JFE Steel Corporation

JFE Steel Carbon Neutrality Strategy Briefing
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Q. My question is about large electric-arc furnaces (EAFs). Installing EAFs would result in less capacity than with blast furnaces, which would upset the production capacity balance between upstream and downstream processes. You also will need to develop a range of technologies, including refractories and electrodes. Are you saying that the technological challenges of implementation look solvable to some extent in the not-so-distant future? What specific issues or other concerns do you need to address?
A. We believe that our R&D projects targeting large EAFs under the GI Fund can arrive at technological solutions by 2027. According to our research, the largest EAF in the world is owned by Colakoglu in Turkey, which manufactures three million tons of mainly construction steel a year. So, an annual production capacity of three million tons is now within the realm of possibility, and our technology development efforts will focus mainly on just how efficiently we can manufacture high-quality steel. The use of direct-reduced iron, in particular, hurts production efficiency and electric power consumption rate, so we need to overcome such issues. We are looking to develop solutions through R&D supported by the GI Fund as we work toward implementation in 2027.

Q. Can you provide a more specific schedule regarding direct-reduced iron in the UAE? Also, your views differ from those expressed by other companies. In today's presentation, you said you can only produce direct-reduced iron using high-grade iron ore with an iron content of at least 67%, yet other companies are saying that it is possible to use iron ore with lower iron content if it is run through a pretreatment process.
A. At present, no decisions have been made on the direct-reduced iron plant in the UAE beyond what we explained today, so we are unable to comment further. Still, I would like to add a bit of background on our partnership with Emirates Steel. Emirates manufactures shaped steel in the UAE using the direct-reduction and EAF processes. The UAE is working toward carbon neutrality and it has geopolitical advantages in terms of abundant natural gas resources and the ability to store CO_2 in its oil fields (EOR). Through our recent discussions with the company, we found its approach to be consistent with our future direction, so we entered into an MOU and commenced work on feasibility studies.
You point out with respect to other companies' direct-reduced iron production that low-grade ore, if pretreated, can also be used as a feedstock for making direct-reduced iron. Iron purity is not the only issue with low-grade ore, however. There is also the issue of ores containing crystalline water*. In particular, iron ore from Australia, a major global supplier, cannot be used to make direct-reduced iron at present due constraints on ore grade, so the use of such ore is a major challenge to address.

*When iron ore with high crystalline water content is used, cracking and degradation can occur during pellet production (sintering process) and inside the reduction furnace, which can greatly reduce production efficiency.

Q. How will you deal with the blast furnace refitting periods ahead? Once you switch the Kurashiki No. 2 blast furnace to an EAF, it will not be all that long before the early 2030s rolls around and you are due to renovating the blast furnace at Fukuyama, your main steelworks. Please give us an idea of your plan. For example, do you plan to renovate the blast furnace as normal and switch to ultra-innovative technologies in the 2040s, or will you be switching to an EAF as a transitional measure?
A. We expect the Fukuyama blast furnace refractory to reach its end of life in the first half of the

2030s, but we have not yet made specific plans. We will decide on a course of action ahead based on a careful evaluation of which technologies would be best once we have dealt with various issues including EAF technology and direct-reduced iron supply as well as hydrogen sourcing.

Q. My question is about the increase in EAF capacity at Sendai. I think capacity is set to drop when you switch from a blast furnace to an EAF at Kurashiki, so is your plan to make up for this reduction in capacity by increasing capacity at Sendai, which manufactures special bars and wire rods, similar to Kurashiki?
A. That is part of our aim in increasing capacity at Sendai. We currently produce special steel bars and wire rods as blast furnace products at Kurashiki because of quality considerations. Once we increase EAF capacity at Sendai, however, if we are able to clear the quality hurdles and make products that are on the same level as those made in a blast furnace, it would be possible to transfer some production from Kurashiki to Sendai. Given such possibilities, we will continue to develop technologies to improve quality.

Q. I think you currently manufacture shaped steel and steel sheets in the Kurashiki blast furnace, but what product varieties do you aim to make at Kurashiki in the EAF? Would this include, for example, electrical steel sheets?
A. We cannot say anything specific about what product varieties we aim to make in the Kurashiki District. We are studying the issue of what products we will be able to make depending on the compositions made in EAFs as well as tramp elements, and we pretty much have an idea of what quality we can achieve with current EAF technology. Some electrical steel sheets can be made in EAFs, so I think this is something we will target.

Q. You said you are enhancing the capacity of locations for collecting iron and steel scrap and the like, but you have many EAFs in West Japan area. When it comes to collecting scrap, do you plan to bolster your collection systems in cooperation with partners like JFE Shoji, for instance?
A. We are naturally working together with JFE Shoji as part of our JFE Group. We are currently in the process of creating a system that includes collecting scrap from our customers.

Q. With respect to the introduction of an EAF in the Kurashiki District, what sort of production capacity per charge are you looking at, and will you need to make new investments in steelmaking processes and the like? Also, what sort of mixing ratio are you looking at for direct-reduced iron (HBI) and scrap?
A. The heat size of EAF in the Kurashiki District is something we are currently considering. We envision something bigger in terms of heat size than the 100–150 tons that is common in Japan, but we will be evaluating the issue carefully and looking to strike a balance with the amount of capital investment. Aside from the EAF itself, we also naturally need scrap collection sites, so we will be making additional investments in berths and cargo cranes, storage facilities, and intra-facility logistics. As for the HBI and steel scrap mixing ratio, this depends in part on what product varieties we produce. There are also issues associated with using large amounts of HBI, such as direct-reduced production efficiency and higher costs, so we will be making a decision once we have considered such hose issues. Looking ahead, we believe that procuring low-tramp-element steel sources will be key if we are to supply high-quality steel using EAFs, so we have commenced feasibility studies with Emirates Steel.

Q. I understand that government policy support is needed if demand for green steel is to be created, but there already are companies that seem to want low-carbon steel even now. Couldn't you work with those companies to begin creating a market for green steel without relying on the government?
A. At present, it is difficult to predict how much demand will arise for green steel down the track.

Currently, the steel industry emits 40% of Japan's total industrial CO_2, so CO_2 reduction in the steel industry is a must if Japan is to achieve its goal of reducing CO_2 by 46% by 2030. We need to create a market for green steel as soon as possible if we are to finance the necessary large-scale investments. If we reduce CO_2 by 30%, for example, then with the mass balance approach we estimate we could independently supply 5 million tons of green steel. If other steel manufacturers also develop the ability to supply green steel by reducing CO_2, this would result in a huge supply volume, so we would need a market with a commensurate scale. While we do not yet have a clear picture of the path green steel demand formation will take, individual companies cannot do it alone; we need to create demand through cooperation among the steel industry, government, steel users, and other parties.

Q. I would like to ask about green steel. Regarding market formation, you explained that the right environment needs to be developed by, for example, unifying terms and conditions and creating standards. But in business terms, isn't there already a real-world need for green steel products? When can we expect to see green steel being deployed?
A. I think we first need to work out the definition of green steel. At the industry level, the Japan Iron and Steel Federation currently has a team working on green steel issues. Another point, one that concerns companies individually, is the issue of how you go about obtaining green steel certification. These two points are something the supply side needs to address. As to when we will see it on the market, these two points need to be properly addressed first. While we cannot say definitely when, we believe that 2025 would be too late, so we hope to deploy green steel as soon as possible.

Q. Once green steel is on the market, how much CO_2 reduction do you think will be realized, and what methods are there for determining this if not relying on the mass balance approach? Also, is green steel limited to EAF products, or can blast furnace products also be called green?
A. I think the definition of green steel will be based on the mass balance methodology. The mass balance approach is not limited to EAFs; it can also be applied to blast-furnace steelmaking by tracking CO_2 reductions supported by process conversions and capital investments. If CO_2 emissions can be reduced by 30%, for example, then the CO_2 emissions from steel products equivalent to 30% of production volume can be considered to be zero. We are looking at offsetting that amount to brand products as green steel, and this is not limited to EAF products.

Q. The slides show 1 trillion yen as the investment needed to achieve carbon neutrality. Can you explain what sort of milestones you envision, including how things will unfold each year, during the term of your current Seventh Medium-term Business Plan as well as the transition period and the innovation period?
A. You can expect investment in carbon neutrality to total around 1 trillion yen over the period from 2022 to 2030. We cannot say how things will unfold each year, but on average, the annual investment would be 125 billion yen. Our Seventh Medium-term Business Plan earmarks total capital investment our steel business at around 250 billion yen per year, so 125 billion yen a year would account for half of that, which is a very big investment. Such investment will absolutely depend on creating a market for green steel [see details below].

Q. How will you gain user acceptance for the prices of green steel? I can imagine you negotiating with steel users about adding the environmental costs likely to be incurred ahead into prices, in addition to the usual practice of passing on raw material cost fluctuations through into prices. So on the pricing front, how will you go about promoting understanding among broader society?
A. From a supply-side standpoint, prices need to reflect the large capital investments to supply green steel as well as the increases of the running costs with the use of direct-reduced iron and so forth. That said, even if the supply side offers to supply green steel, the demand side will not buy it

unless there is an incentive to pay the high prices of green steel products. Hence, it is crucial that we first create a market for green steel, and I think individual companies will then turn to price negotiations once the market has taken shape. We need to look at it differently from the way we view the traditional buying and selling of steel.

Q. Slide 13 shows a CO_2 reduction of 3 million tons for large EAFs, but how much of a reduction as a percentage of blast furnace emissions can you achieve by switching Kurashiki No. 2 from a blast furnace to an EAF?
A. The figure of 3 million tons is an example of what could happen with the introduction of an EAF at Kurashiki. This calculation assumes that the EAF would produce around 2 million tons of steel and that CO_2 unit emissions would be 0.5t per steel ton, which is what is commonly achieved. The figure for blast furnace products is 2.0t per steel ton, so multiplying the difference of 1.5t per steel ton by 2 million tons of output gives a figure of 3 million tons. The actual capacity of the EAF to be installed is still under consideration, but we believe that if we could achieve a stable output of 2 million tons of steel per year, then we could replace Kurashiki's current production scale and capacity with the currently running No. 3 and 4 blast furnaces and a large EAF.

Q. How much do you expect to invest in the Kurashiki EAF?
A. The amount of investment is under consideration, so we cannot give any details. It would include investments in collection sites, berths, logistics and so on, in addition to the EAF itself, so we envision a fairly sizable amount. It should go beyond the ten-billion-yen level and reach at least several dozen billion yen, or possibly even be an order of magnitude above that.

Q. How many carbon recycling blast furnaces, direct-reduction furnaces, and EAFs are you looking at installing, and what would be your ideal process configuration? Also, aside from EAFs, a lot of overseas steel mills are also turning to direct-reduction steelmaking to reduce CO_2 emissions. Please explain your thinking on the strengths of the blast furnace method, including carbon-recycling blast furnaces, with respect to direct-reduction steelmaking.
A. At present, we cannot give specifics on how many units and which processes we will introduce. The decision to install one EAF in the Kurashiki District was made because the renovation of the Kurashiki No. 2 blast furnace was coming due. And beyond that, as mentioned in response to a previous question, the blast furnace in the Fukuyama District will be due for a renovation after 2030. At this time, we do not have an optimal solution for our future manufacturing process. For example, we do not know how soon after 2030 we will be able to apply carbon-recycling blast furnace technology in blast furnace renovations. Whether we can obtain hydrogen inexpensively in large quantities, in particular, is a major issue. Ideally, we will complete our demonstration of the principle by 2026 and then complete tests of the technology in a medium-sized, $700m^2$ furnace by 2030, hoping to achieve productivity equivalent to that of existing blast furnaces using large quantities of inexpensive hydrogen. But we will not be able to make a determination about the hydrogen procurement issue until more time has passed.

Q. How will you deal with tramp elements issues in EAFs? My impression is that you are somewhat confident that you will be able to deal with tramp elements. In specific terms, what kind of technological progress do you expect, and what led to the decision that introducing EAFs would be feasible?
A. Technologies for dealing with tramp elements currently provide no way of removing elements such as copper (Cu) from the raw material, so the only way to prevent the input of copper in steel products is to use iron and steel sources that do not contain copper. The use of collected scrap, which inevitably contains copper, is premised on figuring out the limit in terms of what percentage content of copper is tolerable. We are currently determining the raw material mix for each product based on data on copper ratios in various types of scrap, such as processing scrap, HS and H2, and

we are working to reduce the constraints on the mix by developing heating and rolling technologies.
direct-reduced iron does not cause problems with tramp elements in the way scrap does, but it does have the problem of phosphorus derived from the iron ore. Also, with the EAF process, nitrogen gets mixed in with the liquid steel, and nitrogen has an adverse effect on the processability of steel products. With the support of the GI Fund, we are developing technologies to solve the major problem of removing phosphorus, nitrogen and other impurities. Our success in achieving breakthroughs will affect how many EAFs we install going forward.
Finally, as to how individual companies aim to reduce CO_2 emissions, in simple terms, the European players are focusing on the development of EAFs and direct-reduced iron, while the Japanese players are focusing on the development of blast furnace methods. The reason is that Japanese players have maintained their global competitiveness by mass producing steel in large blast furnaces. While blast furnaces in Europe are very small, in Japan, over half of the space at Japanese steel mill sites is devoted to blast furnaces and related equipment, so switching to direct reduction and EAFs would be a huge decision. We still believe that we should pursue blast furnace methods that could produce less CO_2 emissions and other methods for using or storing any CO_2 that is produced. China, South Korea and India, which also are focused primarily on large blast furnaces, are all aware of the same issues when it comes to efforts to reduce CO_2 emissions with the blast furnace method, so we believe that if we can successfully establish technologies in this area, it will have a major industrial impact.

Q. When will you introduce ferro-coke in actual production equipment in the Fukuyama District [Slide 10], and what is the timeframe for the GI Fund test-EAF in the Chiba District [Slide 13]?
A. R&D on ferro-coke at Fukuyama is still in progress, but we expect to start using it in an operational setting around 2030. R&D on the Chiba test-EAF is scheduled for completion by 2025.

Q. With respect to CCUS, you mentioned storing CO_2 in concrete. Are you already looking into partnering with the cement industry?
A. Partnerships with the cement industry are being looked into, but the GI Fund is also pursuing R&D on collecting and storing the CO_2 produced when cement is created. We realize that in an operational setting, we will need certain capabilities and technologies to enable us to separate, collect and supply CO_2 as well as large work sites, so the question of where we do this is a key consideration. Since we have CO_2 separation and recovery technology with our blast furnaces and we can furnish suitable locations, we intend to actively collaborate in the development of technology for storing CO_2 in cement if other parties express interest, although we are not currently participating in any specific project.

Q. Regarding the promotion of carbon neutrality, are the CCUS & Green Infrastructure Study Team and Green Steel Strategy Study Team looking beyond JFE Steel and considering the prospects of collaborating with parties outside of the group?
A. Going forward, we hope to discuss our understanding of the issues with industry, METI and customers as we work to create a market. We have already commenced discussions, but this is still recent and we have no plans to disclose anything yet.

Q. What is JFE's level of commitment to the goal of reducing CO_2 emissions by 30% in 2030? Does JFE see this as an imperative, or given the Japanese government's goal of achieving carbon neutrality by 2050, do you see 30% as a transitional milestone and thus a rough guide?
A. We see a reduction of 30% or more in 2030 as a goal that we must achieve.

Q. Please provide a breakdown of the CO_2 emission reductions in 2030. The combined reductions from the use of scrap in converters, expansion of the Sendai EAF's capacity and introduction of

large, high-efficiency EAFs is 5.1 million tons. Meanwhile, relative to FY2013 levels, JFE needs to reduce CO_2 by around 17 million tons in 2030 (FY2013 CO_2 emissions of 58.1 million tons × 30%), which leaves you about 12 million tons short. There might be an effect of reducing crude steel production relative to 2013 by shutting down upstream processes at Keihin on CO_2 emission reductions, but what other potential reductions are there?
A. As you say, we need to reduce CO_2 emissions by 17 million tons if we are to reduce emissions by 30% relative to FY2013. Cutting back on crude steel production by shutting down the Keihin blast furnace and restructuring to skew production toward West Japan will cut around 7 million tons. We will need to use technology to eliminate the remaining 10 million tons. We expect a 2-million-ton reduction from the increased use of scrap in converters and a 3-million-ton reduction from enhancing EAF capacity and new EAF installations, totaling a reduction of 5 million tons. In addition, we have over 60 CO_2 emission reduction items on our agenda, including energy-saving technologies and equipment upgrades, through which we believe we can eliminate the remaining 5 million tons.

Q. You have not decided what to do with blast furnaces in operation once the Kurashiki No. 2 blast furnace is switched to a large, high-efficiency EAF, but what is your sense? Do you think you will be able to maintain the other blast furnaces, or will it be tight unless you reduce a little more capacity of blast furnace?
A. We do not have a clear answer at this time. Japan has maintained its global competitiveness on the back of large blast furnaces and large-scale production, so we hope to reduce CO_2 emissions predominantly through the use of carbon-recycling blast furnaces as well as blast furnaces premised on the availability of a stable, inexpensive supply of hydrogen. If we could develop the ultimate CO_2-reducing technology to use blast furnaces, we could deploy them in India, China and the ASEAN region to achieve further global CO_2 reduction and climate-change mitigation.

Q. There are many technical challenges to overcome with EAFs. Aside from working toward high-grade steel in EAFs, you also need a paradigm in which steel users do not demand high-quality products that cannot be manufactured in EAFs. For instance, if self-driving technology eliminates collisions, then material strength requirements could be revised. We think that customers need to be involved in the discussion and make concessions in terms of quality and technology for carbon neutrality. What do you think about that?
A. The idea of eschewing quality in pursuit of greener EAF products may not be entirely out of the question, but high-quality products are what enable Japanese manufacturing industries to compete in global markets, and we hope to uphold this ability at the same time as curbing CO_2 emissions. Meanwhile, if the broader conversations we have about green market formation reveal changes in customer needs, we will need to remain agile and keep up with those changes.

Q. Which raw material is better for making high-grade steel in an EAF: scrap or direct-reduced iron?
A. Scrap and HBI each have their pros and cons. Scrap provides higher productivity in EAFs, but quality is inferior because it contains tramp elements [such as copper and tin]. HBI, on the other hand, can be used to make high-grade products, but the raw material [iron ore] inevitably contains slag or non-iron components, so using direct-reduced iron from low-grade iron ore greatly reduces productivity of EAF. Hence, with the direct-reduction method, high-grade iron ore is currently used. [In EAFs, productivity with high-grade HBI is still lower than with scrap.] In terms of HBI manufacturing technology, the GI Fund consortium we are part of aims to establish technology for direct-reduction steelmaking using low-grade ore as well as direct-reduction steelmaking using hydrogen.