. Environmental Conservation Activities

4.1 Environmental Policy and Environmental Management

Based on the Environmental Policy mentioned in the Introduction, the JFE Group has set high targets for effective utilization of resources, centering on iron and steel manufacturing processes, prevention of atmospheric and water pollution, and efficient use of water resources, and is grappling with these environmental issues.

In JFE Steel, the Head Office Auditing Dept. and the Environment, Disaster Prevention & Recycling Dept. conduct audits once each year, and at Group companies, companies are grouped based on the results of risk assessments, including the condition of the equipment owned by each company, etc., and audits are carried out at a frequency of once a year to once in 5 years.

To improve the knowledge and awareness of environmental conservation among employees, employees are encouraged to acquire qualifications as pollution control managers, and environmental management training is conducted for the environmental managers of each Group company.

4.2 Environmental Impact Reduction Activities

The JFE Group has achieved energy conservation and reduced environmental impacts by improving the efficiency of production equipment and introducing environmental measure equipment. To promote those efforts, the Group invested ¥26.3 billion in environmental conservation measures in fiscal year 2022. **Figure 3** shows the transition of the cumulative total of environmental conservation investment of JFE Steel.

4.2.1 Suppression of discharges of atmospheric pollutants

Based on the voluntary action plan drawn up by the JISF, JFE Steel set KPI (Key Performance Indicators) as priority CSR issues until FY 2022, centering on air pollutants generated by the steel manufacturing process, etc., and stably achieved its targets each year. The targets and results for FY 2022 are shown in **Table 2**.

Beginning with installation of desulfurization and dephosphorization facilities at sinter plants, which are

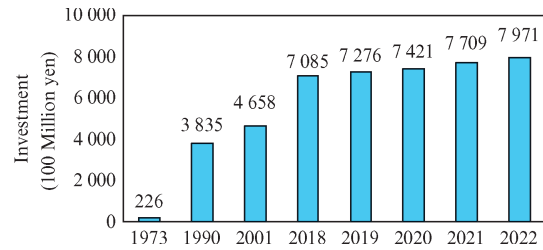


Fig. 3 Trends in the total amount of environmental conservation investment of JFE Steel

Table 2 Target emissions of environmental impact materials

Item	Targets of fiscal 2022	Achievements and initiatives in fiscal 2022
SOx and NOx emissions	To maintain low emission levels Promotion of initiatives	To maintain low emission levels Continued efforts
VOC emissions	30% decrease from 2000 (1 078 tons or less)	Down 67% from 2000 (513 tons)
Benzene emissions	80% decrease from 1999 (46 tons or less)	Down 93% from 1999 (17 tons)
Dichloromethane emissions	40% decrease from 1999 (46 tons or less)	Down 68% from 1999 (25 tons)

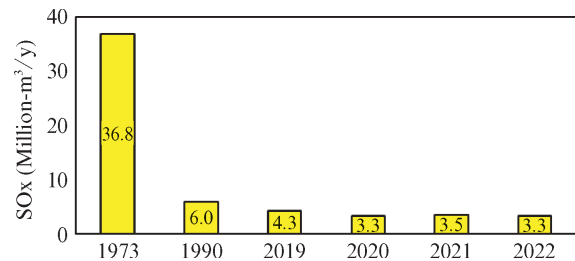


Fig. 4 Trends in SOx emissions of JFE Steel

a main source of sulfur oxides (SOx) and nitrogen oxides (NOx), JFE Steel also introduced low-NOx burners at its heating furnaces, and is now in the process of changing over to low sulfur fuels, etc. The trends in SOx and NOx emissions are shown in **Fig. 4** and **Fig. 5**, respectively.

JFE Steel also promotes measures to prevent dust scattering, including strengthening of on-site cleaning, installation of sprinkling equipment and windbreak fences in raw material yards, strengthening of dust collectors and increasing their capacities, etc.

4.2.2 Reduction of environmental impacts on waters

Because large amounts of fresh water are used to cool and wash products and equipment in steel manu-

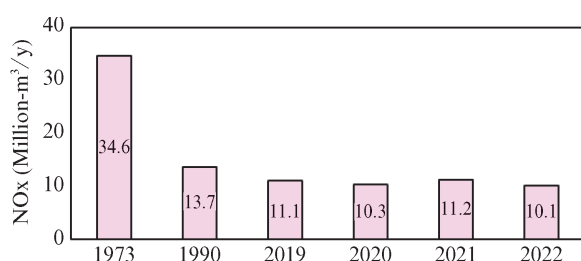


Fig. 5 Trends in NOx emissions of JFE Steel

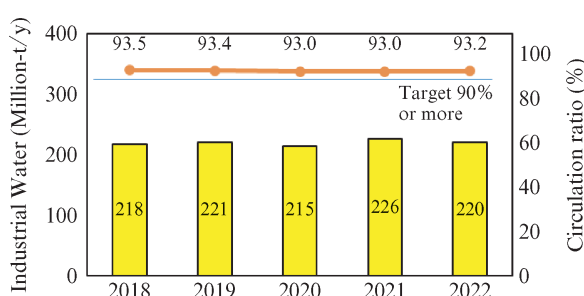


Fig. 6 Trends in amount of industrial water received and circulation ratio of industrial water of JFE Steel

facturing processes, efficient use of water resources is positioned as a priority issue. JFE Steel has constructed water circulation systems to reduce water intake at its steel works and other facilities by purification and circulating use of water used as much as possible. Water management plans have been established at all of JFE Steel's 7 production sites in Japan, targeting a circulation ratio of 90% or higher, and a high circulation ratio is being maintained. The circulation ratio of industrial water in FY 2022 was 93.2%. **Figure 6** shows the trends in the amount of industrial water received and the circulation ratio. In case water used in steel manufacturing processes is to be discharged into public waters, thoroughgoing purification treatment is performed. In order to achieve the standards of agreements concluded with local governments, which are stricter than the national Water Pollution Prevention Act, JFE is working to improve water quality by setting even stricter standards. For example, in FY 2022, the company's actual COD (chemical oxygen demand, an index of effluent water quality) was 2.8 tons/day.

4.2.3 Biodiversity

The JFE Group also recognizes preservation of biodiversity as a priority issue. Based on an assessment of the effects of its business activities on the ecosystem, JFE Steel considers measures to limit those effects to the minimum, and carries out greening and activities to protect rare species at its production sites. Renovation of the equipment at Unit No. 1 of the company's Ogishima Thermal Power Plant was completed in 2019 and operation was started. In carrying out this plan,

environmental impacts were predicted and assessed based on the Environmental Impact Assessment Act and Electricity Business Act. Because the orchid *Cephalanthera erecta* var. *shizuoi* (**Photo 1**), which is listed as a species with an increased risk of extinction, was found growing in the planned site, it was transplanted to a similar environment in the planned site in order to preserve the population.

In another example, a good environment continues to exist in the shallow areas of the sea in front of Yamashita Park in Yokohama, Kanagawa Prefecture. However, mud with a high content of organic matter has been deposited near the sea bottom, and as a result, deterioration of the water quality can be seen in summer, and the area has lost its function as a spawning ground and rearing place for marine organisms.

JFE Steel, in joint research with Yokohama City, carried out an experiment in which a rocky reef (base for adhesion of marine organisms) was constructed using "MARINE BLOCK™" and other iron and steel slag products^{6,7)}, in which carbon dioxide gas is absorbed by steel slag, to improve the environment of the habitat and restore the water purification capacity by the organisms originally possessed by these waters. Starfish, sea cucumbers and other organisms were observed from immediately after the start of the experiment, and filtration of the sea water by filter-feeding organisms (bivalve, sea squirts, etc.) was estimated quantitatively. **Photo 2** shows the coadunate condition of bivalves. This initiative for environmental improve-

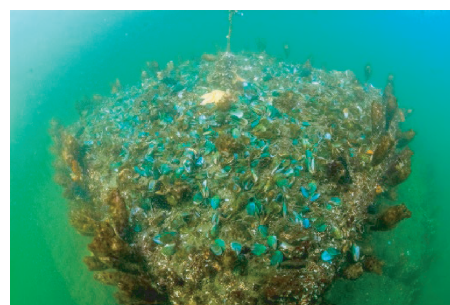
Photo 1 *Cephalanthera erecta* var. *shizuoi* found on site

Photo 2 Epiphytic conditions of bivalves

ment of the waters was highly evaluated, and received the Japan Society of Civil Engineers Environmental Award (Class II) for 2021 and the 5th EcoPro Award (Minister of Land, Infrastructure, Transport and Tourism) for 2022.

5. Effective Utilization of Resources

Problems such as resource depletion and environmental pollution are expected to become even more serious as a result of the economic growth of the emerging economies. Steel is a basic material which is easily recovered and has excellent recyclability, and can be recycled an unlimited number of times as a raw material for the same material products. JFE Steel is contributing to resource recycling and reduction of resource consumption by promoting resource recycling of byproducts of the steel manufacturing processes, reduction of waste at construction sites, global recycling of steel scrap, etc. In particular the company is making efforts to reduce the generation and discharge of byproducts such as blast furnace and steel slag, Fe-containing dust from the blast furnace and converter, water treatment sludge, etc., targeting a byproduct resource recycling ratio of 99% or higher. In addition to effective utilization of blast furnace slag and steel slag in materials for cement, civil engineering materials, and other applications, JFE is also promoting use in iron and steel slag products such as the above-mentioned “MARINE BLOCK™,” and successfully achieved its target for resource recycling of byproducts in FY 2022 with a recycling ratio of 99.5%. **Figure 7** shows the transition of the recycling ratio of byproducts in JFE Steel.

6. Conclusion

This review has introduced the efforts of JFE Steel

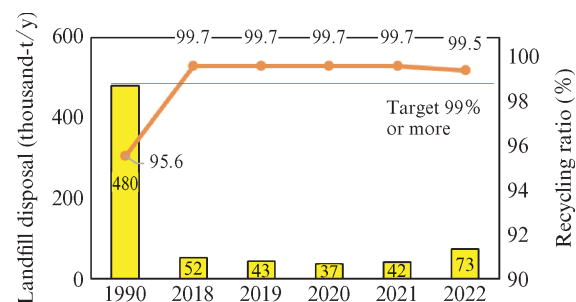


Fig. 7 Trends in landfill disposal of by-products and recycling ratio in JFE Steel

for effective utilization of energy, environmental conservation and resource recycling. With the spreading global sense of crisis about climate change, companies engaged in production activities must continuously promote improvement of energy use efficiency and efforts to reduce and improve environmental impacts with the aim of realizing carbon neutrality and further improving the environment.

In the future, JFE Steel will continue to practice its Corporate Vision of “Actively working to exist harmoniously with the global environment, as well as to raise living standards and advance societies,” and will promote improvement activities in the environmental and energy field.

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