JFE Steel Corporation

JFE Steel Carbon Neutrality Strategy Briefing 2023
Held on November 8, 2023: Q&A summary

Q. When a 5,000 ㎥ blast furnace is replaced with an electric furnace, it is thought that only about 60% of production will be possible. Although you said you are aiming to realize high productivity, have you reached a positive outlook on it from a technological point of view? For example, I think there are various issues such as the longer smelting time compared to a converter and the lower yield when using reduced iron. What is your outlook on these points in terms of technology?

A. Overseas, there are electric furnaces with an annual production capacity of 3 million tons that use only scrap, and that's why we believe that the hurdles for building a large electric furnace itself are not that high. However, the types of steel these furnaces manufacture are limited to general-purpose steel, and there are hurdles to overcome in order to produce high-quality steel at a scale of 2 million tons per year. Addressing this issue, we will develop the technology necessary to manufacture high-quality steel materials at a test electric furnace currently under construction in the Chiba area. The biggest issue is that the production efficiency of electric furnaces decreases when reduced iron is used to improve quality. This problem must be overcome through R&D. Furthermore, in addition to the effects of the tramp elements contained in scrap, elements such as nitrogen and phosphorus deteriorate the workability of steel materials, so they must be reduced. These technical issues are being addressed as elemental technologies by the GI Fund, along with technological development that utilizes existing electric furnaces, and there are prospects for further technological development as well. We will accelerate the technology development toward implementation by FY2027.

Q. Starting in FY2030 and beyond, the following facilities are expected to undergo refurbishment: blast furnaces 5, 4, and 3 in the Fukuyama District, and blast furnace 3 in the Kurashiki District. If the CR blast furnace can reach a reliable phase, there may be an option to keep the blast furnace after refurbishment. What are your thoughts?

A. Implementation timing will be determined through closely monitoring progress in technology development (CR blast furnace, direct hydrogen reduction ironmaking, etc.) and the status of necessary infrastructure improvements. Currently, the GI Project WG at METI's Industrial Structure Council has set the target date for social implementation as 2040, and we will work diligently to achieve this goal. Once the timing for social implementation of CR blast furnaces is in sight, blast furnaces that will be refurbished after that will be replaced with CR blast furnaces. For blast furnaces that will be refurbished before that, there will be two

alternatives: that is, carry out standard blast furnace refurbishment, or convert the process to electric furnaces. To promote CO_2 emissions reduction, we would like to promote the introduction of highly efficient and large-scale electric furnaces to the Kurashiki District as a first step.

Q. You said you are collaborating with other blast furnace companies. Are you considering the best solution even compared with the technology solutions of other companies such as Nippon Steel's SuperCOURSE50 and Kobe Steel's MIDREX ?

A. Our company is now developing the CR blast furnace, whereas Nippon Steel is developing SuperCOURSE50, wherein hydrogen is directly infused into the blast furnace. In both cases, 50% or more CO_2 reduction is the target. As of today, since nobody can exactly predict which technology will be superior, both companies are pursuing technology development along multiple scenarios, and relevant development information is being mutually shared through a consortium. Hydrogen reduction is a heat-absorbing process, so there is a concern that the intra-furnace temperature will fall during the process. On the contrary, in the case of our CR blast furnace, CO_2 generated in the blast furnace is converted to methane, and the methane is then infused into the blast furnace, which means that for this technology, hydrogen is used without directly infusing it into the furnace. To enable this, mass infusion technology for oxygen and methane will be a big challenge in development that needs to be addressed. As for SuperCOURSE50, it is a technology that injects high-temperature hydrogen directly into the blast furnace, but the hurdle is high because the hydrogen must be preheated to nearly 1,000℃ before infusion. Both have high hurdles, so both companies are pursuing intense technology development while sharing information in order to enable the introduction of advanced technologies.

Q. Regarding specifications of the highly efficient and large-scale electric furnaces that you are considering introducing in the Kurashiki District, it was explained that the heat size is 300 tons, the production volume is 2 million tons/year, and the start of operation is in 2027. Are these specifications already finalized, and is this the first specification announcement?

A. The equipment specifications are currently still under consideration, but now that they have been finalized to a certain extent, they have been made public for the first time. We are considering a Second Steelmaking Factory in the Kurashiki District as the target installation site, with the aim of producing high-grade steel with a heat size of 300 tons. Regarding the start date of operation, it is assumed that support from the government will be provided, but the aim is to start operation in FY2027.

Q. If the high-efficiency, large-scale electric furnace that the Kurashiki District is considering introducing is scheduled to start operating in 2027, it would likely take some time for

customers to obtain certification, so I would like to know what the timeline is for the start of operation.

A. As for the timing for operation start, we previously mentioned that it would be around 2027 ~ 2030. But given that competitors around the world have recently announced that they will be installing electric furnaces, and the refurbishment of Kurashiki District's No. 2 blast furnace is expected to be around 2027, we have therefore announced a target year of FY2027. Based on current assumptions, operation will start toward the end of 2027. For details, we are in the consideration process now. Once again, we would like to emphasize that government support is a prerequisite to enable a significant investment for large-scale infrastructure, electric power, scrapyards, cargo loading facilities, electric furnaces, etc.

Q. Regarding the highly efficient and large-scale electric furnaces to be introduced in the Kurashiki District, at last year's briefing session, you explained that CO_2 reduction volume will be 3 million tons, but you mentioned this time that it will be 2.6 million tons. Why the change? Also, about the investment amount, you previously said it would be about ¥100 billion. If this figure has also changed, tell us the current projection.

A. After one year of careful consideration, we have now re-estimated the CO_2 reduction amount to be 2.6 million tons. Regarding investment amount, although we cannot show a clear figure yet, as we are currently in the estimation process, it could possibly be over ¥100 billion.

Q. I understand that JFE's hydrogen reduction technology was implemented around 2040. Compared to other companies' hydrogen direct reduction technology using low-grade iron ore, is the implementation time similar?

A. It is recognized that the direct reduction iron production process currently in operation uses high-grade iron ore with an Fe concentration of 67% or more, mainly from Brazilian ore and Swedish ore, and that there are no direct reduction iron plants in the world that process produce with 100% hydrogen. At present, SSAB and ThyssenKrupp seem to have the earliest plans to implement the hydrogen direct reduction steelmaking method, but I have heard that natural gas will be used at the beginning, and hydrogen will be gradually replaced. I also think that there is a high hurdle for preheating hydrogen. In light of this, I think the timing will be similar. We will use the GI Fund to accelerate the development of hydrogen-based reduction technologies in order to accelerate their implementation in society.

Q. Regarding the introduction of electric furnaces in the Kurashiki District, are you considering converting from one blast furnace to two electric furnaces, or are you thinking of simply using one electric furnace to meet the existing production volume? If you have any plans about installation of the second electric furnace and beyond, tell us the specifics.

A. What we are considering for the Kurashiki District is suspending one blast furnace and

installing one electric furnace. Currently, seven blast furnaces are in operation across the company, but one in the Kurashiki area will reach the end of its lifespan in the late 2020s, and the rest are scheduled to be refurbished in the 2030s or later. Regarding future plans, how we will deal with these blast furnaces will be a major issue for consideration, but we do not have a firm plan at this time.

Q. In the explanation on page 11, it was stated that "We will realize the world's first mass supply system for green, high-quality, and high-functional steel comparable to the blast furnace method." Is it correct to recognize that this is the first system of its kind not only in Japan but in the world as well?

A. I cannot comment on other companies, but if we can implement a high-efficiency, large-scale electric furnace with an annual production capacity of 2 million tons in 2027, we will be able to produce 2 million tons of high-quality steel materials, which are difficult to produce using existing electric furnaces. This would put us first in the world.

Q. In relation to green steel, you are making relevant efforts (formulation of guidelines, etc.) through the Japan Iron and Steel Federation. In the section about participation in the GX League on P22 of the explanatory document, it is described that a "Recommendation for adding value to green merchandise" will be issued in November 2023. About this point, explain whether JFE will issue the recommendation or whether the GX League will issue it under the leadership of JFE.

A. Our company is participating in the GX League's "Working Group to Consider Added Value to Green Products," and the team is currently creating a proposal. We have submitted proposals mainly covering the necessity and implications of the mass balance method, and we recognize that based on our voices as well, the team recommendation is being compiled.

Q. From a global perspective, people in Europe say that electric furnaces that use renewable energy are better. Is it likely that the idea of utilizing existing blast furnaces like the CR blast furnace will be understood by the international community and customers? Also, the mass balance method as well may be exposed to criticism in some areas. However, are you sure it could secure support from the global society?

A. Many Asian companies (in China, India, South Korea, Taiwan, Japan, etc.) produce steel using the blast furnace method. Steel production in Asia using the blast furnace method accounts for more than half of world production volume. To ensure early reduction of CO_2 emissions on a global basis, it is important to realize sizable reduction in emissions by utilizing the blast furnace method in Asia. However, blast furnaces in India and China are relatively new, and it is assumed that it would be difficult to make a business decision to suddenly switch from blast furnaces to direct reduction ironmaking or electric furnaces. Blast furnaces in Asia

produce 1 billion tons of crude steel a year. Given the current emissions intensity of 2.0 tons in CO_2 emissions per ton of crude steel, if a 50% reduction is enabled out of the CO_2 emissions from blast furnaces in Asia, emissions reduction of about 1 billion tons could be realized. As for Europe and the U.S., crude steel production volume is 0.29 billion tons (total of blast furnaces and electric furnaces). Therefore, we believe that reducing CO_2 emissions from blast furnaces would be extremely effective in preventing global warming. To disseminate such understanding internationally, we are organizing briefing sessions. Regarding the mass balance method as well, we think it is also a big challenge for us to secure international understanding. Through Board gatherings of the World Steel Association, we are presenting proposals together with Nippon Steel to deepen understanding about the mass balance method. As of today, ArcelorMittal, ThyssenKrupp, POSCO, Nippon Steel, Kobe Steel, and our company have already created green steel branded products using the mass balance method and started selling them. To expand the circle of deep understanding about the mass balance method, it is necessary to secure understanding from India and China. Going forward, we will continue to take the lead in deepening understanding about the mass balance method through the World Steel Association.

Q. Regarding electric furnaces in the Kurashiki District, the document indicates that direct reduced iron accounts for up to 50% in terms of usage volume. Now, explain the percentage composition of iron sources including returned scrap and obsolete scrap.

A. We believe that returned scrap is also indispensable for making high-quality steel, although we cannot disclose the percentage composition of other types of scrap.

Q. Your explanation appears to state that once CR blast furnace technology is established, CR blast furnaces will be better than electric furnaces. In this context, what type of technology would be preferable?

A. Currently, electric furnaces are the most advanced technology, so we would like to implement them in the Kurashiki District, assuming government support. However, considering the needs for large-scale refurbishment of steel mills in line with the introduction of electric furnaces, we think a CR blast furnace or SuperCOURSE50 would be the most viable option currently, as existing management resources can be effectively used with them.

Q. Regarding the progress of the CO_2 emissions reduction plan described on page 13 of the explanatory material, progress is being made as planned in FY2022, but I would like to know your outlook for achieving the target in the future. Also, explain the types of measures you have successfully implemented to date.

A. In order to achieve the target by the end of FY2024, we are working to reduce emissions by introducing energy-saving technologies and implementing refurbishment of aging coke ovens,

and both are progressing as planned. In addition, due to the suspension of the blast furnaces in the Keihin area, the number of blast furnaces changed from eight to seven, which will increase the operating efficiency of the remaining blast furnaces and enable more efficient operations. Given such positive effects, we expect that the 18% reduction (goal by the end of FY2024) will be achieved as planned.

Q. You explained that toward 2030, reduced iron will be used effectively not only for the highly efficient and large-scale electric furnaces in the Kurashiki District but also for blast furnaces and converters. Are you also considering procurement sources other than the UAE? If that is the case, is investing in upstream interests a positive option for you?

A. For procurement sources, we know that we must consider non-UAE sources as well, so we are collaborating with various countries and companies as well as pursuing certain activities to widen procurement sources. Decisions regarding the acquisition of interests will be made on a case-by-case basis.

Q. How will the cost increase due to the substitution of reduced iron as a raw material be passed on to the product price? Is it a formula method like that for the current main raw materials? Or are you considering a totally different price pass-through method?

A. Pricing for green steel needs to be considered strategically by each company, and we believe that the whole steel industry should proactively pursue CO_2 emissions reduction to ensure prevention of global warming. Regarding the cost increase factor resulting from such efforts, we think it is essential that the reduction value is recognized as a premium part of the environmental value.

Q. What do the process conversion arrows in the green steel supply image diagram on page 25 indicate? Also, does the bar graph for FY2050 in the same figure indicate 20 million tons?

A. All components in the diagram are parts of a merely conceptual diagram as of now, where we envisage that the first step will be determined by the timing to introduce the highly efficient and large-scale electric furnaces in the Kurashiki District, and that the second step and beyond will be determined by the progress of technology development or by the timing to implement blast furnace refurbishment. In addition, the current steel sales volume is around 22 million tons, and since we are aiming for CN by 2050, we cannot predict the steel sales volume at that time, but this means that all of it will be green steel materials.

Q. Regarding the green steel material "JGreeX™" on page 24 of the explanatory material, it has been introduced in the construction field for Kumagai Gumi's projects, but I would like to know about the status of inquiries and contracts for other properties and other users.

A. This is the only contract executed by our company in the construction field to date. However,

we are aiming to expand the customer base through intense discussions with customers. We feel that interest in green steel materials is gradually increasing, not only in the construction field, and by having steel companies, including our company, carry out these activities, we hope to quickly create a trend for Japan as a whole to work to prevent global warming. On the other hand, we also need to receive a premium on environmental value, so we believe that what kind of incentives we provide to our customers is important for future expansion. For this reason, we are requesting that the government formulate policies regarding incentives such as procurement support.

Q. Regarding large heavy plates, it was previously announced that the East Japan Works and West Japan Works would manufacture large single heavy plates of up to 37 tons, but will "J-TerraPlate™" be used for all of them? Or will it be produced by the new factory in the Kurashiki District?

A. In 2022, the No. 7 continuous caster newly installed in the Kurashiki area became capable of manufacturing large single-weight slabs, and these slabs are rolled to approximately 100 mm thick at the plate mill to produce large single-weight slabs weighing up to 37 tons. This is "J-TerraPlate™." Each monopile weighs about 1,400 tons and is manufactured by welding many thick plates, so the number of welds can be reduced by using thick plates with a larger unit weight. Large single heavy plates can contribute to reducing the man-hours required to manufacture large-scale steel structures, so we would like to promote this type of use around the world.

Q. Regarding CR blast furnaces, I have heard that Baoshan Iron & Steel started research on them. Could you please tell me how it is different from JFE's CR blast furnaces, and if there are any advantages or strengths with regard to JFE's CR blast furnace technology?

A. The CR blast furnaces of our company and Baoshan Iron & Steel are similar but different technological developments. Our CR blast furnace is a technology that uses external hydrogen to convert CO_2 in the exhaust gas into methane, which is then injected back into the blast furnace, thereby significantly reducing CO_2 emissions. The main difference is that it uses external hydrogen.

Our strength over other companies is that we have a long history of blast furnace operation, and at the same time, we are currently utilizing DX technology, which we call a cyber-physical system, to visualize the internal state of blast furnaces in the virtual space, and we are also incorporating AI into it to ensure adequate operation. We are proud that our company has strengths in such base technologies. We believe that none of our competitors can easily imitate our CR blast furnace technology.

Q. In the briefing session last year, you said expanding the green steel market would be a challenge; however, when looking at adoption results from the current fiscal year, many cases are related to capital goods such as marine transportation and buildings. It has been announced that the price of green steel is about 40% higher, and I think this will be relatively acceptable for capital goods, but what about cars and home appliances, where the end users are individuals? To secure green steel sales growth from now, I think it will be important to expand the target scope to final consumption goods as well. Therefore, we would love to listen to your future plans about this.

A. We believe that expanding green steel demand continues to be a big challenge for us. This year's sales of green steel materials started with cases in which the cost is widely borne by the entire supply chain, such as ships and buildings, but these cases are relatively easy to accept because the cost burden is light. On the other hand, the entry hurdle is higher in areas where end users are individuals such as the automobile sector and electric appliance sector. Therefore, concerning such sectors, we think it is necessary to think about and discuss the following with the government: what kind of scheme for social distribution would be reasonable; whether relevant policies and support could be made available to enhance purchase incentives, etc. Although we have not yet decided on a firm policy and cannot say anything definitive, discussions have begun in the GX League as well.

Q. Regarding the introduction of highly efficient and large-scale electric furnaces in the Kurashiki District and beyond, power consumption might become enormous. May I ask how you would secure power sources? If that is targeted for 2027, installation of a new nuclear power plant most plausibly cannot be expected. Therefore, tell us how you will secure the needed power volume and power sources with less CO_2 emissions. In addition, considering the procurement of renewable energy power in the future, wouldn't it be better to introduce electric furnaces outside of Japan?

A. Securing electricity usage and making electricity green are major challenges. Most possibly, demand for electricity will continue increasing as Japan makes efforts to realize CN. In other words, we expect fuel electrification to expand. At yesterday's GX Steering Committee meeting, a member of the committee pointed out the need to restart nuclear power plants as Japan's electricity demand increases. Personally, I think it is important to restart nuclear power plants or bring newly built nuclear power plants that are on standby, such as Chugoku Electric's Shimane No. 3 nuclear power plant, into operation as soon as possible. On the other hand, it is possible to secure power procurement for the high-efficiency, large-scale electric furnaces currently being considered in the Kurashiki District. However, investment will be required to build the infrastructure to support large-scale power transmission.

Regarding the question of whether it would be better to introduce electric furnaces overseas, considering that industrial competitiveness is essential for Japan's economic growth, it is

important to consider that steel, the material that supports industrial competitiveness, is manufactured in Japan. I personally believe that Japan should have its own steelmaking process, which is the basis of manufacturing. Therefore, we are asking the government to ensure the international competitiveness of industrial electricity prices, and we believe that having an integrated manufacturing process spanning from the upstream process to the rolling process will be the basis of Japan's industrial competitiveness. At the moment, we have no plans to own electric furnaces overseas.

Q. Regarding the procurement of reduced iron, the company is currently considering starting a joint venture in the UAE to manufacture reduced iron. Do you have any plans to manufacture reduced iron in Japan in the future? When manufacturing in Japan, I think that the procurement of green hydrogen will ultimately become a bottleneck. If hydrogen were to be applied to direct reduction ironmaking, etc., I think it would be impossible to have the reduction process in Japan. What is your opinion regarding this point?

A. The significance of performing the direct reduction iron manufacturing method is that reduced iron is produced using hydrogen. The technical hurdles are extremely high and development is currently underway, but even if technological development is completed, the major issue of procuring green hydrogen remains. Regarding green hydrogen, the government is working on a strategy, and we believe that the introduction of the hydrogen direct reduction iron manufacturing method in Japan will be decided based on the feasibility of that strategy. At this point, I don't think it's impossible in Japan. Where and when to introduce it in Japan will probably be decided based on the progress of technology development and infrastructure establishment.

Q. In order for users to recognize the value of green steel materials, I think it is important that third-party organizations acknowledge that they are green steel materials, but currently, both in Japan and around the world, each company receives certification from different organizations. In today's explanation, you said that there will be a plan for unification in the future, but I would like to confirm the current status.

A. Rather than where certification is obtained, it is more important to determine the criteria used to calculate and judge whether database management is transparent and reliable. Currently, there are no international standards for green steel materials that apply the mass balance method, so the Japan Iron and Steel Federation first created and announced domestic guidelines. It was announced in 2022, and a revised version was released in October 2023. The revised version specifies, for example, data management methods and calculation methods in detail, and aims to ensure transparency and reliability. Since this is a domestic guideline, the challenge is to get it recognized internationally, and the World Steel Association is currently working to formulate common guidance. Furthermore, work has also begun on converting it

into an international standard (ISO). Even though creation of a new set of international standards may take a bit longer, some European and American companies are already selling green steel materials using the mass balance method, so the need for international standards is shared, and eventually international standards will be adopted.

Q. How much offtake will be required for the reduced iron project in the UAE?

Although we cannot say anything definitive as we have not yet reached a formal contract, we believe that the offtake quantity will be at the 1 million ton level.

Q. As a material manufacturer, what kind of cooperation can you expect with equipment manufacturers and others toward CN? For example, if you have accumulated technology, is there a possibility of selling patents and know-how externally?

A. As the steel industry is an equipment industry that is in the position of constructing large-scale facilities to achieve CN, it is necessary to advance various technologies in close collaboration with equipment manufacturers and other suppliers. We think it is possible that the manufacturing technology and know-how acquired through this process could be converted into patents or rights, and for example, CR blast furnace technology could be sold to blast furnace manufacturers in Asia to earn income as royalties. We know that IP protection is crucial.

Q. In order to achieve carbon neutrality by 2050, other blast furnace companies have said that they will need capital investment of 5 trillion yen, which will increase after 2030. How much capital investment do you think your company needs? For the size, how do you divide it between the investment assumed by an individual company and public subsidies?

A. Our company has not yet estimated how much investment will be required to introduce ultra-innovative technology toward carbon neutrality. However, it is estimated that approximately 1 trillion yen in capital investment will be required during the transition period until 2030. From the viewpoint of government subsidies, commercialization of decarbonization technology in the steel industry would require huge investments in process conversion, making it difficult to implement without government support. In other words, unless the domestic steel industry receives support on the same scale as that of other countries, it will lose its international competitiveness and decline as an industry, in my opinion. Therefore, although we cannot give an estimate of the scale at this point, we believe that subsidies are essential, and that support is also needed for OPEX, not only CAPEX, as running costs will rise as well.

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