JFE Holdings, Inc.

JFE Group Investor Meeting
JFE Group Environmental Vision for 2050
Summary of Q&A Session on May 25, 2021

Q. Please explain the mechanism and features of carbon-recycling blast furnaces again. Is it possible to achieve carbon neutrality by combining carbon-recycling blast furnaces and CCU?

A. Carbon-recycling blast furnaces are based on technology that uses green hydrogen to convert CO_2 in blast furnace exhaust gas into methane for injection back into the blast furnace as a reductant agent. As a result, the carbon required for reducing iron ore is recycled, and total CO_2 emissions are reduced.

A problem when hydrogen is used as a reductant agent is that the endothermic reaction can result in insufficient heat, inhibiting the reducing reaction. The methane used as a reductant agent in carbon-recycling blast furnaces, meanwhile, drives an exothermic reaction in the blast furnace combustion area, so it is better than hydrogen when it comes to tackling the issue of furnace chilling.

Also, injecting pure oxygen into a carbon-recycling blast furnace makes it possible to maximize the amount of methane fed in because the energy normally used to heat airborne nitrogen in the conventional blast furnace process can be used to heat the methane. Shifting to oxygen blast furnaces roughly halves the amount of exhaust gas because the blast furnace gas no longer contains nitrogen.

With carbon-recycling blast furnace technology, CO_2 emissions cannot be reduced to zero if carbon is recycled via methanation alone, but we aim to achieve carbon neutrality through the use of CCU (including CCS).

Certain issues do exist—such as the question of whether the methanol produced via CCU can be supplied as a chemical product to potential users at large, and whether this would be cost effective—but we believe there is potential to create a completely carbon neutral blast furnace process by combining the aforementioned methanation technology, pure oxygen blowing technology, and CCU technology.

Q. A range of technologies, such as those in COURSE50 and Super COURSE50, are under investigation as part of the effort to achieve carbon neutrality. What are your thoughts on this multi-track approach to technology development?

A. The COURSE50 initiative aims to reduce CO_2 emissions by 30%, which comprises a 10% reduction in blast furnace CO_2 emissions achieved by injecting hydrogen gas into furnaces and a 20% reduction via CCS. Hydrogen reduction is an endothermic reaction, so there is a limit on how much hydrogen can be blown into the furnace. The Super COURSE50 initiative aims to increase the reduction in blast furnace CO_2 by heating external hydrogen before injecting it into the furnace. Hence, COURSE50, Super COURSE50, and carbon-recycling blast furnaces involve different technologies. But with blast furnaces being the main process used, a full range of super-innovative technologies need to be tried, including to verify which is superior, so all of these technologies are worth considering.

We should also consider combinations of each of these technologies. JFE Steel aims to reduce its CO_2 emissions from the steelmaking process by around 10% by introducing ferro coke, a highly reactive form of coke, to cut down the amount of reductant agent used in its blast furnaces. JFE Steel is currently performing demonstration tests of ferro coke production at our Fukuyama district medium-scale facility. We believe the amount of CO_2 that can be reduced by combining carbon-recycling blast furnaces and ferro coke is another process-development factor to examine.

We also need to verify the amount of CO_2 produced in actual carbon-recycling blast furnaces when reduced iron is fed into the furnace instead of iron ore.

We do not yet have a definitive solution for achieving carbon neutrality by 2050, and as such we believe a multi-track development approach should be promoted in the Japanese steel industry with respect to carbon-recycling blast furnaces in addition to ferro coke, COURSE50, and Super COURSE50 initiatives.

Q. A range of issues need to be addressed on the road to developing technologies for carbon neutrality by 2050. What is your approach to collaborative development with other companies and organizations?

A. Since there are limits to how much funding and manpower any individual company can bring to bear, we will be developing the technologies in collaboration with other companies. JFE Steel intends to initially focus on developing carbon-recycling blast furnace (including methanation) technology as well as associated CCU technologies. We will be working with Japanese reactor manufacturer to develop methanation technologies, and we will be collaborating with RITE to develop CCU technologies. A broad range of discussion regarding carbon-recycling blast furnace is expected to be held, including on the issue of whether it will engage in joint development efforts or not.

As an individual company, we will be working to address issues involved in making high-grade steel with electric arc furnace technology through research & development at our Sendai Works using the special automotive steel-bar manufacturing technology we already have. We will also be exploring the possibility of lowering the applicability limits for electric-arc-furnace steel in high-grade steel applications, specifically by looking at producing high-grade automotive steel based on steel sheet made in electric arc furnaces at NJSM (Nucor-JFE Steel Mexico), our joint venture with Nucor, the biggest electric arc steelmaker in the US.

Also, the issue with hydrogen direct-reduction technology at present is that only high-grade iron ore can be used. JFE Steel has signed a memorandum of understanding with leading resources supplier BHP to develop new technologies for processing low-/medium-grade raw materials in an effort to make them a viable feedstock for direct reduction. We also believe that government support and partnerships with wider society will be key to building inexpensive, large-scale hydrogen supply infrastructure.

Q. Are the CO_2 reductions from carbon-recycling blast furnaces calculated on the basis of green hydrogen being used?

A. The estimated CO_2 reductions presume that green hydrogen is used.

Q. Why do you see carbon-recycling blast furnaces as the central technology for achieving carbon neutrality? Also, are your methanation technology and oxygen blast furnaces JFE's

proprietary technologies?

A. JFE Steel manufactures high-grade steel using blast furnace and converter methods. We believe there are significant hurdles to clear to produce high-grade steel by electric-arc furnaces and the direct-reduction method. We therefore investigated whether there might be a way to achieve carbon neutrality with our current blast furnace and converter methods, and we ultimately identified carbon-recycling blast furnace technology as a promising option.

Methanation technology is not solely JFE's. We will be developing it in collaboration with reactor manufacturers. The technology for oxygen blast furnaces, on the other hand, is JFE's proprietary technology. Key points in the development process will include designing the shape of the furnace based on analytical simulations of gas flow and reactions within the furnace.

Q. In terms of the electric-arc furnace process, what strengths do Steel Plantech Co. and the Sendai Works confer on JFE?

A. We use ECOARC™, electric-arc furnaces from Steel Plantech, at JFE Steel's Sendai Works and JFE Bars & Shapes Corporation's Himeji Works. At both sites we have been able to improve product quality and productivity. The productivity of even the biggest electric arc furnace is currently around 30% lower than that for blast furnaces and converters, but we believe the ability of JFE Steel and Steel Plantech to collaboratively engage in development and design within our group is a key strength to improve electric arc furnace productivity. Also, we produce galvanized steel sheet for automotive applications at NJSM in Mexico, a joint venture with US electric-arc steelmaker Nucor, and our ability to develop high-grade applications for materials produced in electric arc furnaces here is also a strength.

Q. Thinking about the market for offshore wind power generation monopiles and operation & maintenance (O&M), please discuss the current trends and competitive environment with respect to your domestic industry peers and the payback period for JFE Engineering's investment of some 40 billion yen.

A. We are not yet seeing any domestic industry peers looking to enter the monopile market, so we believe our only competition is from the European players at present. The construction of domestic offshore wind power generation capacity is set to ramp up ahead, so specific details for O&M are something we will need to look at going forward, but we expect O&M services to focus mainly on the wind turbines. We will be looking at partnering with manufacturers in this area.

We cannot comment on the capital investment payback period at present as we are currently still assessing equipment specifications, market trends, selling prices, costs, and so forth.

Q. What is the CO_2 recycling rate of carbon-recycling blast furnaces?

A. We will verify the CO_2 recycling rate at a future date, but based on current simulation estimates, we expect a recycling rate of around 30%. We will also be looking to verify whether we can increase this further going forward.

Q. When do you plan to increase the converter scrap ratio from the current 12–15% to 20% or more? Also, will you need to purchase scrap from external sources when this happens, and will it apply to all of your converters?

A. Under our seventh medium-term plan, we will be conducting research & development into burners that use carbon-free fuel, a technology for promoting the use of scrap in converters. We will firstly develop this technology at a specific steel works, and then evaluate the results before looking to roll it out across the board, so even if we were to implement this for all of our converters, it would happen in FY2025 or beyond. As for scrap ratios, the most we can procure internally is around 12%, so we will need to purchase from external sources for anything above that ratio. Around 28 million tons of scrap is distributed annually in Japan, of which 8 million tons is exported because it cannot be fully used domestically. If JFE Steel could increase its scrap ratio, it would be in line with Japan's policy of making use of valuable resources in its domestic market, so the JFE Group is working to develop scrap collection and supply chain infrastructure.

Q. Will NJSM in Mexico be producing galvanized steel sheet from electric-arc furnace products using 100% scrap, or will NJSM use steel made from reduced iron much as Nucor currently does?

A. Manufacturing automotive steel sheet from electric-arc furnace products based on 100% scrap is a difficult proposition at present. Most of the automotive steel sheet produced in electric-arc furnaces in the US comes from high-purity cold iron sources such as pig iron and reduced iron. NJSM produces hot-dip galvanized steel sheet of the most stringent quality standards, so using 100% scrap is not really possible at present.

Q. Is the roughly 30% recycling rate figure calculated based on the presumption that oxygen blast furnaces will be used?

A. The figure is based on furnaces being converted to oxygen blast furnaces.

Q. On what grounds do you base the CO_2 reduction target of 30% solely for a carbon-recycling blast furnace?

A. Carbon-recycling blast furnaces are characterized by the use of oxygen and methane, which are advantageous in terms of supplying heat, but there are still limitations. To produce one ton of pig iron, conventional blast furnace methods use around 350 kg of coke and around 150 kg of pulverized coal to prevent solidification due to a drop in heat at the bottom of the blast furnace. In a carbon-recycling blast furnace, the use of oxygen and methane means that less coke is fed in, but if this were taken too far, it could trigger the worst-possible problem—blast furnace chilling. With these factors taken into account, thermal calculations in our simulations yielded an estimated 30% reduction in CO_2. We plan to verify the validity of our simulation results in a small test furnace (150m^3) that we are looking at building in Chiba district.

Q. What impurities pose the main impediments in electric arc furnaces? Is there any possibility of JFE Steel switching to electric arc furnaces for the production of non-high-grade steel?

A. The biggest impediment to producing high-grade steel in electric arc furnaces is the presence of other elements in the scrap, such as copper and tin. There are strict upper limits on the content of these elements in high-grade steel, and these elements cannot be removed in either electric arc furnaces or converters at present. Therefore, a low-impurity cold iron source made from iron ore is needed for the production of high-grade steel. Meanwhile, there are certainly opportunities for materials produced in electric arc furnaces to be used in non-high-grade steel applications, and JFE Steel has completed its analysis of which products can be made in electric arc furnaces. Looking ahead, we expect products that can be made in electric arc furnaces to increase if electricity costs come down, if the scrap supply chain is built out, and if improvements in productivity—the biggest issue of all—can be achieved.

Q. In the offshore wind power generation field, what business activities will each of the operating companies be engaged in, how large do you expect the monopile market to be when you acquire a 50% market share, and what are JFE's advantages over its competitors?

A. In offshore wind power generation, JFE Engineering will be engaged in monopile design and manufacturing and JFE Steel will supply thick, high-welding-efficiency heavy steel plates for monopiles. JFE Shoji will build a supply chain for steel and processed products and will provide key information and other expertise when the business expands into Taiwan, Southeast Asia, and elsewhere. In O&M, we intend to bring our entire group's knowhow to bear in generating synergies. We estimate the monopile market will be about 100,000 tons/year at startup in around FY2024, and then about 160,000 tons/year from around FY2027 before rising to 200,000 tons/year in the 2030s as the number of deep-water projects increases. JFE Engineering aims to do 80,000–100,000 tons/year of business by acquiring a 50% share of this market.

Turning to offshore wind power foundation structures, projects such as the one off the coast of [Japan's] Akita Prefecture are currently using materials imported from Europe, but we think the future lies in JFE Engineering's track record of producing offshore structures and pipe jackets for Japan's coastal waters, and its ability to design structures resilient to typhoons, earthquakes, and so forth. The cost of importing materials from Europe is high and considerable losses can occur if problems arise during transport. Therefore, we believe there are competitive advantages in terms of productivity and stable and cost-effective supply if JFE Group handles the entire manufacturing process starting with the base materials made by JFE Steel.